A SELF-GUIDED E-LEARNING PROGRAM IMPROVES METAMEMORY OUTCOMES IN HEALTHY OLDER ADULTS: A RANDOMIZED CONTROLLED TRIAL

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Abstract

The majority of older adults will experience normal age-related memory changes. Memory programs offer a promising solution to mitigate decline and promote brain health. Memory programs have evolved over time, progressing from single mnemonic techniques to the combination of mnemonics, then to multicomponent programs offering participants a more holistic approach to enhancing their memory and brain health. A large body of literature demonstrates that in-person memory interventions can increase knowledge, support the acquisition of memory strategies, improve metamemory outcomes, and promote healthy lifestyle behaviors among participants. With the advancement of technology and the goal of attaining scalable and accessible solutions, researchers and clinicians are developing online memory programs. Our team developed a self-guided, e-learning program based on the well-validated, in-person Memory and Aging Program®. The objective of this dissertation was to evaluate efficacy of the e-learning program compared to a waitlisted control group through a randomized controlled trial. The trial was registered at clinicaltrials.gov (identifier: NCT03602768). As part of a larger, multi-arm, controlled trial, 115 healthy older adults (ages 60-84, 71% female) were randomized into an intervention or a delayed-start control condition. Team members involved in data collection were masked to participant grouping. Outcome measures were completed by telephone interviews (assessing memory knowledge) and online questionnaires (assessing metamemory and health-promoting lifestyle behaviors) at three time points (pre-program, post-program, and 6- to 8-week follow-up). Reasons for attrition were explored with a brief feedback survey. Improvements over time in memory knowledge, the acquisition of memory strategies and their use in daily life, and memory satisfaction and ability were larger in the group that completed the intervention than the control group. There

was no interaction effect for health-promoting lifestyle changes. Attrition was 43%, and the most common participant-reported reasons for attrition included a breakdown in communication, personal circumstances, dissatisfaction with the e-learning program, and technical/instructional issues. Overall, this self-guided, e-learning memory program may be an effective, accessible, flexible, and potentially cost-effective intervention that has the potential to achieve similar metamemory outcomes as the original in-person version in participants that complete the program. This research identified opportunities to design e-learning interventions to better support healthy lifestyle changes and potentially improve participant retention. Findings are discussed in relation to evidence-based practice in psychology.

Keywords: Memory intervention, e-learning, self-guided, healthy older adults, metamemory

Dedication

This work is dedicated to my son, Hudson, the sunshine of my life. It is also dedicated to the love of my life, Brayden, and the people who give my life purpose, my family and friends.

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Chapter 1

Overview

As the world population ages, it becomes increasingly important to prioritize the well-being and functional independence of older adults. This concerted effort not only promotes general population health but also fosters an inclusive and accessible society. Most healthy older adults (i.e., individuals without objective cognitive impairment and who are functionally independent) experience some age-related changes in memory. Real and perceived changes in memory functioning are associated with a greater worry of developing Alzheimer's disease (Cutler, 2015; Reese & Cherry, 2004). Worries related to memory can have negative effects on overall psychological well-being (Cutler & Brăgaru, 2017) as well as daily functioning (McAlister & Schmitter-Edgecombe, 2016). Further, experiencing negative beliefs about one's memory is associated with seeking help from a medical professional (Rotenberg et al., 2019). According to a cost-benefit analysis, offering a community-based memory program that includes psychoeducation on memory as well as memory strategy training can potentially alleviate healthcare costs associated with individual memory consultations with specialists and subsequent laboratory investigations (e.g., blood work, brain imaging etc.; Baker et al., 2022). In the long-term, such an approach aligns with primary prevention recommendations for reducing the risk of cognitive decline by focusing on the optimization of various lifestyle factors associated with the promotion of optimal brain function such as physical exercise, cognitive stimulation, and social activity (Sabbagh et al., 2022). Thus, considering solutions for memory and brain health concerns in older adults is important from both a societal and an economic perspective.

Understanding the evidence that supports the suitability and efficacy of memory interventions is critical for clinical psychologists and neuropsychologists who are providing evidence-based care for older adults. Evidence-based practice in psychology emphasizes three key elements to improve patient outcomes and the quality of service provided, including (a) research evidence, (b) clinical expertise, and (c) patient factors such as background and preferences (American Psychological Association, 2006). Chapter 2 of this dissertation provides a historical review of memory interventions and how they have evolved based on scientific research on memory processes and real-world concerns faced by older adults. The literature review begins with a description of early theories of memory and intelligence, which subsequently informed experimental research on mnemonics. As understanding increased of the many factors that can impact memory such as stress, mood, attitude, and lifestyle choices, memory interventions evolved to offer psychoeducation on such topics in addition to memory strategy training.

General findings are reviewed from studies evaluating the benefits of memory programs including objective memory performance and subjective memory outcomes. The second half of the review focuses on the evolution of memory programs as a result of the boom in technology and internet access. As the field of memory programs is moving towards virtual and mobile delivery, emerging recommendations for developing such programs for older adults are discussed. In response to the need for more accessible and scalable solutions for older adults, a description of our team's development of an e-learning memory program is provided. A limited number of other multicomponent online memory programs have been developed, and a review of preliminary feasibility and acceptability studies are provided. Overall, there is a need to better understand the benefits of such newly developed programs.

This dissertation was motivated by just such a desire, namely to examine the efficacy of an e-learning psychoeducational memory program for healthy older adults. The current study and its objectives are introduced at the end of Chapter 2. The e-learning program was modelled after an empirically validated in-person program. The benefits of this in-person program are reviewed and serve as the basis for the hypotheses in the present study.

In evidence-based practice in psychology, the quality of available research is important to consider when evaluating a study for its validity and generalizability. Randomized controlled trials are considered sophisticated empirical methodologies (American Psychological Association, 2006). These experiments offer a more stringent approach to evaluating the efficacy of a treatment by minimizing threats to internal validity (American Psychological Association, 2002). Methods for the randomized controlled trial conducted here are presented in Chapter 3, including a detailed description of participant recruitment and study procedures according to Consolidated Standards of Reporting Trials (CONSORT) – Outcomes 2022 Extension (Butcher et al., 2022). Extensive screening procedures are provided that ensured participants were healthy older adults without significant health concerns affecting their cognition. The content and the features of the e-learning program are reviewed. Brief descriptions of the outcome measures and their psychometric properties are provided.

Chapter 4 presents the results, beginning with an overview of participant characteristics in each of the two groups (intervention and waitlist control group). The efficacy of the program is determined by a comparison between both groups across three time points. Participant-reported reasons for attrition are presented.

Chapter 5 offers a discussion of the results in relation to previous outcomes of the in-person version of the program, and possible explanations for the observed differences are explored. Reasons for attrition are considered, and potential solutions are reviewed in hopes of strengthening design of future studies and bolstering adherence in virtual health care programs. Lastly, the implications of the study through the lens of evidence-based practice and the field of clinical psychology are presented, and suggestions for future research are offered.

Chapter 2

Review of Age-Related Memory Changes and Memory Interventions

Early Theories of Intelligence and Memory

Cattel (1957) distinguished two broad categories of intelligence: fluid and crystallized. Fluid intelligence is implicated in tasks requiring novel problem-solving abilities, whereas crystallized intelligence refers to one's fund of accumulated factual knowledge (Cattel, 1957). It has been postulated that along the trajectory of normal aging, fluid intelligence declines while crystallized intelligence remains relatively preserved (Horn & Cattel, 1967; Park et al., 2002). Notably, crystallized intelligence exhibits a steady increase until the approximate age of 60 years, at which point it tends to plateau, whereas fluid intelligence continues to decline (Murman, 2015; Salthouse, 2010). Separately, Tulving (1972) made the distinction between episodic and semantic types of memory, in which the former involves personal and temporally dated events, and the latter involves timeless knowledge. Integrating these two constructs, Kinsbourne (1980) argued that fluid intelligence maps on to episodic memory, and crystallized intelligence maps on to semantic memory. Specifically, retrieving unique events (episodic memory) requires a greater reliance on fluid intelligence and is associated with age-related declines, whereas older adults can successfully retrieve overlearned and rehearsed semantic memories (Kinsbourne, 1980).

This theory was investigated qualitatively by querying the types of memory challenges older adults experience in daily life. The majority of challenges reported by older adults can be classified as episodic events. Examples include difficulty remembering new names, the location of items, autobiographical events, and prospective tasks such as remembering appointments and taking one's medication (Cavanaugh, 1987; Leirer et al., 1990; Lowenthal

et al., 1967; Reese & Cherry, 2004; Roberts, 1983; Tenney, 1984; Weaver Cargin et al., 2008). Early surveys revealed approximately 50% of older adults over the age of 60 experience some form of memory complaints (Lowenthal et al., 1967; Roberts, 1983). Taken together, common memory challenges, particularly in the domain of episodic memory, have been a well-documented experience of older adults.

Historical Overview of Memory Interventions for Older Adults

The body of research building from the 20th century demonstrated that cognitive neuroplasticity could occur in older age (Karbach & Verhaeghen, 2014a; Park & Bischof, 2013), thereby highlighting the promise of memory interventions as a possible solution for commonly experienced memory challenges that increase with age (West, 1999). Historically, memory interventions evolved over time from single memory strategies to multicomponent programs including memory strategy training, education, and lifestyle changes. Research on memory interventions is commonly organized into categories based on the cognitive health and functional status of the target population, resulting in three discernible groups (Moreira et al., 2019). The first group encompasses healthy older adults, defined as individuals who experience normal age-related cognitive changes (i.e., they exhibit performance within expected ranges on standardized cognitive tests) while preserving their independence in basic and instrumental activities of daily living. The second group involves individuals with mild cognitive impairment (MCI), which is characterized by cognitive decline beyond what is expected in healthy aging in the context of a preserved ability to function independently (Petersen et al., 1999). The third group comprises individuals with dementia; these individuals experience cognitive impairment that is severe enough to disrupt their ability to care for

themselves. The present historical review is focused on memory interventions developed for healthy older adults.

Mnemonics

The foundation for multicomponent memory programs began with experimental research on the efficacy of a variety of mnemonics, which are internal strategies to aid in remembering. The use of mnemonics has been documented as early as 500 BC in ancient Greece and within the scientific literature as early as the late 1800s; a revival in experimental research on mnemonics began in the 1960s (Higbee, 1976). Applying mnemonics to improve performance on everyday memory tasks was popularized by Lorayne and Lucas (1974) in their book entitled *The Memory Book*. Readers learn about applying mnemonics such as associations, peg word, visualization, and organizational strategies for tasks such as remembering numbers, appointments, birthdays, names, and locations.

In one of the earliest meta-analyses of mnemonic training in healthy older adults, Verhaeghen et al. (1992) evaluated the preceding decade's research. The earliest work included in the analysis involved training with repetition and mediation (i.e., making associations; DeLeon, 1974). The meta-analysis included 33 studies and found significantly greater improvement on episodic memory tasks in groups who received mnemonic training relative to control (no treatment) and placebo (treatment that does not include mnemonic training) groups (Verhaeghen et al.). When examining studies that involved the training of a single mnemonic, such as method of loci, associations, peg word, or organization, individual mnemonics were equally effective. Mnemonics broadly served as a tool to enhance the richness and extensiveness of the information being encoded; improved performance was

therefore attributed to a deeper level of processing and elaboration during encoding resulting from the mnemonic (Craik & Lockhart, 1972; Craik & Simon, 1980).

Mnemonic Combinations. Zarit et al. (1981) published one of the earliest works combining three internal memory strategies--categorization, associations, and visual imagery—to form a training program. These strategies were taught to community-dwelling older adults across four sessions and applied to tasks of list learning, names, and paragraph retention. In a series of two studies, memory training participants were compared with a current events discussion group and a waitlist group with a pre- and posttest study design (Zarit et al.). Significant gains were observed only on the list learning task for the memory training participants relative to the control groups. One of the objectives of the study was to evaluate subjective memory concerns, which did not show a significant reduction. Zarit et al. concluded that improvement in objective memory performance was not necessarily associated with a reduction in memory concerns, which may be more strongly influenced by older adults' expectations of aging.

Mnemonics Paired with Relaxation Strategies to Bolster Efficacy. Certain studies included additional strategies to enhance mnemonic use such as training participants on relaxation techniques to reduce anxiety before the application of a mnemonic in an effort to optimize the encoding process (Gratzinger et al., 1990 Yesavage, 1984; Yesavage & Jacob, 1984). This approach was grounded on previous pharmacological research that demonstrated reducing autonomic arousal in older adults can improve verbal list learning (Eisdorfer et al., 1970). Reducing self-reported anxiety through progressive muscle relaxation in individuals with high levels of anxiety may similarly improve performance on list learning (Yesavage et al., 1983). This area of research aligned with early work that argued that memory mistakes

arise from a variety of sources and thus older adults would benefit from multifaceted strategies that target different stages of memory functioning (Bäckman, 1989; Neely & Bäckman, 1993).

Memory Strategies Involving Attention

Theoretical models of age-related memory decline implicated general slowing of speed of processing (Birren, 1962), limited attentional resources (Craik & Byrd, 1982), and difficulty inhibiting irrelevant information (Hasher & Zacks, 1988). Thus, one category of strategies focuses on the importance of effective attention allocation during the encoding process. As a practical memory strategy, Cermak (1975) recommended paying closer attention to the material that one wanted to remember. Yesavage et al. (1983) examined order effects among two types of training in a group of older adults. Concentration training (i.e., strategies to improve selective and sustained attention) occurred before or after mnemonic associative imagery strategy training. Results showed that receiving concentration training prior to mnemonic training was more effective for improving immediate and delayed serial recall. Backman (1989) included attentional guidance as an essential component for training older adults in memory compensatory strategies.

Gollwitzer (1990) proposed the concept of *implementation intentions*, a single mental act of linking a future event (e.g., arriving home after work) to a particular goal-directed behaviour (e.g., placing keys on the hook; Gollwitzer, 1993). In an experimental study, participants who were instructed to form implementation intentions had a greater likelihood of completing project goals than participants who were not instructed to form intentions (Gollwitzer & Brandstätter, 1997). Forming an association between a behaviour and its context supports memory retrieval of prospective intentions, whereas mental contemplation of

future time and place mirrors behavioural rehearsal necessary for the formation of habits (Orbell et al., 1997). Experimental work with implementation intentions with older adults was found to be effective for prospective memory tasks (McFarland & Glisky, 2011; Schnitzspahn & Kliegel, 2009). The importance of attention for successful memory performance is further supported by studies showing that divided attention during encoding negatively impacts memory retrieval in older adults and younger adults (Park et al., 1989). Overall, this body of research formed a foundation for the use of attentional strategies for optimizing everyday memory.

External Memory Strategies

External memory aids have emerged as a powerful complement to internal strategies to optimize daily memory functioning (Harris, 1978; West, 1989). Without training, older adults often underutilize external aids such as calendars, telephone books, and environmental cues during everyday memory tasks (West & Walton, 1985). Harris (1978) provided practical guidelines to promote the adoption, generalizability and maintenance of external memory aid use. The most appropriate aids are specific to the memory task while being generalizable to a variety of common memory tasks, portable if possible, easy to use, time-tied to the task as opposed to temporally distant, and function as active reminders.

Developing Memory Programs

Treat et al. (1978) provided one of the earliest sets of recommendations for the elements of effective memory training programs for older adults. First, mnemonics and other techniques such as attentional strategies should be adapted for older adults in order to optimize the encoding and retrieval of information. Second, skill acquisition of learning and applying memory strategies effectively can be supported in a variety of ways. For example,

older adults can be provided with meaningful opportunities to practice applying strategies in daily life and support habit formation. In order to bolster intrinsic motivation, older adults may be invited to participate in the design of personalized memory programs. Offering programs in a group setting can also provide social reinforcers through feedback and advice from others experiencing similar memory concerns. It may also assist in boosting motivation and promoting a positive attitude. Third, individual differences among participants can inform program design. Factors such as education, occupational history, cognitive style, learning preferences, and personality can be considered when individualizing the approach to training. Lastly, medical and psychiatric care may be integrated when necessary. For example, treating an underlying depressive condition may be an antecedent to participation in a memory program (Treat et al.).

Multicomponent Memory Programs. Peer-reviewed literature on the evaluation of multicomponent memory training for older adults began in the 1980s. For the purpose of the current review, multicomponent memory programs are those that include memory strategy training and at least one other additional component such as psychoeducation or relaxation training. Scogin et al. (1985) developed a manual of self-guided memory training for older adults. The manual included psychoeducation on memory and aging and how to apply a variety of memory strategies including external aids such as calendars, lists, and environmental cues, and internal strategies including chunking, categorization, mnemonics, method of loci, and other imagery techniques. In controlled evaluations of the self-taught program, participants received weekly telephone calls from a research assistant of approximately 5 minutes to provide support, gauge progress, and answer participant questions (Scogin & Prohaska, 1992; Scogin et al., 1985).

In its first evaluation relative to a waitlist control group, Scogin et al. (1985) found improvements on memory tests following the program but no changes in self-reported memory complaints and depression scores. At a 3-year follow-up, participants in the training group demonstrated significant decreases in objective memory performance and no change in the number of memory complaints (Scogin & Bienias, 1988). In other words, gains obtained immediately following the program were lost over time. Scogin and Prohaska (1992) found no difference in memory performance improvement between the memory program group and a control group that read a self-help attentional control book. However, the memory program group demonstrated greater confidence in memory ability relative to the attention group and a delayed start control group, but this effect was not transferable to other metamemory constructs such as frequency of memory failures in daily life and its impact (Scogin & Prohaska, 1992). The researchers recommended a greater focus on working with attitudes and beliefs within the memory program. Further, all participants demonstrated a decrease in complaints of depression over time, with no differences between the three groups (Scogin & Prohaska, 1992).

Flynn and Storandt (1990) compared three groups of participants: one group completed the self-taught memory manual only; one completed the manual and also participated in group discussions related to coping in later life; and one was a wait-list control group. The manual-plus-discussions group demonstrated a greater improvement on a word list memory task compared to the other two groups; however, improvements in face recall, digit span, and paragraph recall were not observed.

Stigsdotter and Backman (1989a) argued that a memory failure can occur at the stage of encoding, storage, or retrieval and be further influenced by attentional allocation. Thus, a

multifactorial approach to memory training may lead to greater improvements that are maintained for longer. Based on these assumptions, the researchers developed a multifactorial memory program with three major components (Stigsdotter & Backman, 1989a; 1989b). The first component involves memory strategy training to bolster encoding including interactive imagery and method of loci; the second component involves training of attentional skills and awareness; the third component focuses on relaxation training to mitigate anxiety through deep breathing and muscle exercises. The program was offered in a group setting for 10 1.5-hour weekly meetings. The group tutor led participants through practice activities implementing the new memory, attentional, and relaxation techniques. Participants were encouraged to discuss areas of challenge and to troubleshoot as a group (Stigsdotter & Backman, 1989b).

The multifactorial memory program was evaluated and compared to results of participants in a general cognitive activation program focused on visuo-spatial skills and problem solving. Outcome measures included a verbal free recall test, digit span, and the Benton Visual Retention Test. Relative to the active control group, older adults in the multifactorial memory program demonstrated improvements only on the free recall measure immediately following the program and at a 6-month follow-up (Stigsdotter & Backman, 1989b). These findings were replicated in a series of evaluations demonstrating improved memory recall of participants in the multifactorial program compared to a no-training control group and a unifactorial training group that received only encoding memory strategy training (Neely & Bäckman, 1993; Stigsdotter & Backman, 1989a), with evidence of task-specific gains maintained for 6 months although evidence of generalizability was weak (Neely & Bäckman, 1995).

Identifying Target Program Participants. It has become a standard practice to screen participants for cognitive status prior to their participation in memory intervention research intended for healthy older adults. Hill et al. (1989) provided a 2-week memory program delivered in small groups for 2 hours a day during which participants learned memory strategies including visual associations, making verbal judgments, the name-face mnemonic, and the method of loci for the recollection of names, faces, and lists. The purpose of the study was to evaluate the relationship between cognitive status as measured by the Mini–Mental State Examination (MMSE) and performance improvement from pre- and post-test which indicated a positive correlation between MMSE scores and improvement in performance (Hill et al., 1989). Screening for cognitive status also allows program facilitators greater confidence in validating that common memory mistakes are not necessarily indicative of early signs of dementia (Zarit et al., 1980).

Additional Psychological Components. The next major development in the field was to explore the benefits of targeting psychological processes such as beliefs about memory abilities based on the discrepancy between subjective memory and objective memory performance. In essence, mood, age stereotypes, and level of self-efficacy can impact perceptions of one's memory in a positive or negative direction (Kahn et al., 1975; Lachman et al., 1987). Thus, in studies involving cognitive restructuring, older adults were encouraged to identify negative automatic thoughts related to aging and memory decline, identify whether a cognitive distortion was present, and restructure thoughts to more adaptive responses (Caprio-Prevette & Fry, 1996; Lachman et al., 1992). The aim was to empower older adults to view their memory as a skill that could be enhanced within the aging trajectory. Lachman et al. (1992) compared five groups of older adults allocated to various programs including

memory skills training, cognitive restructuring to promote adaptive memory beliefs, a combined memory skills training and cognitive restructuring group, memory task practice, and a no-contact control group. The combined memory skills training and cognitive restructuring group demonstrated the greatest gains on metamemory outcomes (Lachman et al., 1992).

Best et al. (1992) further highlighted the benefit of expectation management by comparing four experimental groups: (a) memory training, (b) expectation management, (c) art discussion control, and (d) no-intervention control. In this study, expectation management involved four 45- to 60-minute sessions during which participants discussed their feelings about age stereotypes and were presented with research that highlighted the positive aspects of aging. Self-efficacy and self-esteem were developed through tracking of memory successes in participants' personal memory organizers (Cavanaugh et al., 1983) in order to accumulate evidence to promote a sense of competency in their memory skills. Results indicated that managing expectations decreased participants' complaints in their daily functioning, but there was no effect on objective performance (Best et al.). Conversely, participants in the memory training condition demonstrated improved memory performance on the recall of phone numbers, grocery list items, unrelated words, and prose paragraphs, yet there were minimal effects on memory complaints. Based on these findings, the authors argued that memory training programs may consider including both memory training and addressing participants' concerns and beliefs about the aging trajectory and their memory changes.

Subsequently, Caprio-Prevette and Fry (1996) compared the effectiveness of a cognitive restructuring program compared to a memory skills training program with the addition of psychoeducation within each program. Participants learned about memory

processes, theories of forgetting, pathological aging, and the impact of lifestyle factors such as nutrition, sleep, medication, and physical activity on memory. Results indicated significant improvements on memory performance measures for both groups at post-test, but these effects were maintained only by the cognitive restructuring group who also demonstrated greater gains on metamemory outcomes. The researchers noted that an additional future area to explore is the addition of partners or family members invited for active participation in the memory training programs.

An emphasis on subjective memory functioning was highlighted in a meta-analysis of memory programs (Floyd & Scogin, 1997) which found typically greater improvements on objective rather than subjective memory outcomes. The inclusion of interventions that focused on such psychological beliefs about memory and aging improved metamemory gains.

Foos (1997) evaluated whether a multicomponent memory course offered in a classroom setting was effective in reducing anxiety while improving memory in older adults. The course involved seven classes including psychoeducation and memory strategy training. Participants learned how memory works, how it changes with age, and how to identify normal or pathological signs of aging. Memory strategies included mnemonics, focusing attention, and external aids. Participants of the program demonstrated a significant reduction in anxiety ratings, the adoption of at least one new memory strategy, and improved performance on a paragraph recall task.

At about the same time, Mohs et al. (1998) evaluated a 9-week memory enhancement program that focused on memory education (i.e., how it works, memory processes), memory strategy training (including focusing attention, organization, associations, and use of external memory aids), and building self-efficacy through homework and positive feedback. Mood and

stress were also addressed as participants discussed strategies for stress management and were instructed in the Jacobson Relaxation and Systematic Desensitization Technique (Jacobson, 1938). Healthy older adults who participated in the memory enhancement program were compared to participants who watched and discussed content from a television series about the brain and the mind (Mohs et al., 1998). Results indicated a significant benefit on a single cognitive test that assessed verbal memory immediately following the intervention in favor of the memory enhancement program group; there were no differences between groups at the 6-month follow-up. Nevertheless, the memory enhancement group reported significant gains on a self-reported memory questionnaire including increased perceived ability of daily memory functioning, fewer concerns related to memory, and increased use of strategies. This effect was sustained at 6-month follow-up. In terms of mood, there was no difference between groups on mood ratings. Mohs et al. noted that at baseline, their sample reported relatively low levels of affective symptoms; however, this finding supports previous early work that did not find a correlation between affect and subjective memory perception (West et al., 1984).

Schmidt et al. (1999) further demonstrated the potential benefits of an intervention that focuses on targeting negative beliefs about memory. Participants in the intervention reported increased acceptance of memory failures and decreased worry compared to the no-treatment control group, although there were no effects on objective memory tasks. In general, the intervention was more beneficial for participants with greater memory concerns.

Interim Summary

The preceding review provided an outline of the early research on memory interventions, which began with training on individual mnemonics in a laboratory setting. The larger body of research on memory processing as well as the various factors that promote

successful memory functioning inspired the inclusion of additional intervention components that focused on attentional strategies, relaxation, healthy lifestyle behaviours, and beliefs about memory. Considering the personal experience of older adults and identifying individuals who would benefit most from a memory program were important developments in the field. Overall, there was a shift from thinking about a single tool to improve memory in the moment towards offering older adults a comprehensive program designed to bolster current memory functioning as well as optimize brain health in the long run.

Contemporary Memory Programs

In an effort to continue increasing the ecological validity of memory programs and their practical applications to older adults, Troyer (2001) developed a 5-week memory program delivered in 2-hour weekly group sessions called the Memory & Aging Program®. Participants learned about age-related memory changes, how to minimize such changes, and medical disorders affecting memory. In the memory strategy training component, participants were instructed on the use of external memory aids such as calendars and internal strategies such as spaced retrieval. Preliminary findings from a pre- and post-test evaluation of the multicomponent program relative to a control condition indicated increased memory knowledge and self-reported outcomes on the Multifactorial Memory Questionnaire (Troyer & Rich, 2002), which included satisfaction with one's memory ability, perceived memory functioning, and use of strategies in daily life. There were also significant group differences on an objective prospective memory task (but not other memory tasks) in favor of the memory intervention group (Troyer, 2001). Later randomized controlled trials of this program replicated these findings and further indicated that participants reported a decrease in intentions to seek unnecessary medical attention for their memory concerns (Wiegand et al.,

2013) and that they made a positive change in healthy lifestyle domains (Vandermorris et al., 2020). In a qualitative evaluation, participants also reported feelings of acceptance and reduced anxiety about normal age-related memory changes having learned from not only the facilitator but from a shared experience with other program participants (Vandermorris et al., 2017).

In a similar program, referred to by Villa and Abeles (2000) as a broad-spectrum intervention group for healthy older adults, participants learned about how memory changes with age, how to improve mood and manage stress, and how to utilize internal and external memory strategies across seven sessions. In this pilot, intervention participants improved on a prospective memory task and reported improved mood and a decrease in memory worries.

Valentijn et al. (2005) set out to investigate whether group or individual multicomponent memory interventions were more effective for improving both subjective and objective memory in healthy older adults. Through a randomized controlled trial, participants were allocated to one of three conditions: a) an 8-week multicomponent group intervention (12 participants per group), b) an individual memory training group where participants read a memory support book that covered similar content to the group intervention and received telephone support, and c) waitlist control group. Relative to the other two conditions, the group intervention participants reported more stability in memory functioning as well as decreased worry related to memory and improvements in word-list recall. The researchers attributed this effect to the opportunity to share memory concerns with other participants and the mechanisms of social influence and observation as sources of self-efficacy (Bandura, 1989).

Ball et al. (2002) conducted a randomized controlled trial of 2832 community-dwelling older adults (age 65 to 94 years) called the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study. Participants were randomized into one of three treatment conditions — involving 10 group training sessions for either (a) verbal episodic memory, (b) problem-solving, or (c) speed of processing — or a control condition; participants in any of the three treatment conditions improved on the targeted cognitive ability compared with baseline performance, and this was maintained for 2 years. Later investigations utilizing the ACTIVE dataset highlighted that individuals with more severe memory impairment benefitted less from memory training, and greater educational attainment was associated with better response to training (Langbaum et al., 2009; Unverzagt et al., 2007). Adding to the discussion of mood and memory, Lohman et al. (2013) demonstrated that participants with elevated depressive symptoms performed more poorly at baseline and had a faster decline in memory performance over time compared to participants with fewer symptoms. Nevertheless, depressive symptoms did not attenuate training benefits (Lohman et al., 2013).

Around the same time, many other researchers around the world demonstrated similar findings from evaluations of memory programs with healthy older adults. For example, in Canada, Belleville et al. (2006) developed an 8-week group intervention that offered psychoeducation on normal aging as well as training of attentional and memory strategies. Participants who completed the program demonstrated improvements in areas of episodic memory performance, subjective memory, and overall ratings of well-being compared to controls. In Australia, Kinsella et al. (2016) developed a 6-week group intervention where participants were permitted to have a friend or family member join; the sessions focused on

psychoeducation on memory and how it changes with aging and in response to various lifestyle and health factors. Participants were also instructed to apply various memory strategies to common memory problems, as well as trained in goal planning and the use of an external memory aid. Relative to a waitlisted control group, the intervention group demonstrated gains in memory knowledge, strategy use, perception of one's memory ability, performance on a prospective memory task, and ratings of well-being. The results of this randomized controlled trial, as well as others, are captured in a meta-analysis by Hudes et al. (2019) which demonstrated the benefits on participant-reported memory and well-being outcomes from participation in in-person memory programs.

Overall, this large and growing body of research has supported the idea of brain plasticity in older age and propelled the exploration of scalable interventions to produce such gains in cognitive ability while bolstering the well-being of older adults. Indeed, the World Health Organization launched a Global Observatory for eHealth, which is described as the use of information and communication technologies for health and is identified as the most rapidly growing area in health at the time (World Health Organization, 2005).

The eHealth Era

In the early 2000s, the field of memory interventions included more cost-effective, accessible, and personalized training options through the development of computerized programs. For example, computerized training of targeted cognitive functions offered participants tasks that increased in level of challenge depending on their performance (Eckroth-Bucher & Siberski, 2009; Mahncke et al., 2006; Smith et al., 2009). Dakim's *Brain Fitness* program was investigated as an intervention to improve cognitive performance in a sample of healthy older adults (Miller et al., 2013). The program similarly adjusted to

participants' performance level and offered exercises targeting memory, language, spatial processing, reasoning, and calculation skills. The program additionally incorporated instruction on memory strategies including visualization, associations, and the story method. Participants were afforded the freedom and flexibility to complete the exercises at their convenience with the goal of 20-25 minutes per day for at least 5 days for 8 weeks (Miller et al., 2013). Compared to a wait-list control group, participants in the intervention group demonstrated improvements on delayed memory performance (no difference on measures of immediate memory and language tasks). The researchers highlighted the need for future research to investigate the potential benefits of computerized programs on real-world function that goes beyond improvements on a cognitive test score (Miller et al., 2013).

In an exploratory mixed-method design study of a computerized training program (Posit Science's Brain Fitness Program), Walker et al. (2014) sought to understand participants' lived experience of completing the program as well as its impact on both cognitive outcomes and quality of life. This small study (n = 10) required participants to complete an interview, measures of cognition (assessing attention, concentration, memory, planning, and response inhibition), and a questionnaire to measure self-reported quality of life called the Control, Autonomy, Self-realization and Pleasure Questionnaire (CASP-19: Hyde et al., 2003). The program consisted of computer-based exercises that target auditory attention, speed, and memory with graded challenge and intensive repetition (Walker et al., 2014).

Results indicated that all participants demonstrated improvements on measures of attention and concentration, and 6 out of 10 participants indicated improvements in thinking/communication skills in everyday life. Qualitative feedback revealed both positive

aspects and areas for improvement. Participants indicated that the program was easy to use (even with limited computer skills), and they appreciated the flexibility of completing the program at their convenience and in their desired location. In addition, participants reported that the program offered them hope for mitigating cognitive decline (Walker et al., 2014). Conversely, some participants reported frustration with the repeated instruction, and one participant mentioned a physical barrier of arthritis in her hand that was wearing out after an hour of training. As participants were Australian, the American-developed program was confusing and distracting due to its American accent and vocabulary; participants also felt as though it did not reflect Australian culture. In addition, two participants reported missing the human interaction that was not provided within the program (Walker et al., 2014).

Chambon et al. (2014) evaluated a computer-training program with healthy community-dwelling older adults who were trained on memory, attention, and executive function tasks. Participants were provided with a choice of mnemonic and executive strategies to decide which was best suited for a given task, and task difficulty was adapted to the individualized progression of each participant (Chambon et al.). Older adults were randomly assigned to one of three conditions: a) participating at home in the computer-training program, b) participating at home in a paper-and-pencil game training (e.g., crosswords, Sudokus from newspapers/magazines), and c) no training. Results of objective tests indicated improvement of recognition and of immediate and delayed semantic free recall for the computer-training condition as well as improved total score on self-perceptions of everyday memory functioning as measured by the Memory Failure Questionnaire (MFQ; Gilewski et al., 1990). Whereas the paper-and-pencil condition and the control condition did not demonstrate any cognitive benefits, the paper-and-pencil condition as well as the computer-

training condition both showed an increase on the Rosenberg Self-Esteem Scale (RSE; Rosenberg, 1965). At the 6-month follow-up, the only benefit maintained for the computer-training group was on semantic free recall, which led the researchers to suggest the need for regularly practiced cognitive training to mitigate age-related decline. An additional area that was identified as a future focus was preventative training programs for healthy older adults (Chambon et al., 2014).

The research area focusing on computerized programs expanded due to the potential for scalability and commercialization, which garnered interest from researchers and industry stakeholders alike. A meta-analysis conducted by Lampit et al. (2014) demonstrated small to moderate effect sizes for improvements in aspects of memory, processing speed, and visuospatial skills from computerized cognitive training programs. Many subsequent studies demonstrated similar benefits from computerized programs (see Tetlow and Edwards, 2017, for a review and meta-analysis of commercially available computerized training programs), with more recent research expanding to evaluate the benefits on subjective memory and psychological well-being (Viviani et al., 2023). In clinical practice, the COVID-19 pandemic accelerated the adoption of videoconferencing platforms to provide health care services remotely, referred to as telehealth. For example, the Memory and Aging Program offered in person at Baycrest Health Sciences in Toronto was quickly transferred to a facilitator-led virtual group offered through the Zoom platform at a regularly scheduled time. Research in the coming years will reveal the efficacy of such a delivery method.

The mHealth Era

Next, the widespread use of mobile telephones emerged as an opportunity to develop accessible and user-friendly applications aimed at improving health (Ly, 2011). Within its

Global Observatory of eHealth services, the World Health Organization launched the survey of the status of mHealth, described as medical and public health practices supported by mobile devices (Ryu, 2012). Researchers first began exploring mobile and smartphones as an external memory aid with rehabilitation populations (e.g., traumatic brain injury) demonstrating training on features such as voice-recordings, calendars, and alerts on everyday memory functioning (Stapleton et al., 2007; Svoboda & Richards, 2009; Wade & Troy, 2001).

Subsequently, memory interventions were explored as a preventative tool to delay onset of cognitive compromise for healthy older adults with memory complaints because the subjective experience of cognitive decline was identified as a potential risk factor for future decline (Reid & MacLullich, 2006). Oh et al. (2018) evaluated two smartphone programs with a group of healthy older adults ranging in age from 50 to 68 years. The first program, called SMART, was developed to improve attention and memory through 10 task training areas of sustained and selective attention, verbal and visual-spatial memory, processing, calculation, and visual-spatial working memory (Shin et al., 2017). As a comparison, the web-based and smartphone program called Fit Brains® was selected (available publicly on www.fitbrains.com). Fit Brains® involves training tasks focused on problem solving, memory, processing speed, concentration, and visual perception. Along with a third waitlist condition, participants across the three groups were evaluated on objective cognitive outcomes as well as subjective impressions of memory using a modified version of the Multifactorial Memory Questionnaire (MMQ: Troyer & Rich, 2002) for their Korean study sample. Overall, participants receiving the SMART intervention demonstrated improved performance on aspects of verbal working memory, whereas memory contentment was improved only in the Fit Brains® condition (Oh et al., 2018). The researchers noted that gains

in working memory in the SMART group did not necessarily lead to a decrease in subjective memory complaints (Oh et al., 2018). This finding lends further support for in-person memory interventions to include multicomponent memory programs rather than training on cognitive tasks alone.

Multicomponent Online Memory Programs. Pike et al. (2018) published a set of recommendations for researchers and clinicians seeking to develop online memory programs for healthy older adults. Namely, it was recommended that online programs be based on validated in-person multicomponent programs, be targeted to older adults with subjective cognitive complaints, and be tailored to the end-user and their needs (Pike et al., 2018). Rebok et al. (2020) compared the previously discussed intervention from the ACTIVE study (Ball et al., 2002) with a web-based offering of the program and a waitlist control condition. The web-based intervention involved facilitator-led instruction on memory strategies and their application to real-world scenarios across 10 sessions. Neither format yielded any significant training effects or impact on everyday function. However, the researchers reported equal participant satisfaction between the in-person and web-based version highlighting its acceptability and feasibility for older adults seeking a memory program (Rebok et al., 2020).

A user-friendly design is an important element to support the use of e-learning programs in older adult populations (Bai et al., 2020). Our team proposed a framework for developing and piloting an online e-learning memory program tailored to the needs of the end-user (Yusupov et al., 2022). The e-learning program was developed based on the validated in-person multicomponent memory program called the Memory & Aging Program (Troyer, 2001). We adopted the agile development cycle (an iterative process that incorporates user feedback at each step of development) and the Harvard Clinical and

Translation Science Center's translational phases (Harvard Catalyst, 2021) to pilot the e-learning program. Twenty-five community-dwelling older adults were invited to pilot the individual modules; participants were observed and completed feedback questionnaires. This stage of piloting was instrumental in identifying a number of technological glitches and settings that needed adjustment (e.g., volume, speed, font size etc.). Overall, participants indicated that they found the modules user-friendly and enjoyable to use (Yusupov et al., 2022).

Once program modifications were made based on feedback collected from individual modules, an additional 20 community-dwelling older adults completed the program in its entirety by remote access. In order to gauge preliminary clinical outcomes (as demonstrated in previous evaluations of the in-person version), participants were administered select memory measures before and after completion of the program. Prior to starting the program, participants were also asked to select three program-specific goals and rate them in terms of satisfaction upon program completion. Participants demonstrated a significant increase in memory knowledge and strategy use, adaptation of healthier lifestyle behaviors, and overall satisfaction with their program-specific goals. Piloting of the full program resulted in 50% attrition (Yusupov et al., 2022).

Recently, a similar online multicomponent memory program called the Online Personalised Training in Memory Strategies for Everyday (OPTIMiSE) was evaluated through a single-arm pre-post trial (Pike et al., 2023). OPTIMiSE included six modules and a 3-month booster session; the content included instruction on compensatory memory strategies and psychoeducation about memory, what to expect with normal aging, well-being, and sleep. Participants were encouraged to post on moderated discussion boards and complete regular

homework. Results of the pre-post study indicated that the program was acceptable (97% of participants agreed that they would recommend the program) and efficacious in that participants showed moderate to large effect sizes across all outcomes including memory goal satisfaction, strategy knowledge and use, metamemory, and mood. Similar to our study (Yusupov et al., 2022), the attrition rate was 51% (Pike et al., 2023). A limitation identified by the researchers was the lack of a control group to account for potential natural changes that may occur over time.

Klaming et al. (2022) designed an app for IOS and Android tablets called *MemoryUp* and evaluated its efficacy with a Dutch sample of older adults. The training involved psychoeducation, memory strategy training, and tips for transfer strategies to daily life. Relative to a wait-listed comparison group, participants who completed the *MemoryUp* training demonstrated improvements in an associative memory task, memory satisfaction, use of internal memory strategies, and quality of life. A few limitations noted by the study authors included the lack of standardized measures to screen for cognitively healthy older adults (screening was based on self-report measures) and the absence of a follow-up to evaluate whether benefits were maintained over time.

Investigation of Other Interventions for Memory

Outside of the field of eHealth and mHealth memory interventions, researchers have investigated the benefits of other interventions theorized to impact memory. Ramírez et al. (2014) demonstrated benefits for mood, the recollection of specific memories, and overall life satisfaction following a positive psychology intervention focused on autobiographical memories, forgiveness, and gratitude. A research team in Hong Kong demonstrated the benefits of a Chinese *Chan*-based lifestyle intervention called the Deijan Mind-Body

Intervention (Chan et al., 2014). The goal of the holistic intervention was to alleviate psychological suffering through insight of the root cause of problems according to Buddhist philosophy. The intervention had three major components: a) *Chan* practice, which involved self-awareness and self-control surrounding unrealistic desires; b) *Nei Gong* (i.e., mind-body) practice that focused on fostering the mind-body connection through breathing exercises, physical flexibility, and relaxation; and c) dietary modification, which involved consuming healthy foods and avoiding foods that generated excessive internal heat (e.g., spicy foods, eggs, meats). Throughout several evaluations, the program's benefits included significant improvements in verbal and visual memory (Chan et al., 2014; Chan et al., 2018), improvements in ratings of subjective physical and psychological health (Chan et al., 2018; Yu et al., 2014), and a reduction in depressive symptoms in individuals with depression (Chan et al., 2012; Yu et al., 2014).

Other interventions that involved the body were also evaluated for memory benefit with older adults. Some were effective; for example, McEwen et al. (2018) demonstrated improvements among older adults with subjective cognitive complaints for overall memory composite scores, reasoning abilities, and attention for a memory strategy-training program that was completed while simultaneously cycling a stationary bicycle. A moderate- to high-load resistance training program was found to have isolated improved performance on delayed memory tasks in healthy older adults (Marston et al., 2019). A yoga education program that was aimed at memory enhancement involved postures, relaxation, slow movements, and cultivating inner awareness (Pandya, 2020). The intervention involved guided classes and self-practice with participants demonstrating improvements on the MMSE (Folstein et al., 1975), as well as the Rivermead Behavioural Memory Test-3rd edition (Wilson

et al., 2008). As a part of a brain health promotion strategy, there is a need for further controlled evaluations of nonpharmacological, multidomain programs aimed at reducing dementia risk in older adults (Solomon et al., 2021).

Interim Summary

Thus far, the current review provides a history of the evolution of memory programs for healthy older adults. Early research focused on the efficacy of single mnemonics in a laboratory setting. This evolved to evaluating multiple mnemonics and later to the training of compensatory memory strategies within interventions. The overall consensus grew to the promotion of multicomponent memory programs due to the breadth of potential benefits for participants. Along with strategy training, multicomponent programs included additional aspects such as psychoeducation on how memory works, normal versus pathological memory changes, lifestyle factors that affect memory, stress management, exercise, and mood. Next, researchers capitalized on the emerging era of eHealth and mHealth by developing memory interventions on platforms that can increase accessibility, scalability, privacy, and patient autonomy. Future research is needed to continue validating online technologies that are tailored to the needs of healthy older adults seeking to bolster the memory and brain health.

Subjective Cognitive Decline

Older adults continue to experience memory challenges such as forgetting the location of items, newly learned names, or intended future actions (Burmester et al., 2015; Craik & Rose, 2012; Luck et al., 2018; Ossher et al., 2013), as they did generations ago (Cavanaugh, 1987; Leirer et al., 1990; Lowenthal et al., 1967; Roberts, 1983; Tenney, 1984). Despite major advances in health literacy, education, and access to health services, noticing such cognitive changes may nevertheless lead to significant worries (Jessen et al., 2020), especially in the

context of increased health-related anxiety associated with the COVID-19 pandemic (Kini et al., 2020). Noticing changes in memory can impact an individual's feelings and views of themselves, their relationships and social interactions, their work, and their recreational activities (Parikh et al., 2016). Moreover, negative beliefs and feelings of low self-efficacy in regard to one's memory can impact objective memory performance as well as overall well-being and quality of life (Horton et al., 2007; Levy, 2003). To capture this experience, the term *subjective cognitive decline* has been used to describe cognitively normal individuals feeling concerned about a perceived decline in their cognitive functioning, predominantly within the memory domain (Jessen et al., 2014).

Providing timely, accessible education and support has the potential to alleviate concerns, empower older adults to optimize their brain health, prevent unneeded medical consultations and testing, and help direct those needing medical follow-up to the appropriate resources. Indeed, research shows that memory interventions can not only improve performance on trained memory tasks (Karbach & Verhaeghen, 2014b), but also increase perceived memory abilities and strategy use as well as psychological well-being and overall quality of life (Hudes et al., 2019). A recent systematic review has identified educational programs as most effective (in comparison to physical intervention, cognitive training, and pharmacological treatments) in improving memory performance in individuals with subjective cognitive decline (Roheger et al., 2021). This research supports the idea that cognitive health across the lifespan can be mediated in a positive direction by memory training and psychoeducation about modifiable lifestyle factors (Hertzog et al., 2008; Livingston et al., 2020). These may include direct training of cognitive processes, training to use compensatory strategies, and modification of lifestyle behaviors such as exercise, diet, sleep, and stress

management. Providing further evidence for neuroplasticity even in older adulthood, Engvig et al. (2010) demonstrated changes at the structural brain level in older adults who participated in memory training.

Benefits and Limitations of Memory Interventions

Despite the accumulating evidence for the potential benefits of memory programs, there are also limitations for both in-person and online interventions. For example, there are several barriers associated with in-person interventions including costs and resources from the provider's end (Baker et al., 2022) and accessibility considerations on the part of participants (Fitzpatrick et al., 2004; Pike et al., 2018). In this regard, online programs can offer several advantages including cost savings, increased accessibility and program reach, and improved participant self-efficacy (Pike et al., 2018; Pike et al., 2023; Rebok et al., 2020). In contrast, e-health interventions tend to yield poorer adherence and greater attrition compared to in-person offerings (Boekhout et al., 2019; Eysenbach, 2005; Peels et al., 2012; Ratz et al., 2021). Accessing online applications may be difficult for those without adequate technology and internet access as well as for individuals with poorer perceived computer skills (Bai et al., 2020; Hurmuz et al., 2021). Lastly, older adults may present with a preference for traditional in-person service delivery, a mistrust of technology and the internet, and physical and cognitive changes associated with aging (Pike et al., 2018). Nevertheless, as societies around the world continue to recognize the growing need to support individuals in maintaining independence and functioning during later life, the need for designing and evaluating accessible and scalable solutions cannot be ignored.

Attrition. Reducing attrition is an important objective for clinicians and researchers offering any type of health intervention. Research investigating attrition in older adults

participating in in-person studies have identified various demographic and health-related predictors. Compared to study completers, individuals lost to follow-up tend to be older, have lower levels of education and income, belong to a racial minority group, and may have poorer subjective health, cognitive status, and greater chronic illness (Cacioppo & Cacioppo, 2018; Hardy et al., 2009; Heid et al., 2021; Jacomb et al., 2002; Slymen et al., 1996). Other common reasons for attrition among older adults include external life circumstances, unwillingness to participate, death, and transportation challenges (Bonk, 2010; Jacomb et al., 2002; Lacey et al., 2017).

To date, reporting of attrition and missing data within geriatric journals is suboptimal (Okpara et al., 2022). However, the investigation of attrition among older adults participating in online interventions is an emerging area of research. Eysenbach (2005) described the phenomenon of the "law of attrition" denoting it as a fundamental challenge within online health intervention studies. Conversely, this law should not be considered as a purely negative consequence of eHealth interventions, as much as it should be considered a common experience for researchers and practitioners. Attrition data should be reported explicitly within manuscripts and explored with a manner of curiosity to gain knowledge about how studies may be best designed for their target group (Eysenbach, 2006). Minimizing attrition is an important consideration to maintain study power, reduce biased results, and improve intervention uptake and its effectiveness (Bouwman et al., 2019; Eysenbach, 2005). From a clinical perspective, reducing attrition translates to more people who can benefit and a greater impact on population health.

Current research in the field is now beginning to explore reasons for attrition from online interventions. In a survival analysis of an online loneliness intervention for older

adults, it was found that an active coping style, earlier access to intervention content that promoted behavioural activation, and greater engagement with intervention activities was associated with lower attrition (Bouwman et al., 2019). In an investigation of attrition in a web-based physical health intervention for Dutch, single, community-dwelling older adults (ages 65 years or older), the only predictor of attrition was lower educational attainment (Boekhout et al., 2019; Ratz et al., 2021). In a web-based falls-prevention program, Dutch community-dwelling older adults who had greater perceived computer skills and lower need for external regulation such as rewards showed higher levels of program retention (i.e., lower attrition; Hurmuz et al., 2021). The paucity of research lends an opportunity to investigate participant-reported reasons for attrition that can bolster the design of online research interventions for older adults.

Overall, in-person and online interventions each have benefits and limitations. When considering evidence-based practice, individual characteristics and preferences will affect which modality is best suited to meet the unique needs of a patient (American Psychological Association, 2006). However, as this is an emerging area, more research is needed to evaluate the efficacy of online memory programs.

Current Study

To overcome the aforementioned limitations of in-person programs and to contribute to the new direction of the memory intervention field, we conducted a randomized controlled trial of the self-guided, e-learning memory program described above (Yusupov et al., 2022). We modeled our program on the Memory & Aging Program®, a 5-week in-person group psychoeducation and memory-strategy training intervention developed and offered for over 20 years at Baycrest (Troyer, 2001; Troyer & Vandermorris, 2012). The program is intended

for use among healthy older adults who are concerned about their memory and/or are interested in optimizing their brain health and memory performance. A minimum age of 60 years old was selected for recruitment in the current study because cognitive decline tends to accelerate after age 60 to 65 (Hedden & Gabrieli, 2004; Nyberg et al., 2012; Salthouse, 2009). The program focuses on teaching and applying evidence-based external and internal memory strategies to real-life scenarios. This specific teaching is built on a holistic foundation, including biological, psychological, social, and environmental determinants of cognitive health in older adults (Troyer & Vandermorris, 2017). Previously demonstrated benefits of the in-person program include gains in memory knowledge and strategy use, increased satisfaction and confidence with one's everyday memory functioning, positive change in healthy lifestyle domains, decreased intentions to seek unnecessary medical attention for memory concerns, and feelings of acceptance and reduced anxiety about normal age-related memory changes (Troyer, 2001; Vandermorris et al., 2017; Vandermorris et al., 2020; Wiegand et al., 2013).

Objectives

The objectives of the current study were two-fold: (a) to determine intervention efficacy and (b) to explore participant-reported reasons for attrition. This is the first study to examine the potential benefits of an e-learning multicomponent memory program utilizing a rigorous methodology in order to minimize risk of bias and threats to internal validity. Our aim was to replicate postintervention benefits that were consistently observed with previous evaluations of the in-person program (Troyer, 2001; Vandermorris et al., 2017; Vandermorris et al., 2020; Wiegand et al., 2013) when compared to "treatment as usual" for healthy older adults with normal age-related memory concerns (i.e., no intervention; Petersen et al., 2018).

As the online program was designed to be similar to the in-person version in terms of content, activities, and levels of engagement, we expected similar outcomes between the two versions. Thus, we expected participants in the intervention group to demonstrate greater knowledge about memory and brain health, improved acquisition of practical memory strategies, increased confidence and satisfaction with their memory, and greater participation in health-promoting lifestyle behaviors when compared to a control group. A secondary objective of this research was to explore participant-reported reasons for attrition to better understand the online experience and to inform the design of future online studies for healthy older adults (Eysenback, 2006). Chapter 3 describes the methodology for the study.

Chapter 3

Methods

Participants and Procedure

The CONSORT flow chart in Figure 1 details study procedure and participant flow. The current study was conducted at Baycrest Health Sciences in Toronto as part of a larger, multi-arm, controlled trial with healthy older adults recruited between March 2018 and December 2020 on a rolling basis through online advertisements and an institutional volunteer pool. The recruitment advertisement was targeted towards individuals interested in cognitive fitness, aging, and brain health (see Appendix A). It specified that the study involved testing online interventions for common age-related cognitive changes that were based on well-validated, in-person programs offered at the host institution. Recruitment materials and study procedures were constructed to support participant perception of clinical equipoise between conditions. Specifically, study details did not specify at which point of participation access to the e-learning program would be provided. Ethics approval was obtained from the institutional Research Ethics Board, and the study was prospectively registered at clinicaltrials.gov (identifier: NCT03602768).

To determine study sample size, we calculated change scores among participants and controls in previous evaluations of the in-person Memory and Aging Program, which indicated effect sizes ranging from medium to large (0.6 to 0.7). Thus, with a desired power of 0.9 and effect size of 0.6, Cohen's sample size table (1988) indicated a minimum of 49 participants in each group would be necessary to detect a statistically significant difference at $p = .05$.

Interested participants who replied to the online advertisement (n = 1,320) were emailed the informed consent form (see Appendix B). Following pre-screening (conducted serially online and via telephone), 394 participants met the following inclusion criteria: age 60+, self-reported English proficiency, both access to and familiarity with computers (see Appendix C for questions assessing computer access and familiarity), independence in activities of daily living (see Appendix D), absence of self-reported major health conditions affecting cognition (e.g., stroke, brain injury, dementia, seizures, and types of cancer), mental status in the unimpaired range, operationally defined as a score of 30 or higher on the Modified Telephone Interview for Cognitive Status (mTICS; Brandt et al., 1988; Welsh et al., 1993), and low endorsement of depression symptoms defined by a score of less than 10 on the Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001). In addition, participants had to endorse at least one of the following cognitive complaints during the online screener: difficulty remembering names, focusing attention, remembering the location of items, making decisions, remembering intentions, or solving problems. Finally, participants had to endorse interest in learning how to improve cognitive functioning. Primary reasons for exclusion of potential participants during the online screening phase included, in order of number of participants excluded, failure to complete the screening, an affective disorder diagnosis or a score greater than 10 on the PHQ-9, no subjective complaints or indication of an interest in learning about improving cognition, and a health condition affecting cognition. The greatest reason for exclusion at the telephone interview screening phase was withdrawal from the study. A CONSORT Flow Diagram is provided in Figure 1 with details regarding the number of participants assessed, excluded, enrolled, and followed at each stage of the study.

Informed consent was obtained online prior to the completion of the prescreening questionnaire and over the telephone, which allowed participants the opportunity to ask the research team questions related to their participation. Eligible participants were emailed a link to complete the pre-program outcome measures described below. Subsequently, participants were randomly assigned to one of four conditions, two of which are relevant for the current study: e-learning Memory and Aging Program or waitlist control. A blocked randomization scheme stratified by age (60-69 and 70+) was created using an online software application (Sealed Envelope Ltd., 2017). The randomization list was managed by a study member not known to participants or involved in data collection. Of 1,320 participants who were screened for eligibility, 202 were assigned to the intervention or control arms of the current study.

Participants randomized to the intervention condition were emailed a link to access the e-learning Memory and Aging Program remotely from their homes or location of choice. Participants in the control condition were offered the opportunity to complete the program once all assessment sessions were completed. In addition, team members involved in data collection were masked to participant grouping. Outcome measures were administered through telephone interviews and online questionnaires at three time points: baseline, immediate postintervention completion, and 6 to 8 weeks later for the intervention group, with corresponding time points for the control group. Participants were compensated $30 for each completed testing session for a maximum of $90, which was provided as an Amazon gift card, cheque, or donation to the host institution.

Participants who withdrew or were lost to follow-up were emailed a link to the online feedback survey to better understand their experience and reasons for attrition. Participants were informed that the survey was optional and would take approximately 5 minutes to

complete. They were provided with their initial participant ID as the identifier at the beginning of the online survey in order to keep any personal identifying information separate from the feedback data.

Self-Guided E-Learning Memory and Aging Program

The program consisted of eight modules, requiring approximately 10 hours of engagement overall. It was recommended that participants complete one module per week, although they had flexibility to complete the modules at their desired pace. Participants were required to complete the preceding module before the next one became available. Table 1 provides an overview of program content. The information was delivered in a variety of formats, including explanatory videos, animations, interactive games, practice questions, and discussion boards to support various learning styles and cognitive profiles of older adults (Pappas et al., 2019; Yusupov et al., 2022). Participants completed homework assignments in a participant workbook that was mailed to them at the onset of the intervention.

Outcome Measures

Memory and Brain Health Knowledge

The Memory Knowledge Quiz was adapted from previous evaluations of the in-person version of the Memory and Aging Program (Troyer, 2001; Troyer & Vandermorris, 2012). Over the telephone, participants were asked 12 short-answer questions related to memory and brain health. Participant responses were recorded verbatim in an online form (see Appendix E). Each answer was then scored using a scoring rubric of acceptable responses, for a total of 25 possible points.

Memory Strategy Application

The Memory Strategy Toolbox (Troyer, 2001) was administered through an online questionnaire (see Appendix F). Participants were presented with six common memory-demanding scenarios (e.g., learning a new name), and were required to list memory strategies that would be useful for the situation. The responses were scored according to the quantity of different strategies and their quality; each strategy was awarded a score from 0 (indicating an ineffective strategy) to 2 (indicating the most effective strategy). There was no maximum score, as participants were able to list as many strategies as possible for each scenario.

Memory Satisfaction, Ability, and Strategy Use in Daily Life

The Multifactorial Memory Questionnaire (Troyer & Rich, 2002) was administered online and consisted of 57 items rated on a 5-point Likert-type scale based on the participant's experience within the last 2 weeks. There are three MMQ subscales, each of which measures a separate aspect of metamemory. MMQ-Satisfaction provides a measure of one's satisfaction or concern for memory with scores ranging from 0 to 72, with higher scores indicating greater satisfaction (see Appendix G). MMQ-Ability measures perceptions of one's memory ability by having participants indicate how often they experience common memory mistakes (see Appendix H). Scores range from 0 to 80, with higher scores indicating better self-reported memory ability. MMQ-Strategy measures the frequency of memory strategy use in daily life with scores ranging from 0 to 76, with higher scores indicating greater use of strategies (see Appendix I). The measurement properties of the MMQ, including factor structure, internal consistency, stability, measurement error, and validity, have been reported in a number of studies and a meta-analysis (Shaikh et al., 2021; Troyer et al., 2019).

Healthy Lifestyle Behaviors

The Health Promoting Lifestyle Profile II (HPLPII; Walker et al., 1987) was administered online and consisted of 52 items rated on a 4-point Likert-type scale to measure the frequency of healthy behaviors. The questionnaire provides a score for six domains: health responsibility, physical activity, nutrition, spiritual growth, interpersonal relations, and stress management. For example, participants were asked to rate the frequency that they: *follow a planned exercise program* (physical activity domain), *eat 2-4 servings of fruit each day* (nutrition domain), *spend time with close friends* (interpersonal relations domain), and *take some time for relaxation each day* (stress management domain). Mean frequencies were computed for each domain ranging from 1 to 4 (1 = Never, 2 = Sometimes, 3 = Often, and 4 = Routinely), and an overall score was computed summing responses from all 52 items for a total possible score of 208. Higher scores indicate a greater frequency of participant-reported healthy behaviors in their daily life. The HPLPII has been widely validated across age groups and cultures (Chuang et al., 2017; Sousa et al., 2015; Tanjani et al., 2016), and psychometric properties including its factor structure, internal consistency, and reliability have been reported (Walker et al., 1987).

Attrition Feedback Survey

The feedback survey was developed to be short and concise in an effort to increase response rate (see Appendix J). The main question was open-ended and asked participants, *"What was the main reason for your decision to withdraw from the study*?" To further gauge participant sentiments about their participation, participants rated the following statements: *This research study is meaningful; I felt like my participation was important*; *I was interested in the study topic.* Participants were also asked whether this was their first time participating

in an online research study, how many hours per week they work or volunteer, whether they had any privacy concerns, and suggestions for improving the study experience.

Statistical Analyses

All per-protocol analyses were conducted in R studio (R Studio Team, 2019) with the following packages: psych (Revelle, 2018), nlme (Pinheiro et al., 2007), stringr (Yarberry, 2021), and spida2 (Monette et al., 2018). *T*-tests were calculated to assess group differences in age, years of education, and mTICS score; a chi-square analysis was used to examine group differences in sex. A review of the raw data indicated that assumptions of linearity, homogeneity of variance, and normality were met. On a per-protocol basis, linear mixed effects models were run on all four outcome measures (treated as continuous) to assess baseline differences between the two groups (intervention and control), group by time interactions (baseline, postintervention, follow-up), and whether any main effect postintervention was sustained at follow-up.

Group and time were set as fixed effects, and participants were set as a random effect. Wald tests were conducted to analyze the simple effects to explain significant interactions within each model. Package spida2 was designed to handle missing data at random (reflected in the models' standard error and confidence intervals), which included 5.8% of missing data in outcomes assessed through the online questionnaires (including the Memory Strategy Toolbox, the MMQ, and the HPLPII) and 10.4% of missing data in the Memory Knowledge Quiz, which was administered by telephone. Cohen's *d* effect sizes were calculated using the reported test statistics and degrees of freedom; 0.2, 0.5, and 0.8 correspond to a small, medium, and large effect size, respectively (Cohen, 1988). Unstandardized parameters were used for reporting, and a nominal alpha level was set at .05.

Sensitivity analyses were conducted to mitigate overestimation of treatment effects, preserve the principle of randomization, minimize the risk of selection bias due to differential attrition, reflect realities of treatment adherence in clinical practice, and provide information related to the clinical utility of the program (Brody, 2016). An intention-to-treat analysis was conducted including all participants who were initially randomized into the intervention or control condition and who had baseline data in order to gain a more comprehensive understanding of treatment effectiveness (Gupta, 2011). The last observation carried forward approach was used to impute values for missing observations. Specifically, baseline data for participants included in the ITT analysis were carried forward for both the post and follow-up time points. For participants from the initial per-protocol analysis who had missing data, this was imputed with their last observed value. A repeated-measures analysis of variance (ANOVA) was conducted, followed by post-hoc analyses on any significant interaction to assess effect sizes.

To enhance understanding of clinical utility, the number needed to treat (NNT) in order to achieve one successful outcome from baseline to posttest was calculated on a per-protocol basis (Cook & Sackett, 1995). Successful outcomes were defined by computing reliable change indices for outcome measures with a reported reliability coefficient in order to calculate the standard error of the difference and subsequently the z-score. Positive reliable change indices greater than 1.96 representing $p < .05$ in a normal distribution were categorized as successful outcomes (Jacobson & Truax, 1991). These measures included the MMQ with a reported reliability for each domain including Satisfaction (r = .93), Ability (r = .86), and Strategy Use (r = .88) and the HPLPII (r = .92). For the Memory Knowledge Quiz and the Memory Strategy Toolbox questionnaire, a successful outcome was defined by an

increase of one standard deviation or more from baseline to posttest on each measure. Individuals with missing outcome data were categorized as no change. The above sensitivity analyses were conducted using IBM SPSS Statistics 25.

Descriptive statistics are presented for response rate and categorical questions from the attrition feedback survey. A qualitative content analysis was conducted to analyze responses for the open-ended question querying participants' main reason for attrition. The triphasic process of preparation, organization, and reporting provided the framework for the analysis (Elo & Kyngäs, 2008). In the preparation phase, two researchers (IY and DA) became familiar with the data by reading through participant responses several times. We selected an inductive approach to generate categories driven by manifest content. In other words, categories were not generated beforehand based on theory; instead, we used the explicit responses of participants to generate appropriate categories. This was done in the organizational phase, where both researchers freely and independently generated codes for the data. Members of the study team discussed any discrepancies in coding and grouped several codes to capture higher order categories (as recommended by Elo & Kyngäs, 2008). All categories were then reviewed and revised based on feedback from a senior researcher (Jordan Lass) with expertise in technology and older adults. In the final reporting phase, a frequency tally was conducted based on the number of participants who endorsed select categories. To provide additional details of each category, excerpts from the data were reported. Results are presented in Chapter 4.

Chapter 4

Results

Participant Characteristics

Participants (n = 201) were 69% female with ages ranging from 60 to 91 years (M = 70.6, SD = 6.9). Overall, participants were highly educated (M = 15.3 years of education, SD = 2.3) and had normal mTICS scores (M = 38.8 of 50 possible points, SD = 4.0). Following randomization, attrition in the current study was 43%. Participants who completed baseline testing and at least one posttest (either postintervention or follow-up) were included in the analyses. Of the 115 participants whose data were analyzed, demographic information for the intervention and control groups is presented in Table 2. The group of participants who completed the intervention and the control group did not differ significantly on these variables (ps > .05).

Table 3 provides an overview of demographic information and descriptive statistics of outcome measures at baseline comparing the study sample with participants who withdrew or were lost to follow-up (n = 86). The study group was significantly younger, $t(199) = -3.14$, $p = .002$, and more educated, $t(199) = 2.06$, $p = .04$, than the attrition group. There was also a small difference in scores on the Memory Knowledge Quiz, with the study group scoring significantly higher at baseline, $t(176) = -0.199$, $p = .049$. There were no significant group differences in sex, mental status as measured by the mTICS, or any other outcome measure at baseline (ps > .05).

Outcome Measures

There were no significant differences between the intervention and control groups at baseline on any outcome measure (*p*s > .05). Descriptive statistics for outcome measures are provided in Table 4.

Memory and Brain Health Knowledge

There was a significant group by time interaction on the Memory Knowledge Quiz, with Wald tests specifying a large significant difference between groups at postintervention, $B = 6.38$, $SE = 0.71$, $p < .001$, 95% CI: [4.98,7.78], $d = 0.80$, and a medium significant difference at follow-up, $B = 4.54$, $SE = 0.66$, $p < .001$, 95% CI: [3.25, 5.84], $d = 0.62$, in favor of the intervention group. There was a small significant decline in scores from postintervention to follow-up within the intervention group, $B = -1.84$, $SE = 0.73$, $p = .01$, 95% CI: [-3.273, 0.40] $d = 0.23$ (see Figure 2).

Memory Strategy Application

There was a significant group by time interaction on the Memory Strategy Toolbox questionnaire, with Wald tests specifying a medium significant difference between groups at postintervention testing, $B = 4.94$, $SE = 0.82$, $p < .001$, 95% CI: [3.33, 6.56], $d = 0.56$, and at follow-up, $B = 4.06$, $SE = 0.83$, $p < .001$, 95% CI: [2.43, 5.68], $d = 0.43$, in favor of the intervention group. Postintervention scores were maintained at follow-up within the intervention group, $B = -0.89$, $SE = 0.85$, $p = .30$, 95% CI: [-2.56, 0.79], $d = 0.09$ (see Figure 3).

Memory Satisfaction, Ability, and Strategy Use in Daily Life

There was a significant group by time interaction on metamemory scores within each domain of the MMQ. There was a small significant difference between groups at

postintervention for memory satisfaction, $B = 3.47$, $SE = 1.42$, $p = .015$, 95% CI: [0.68, 6.26], $d = 0.22$, memory ability, $B = 4.64$, $SE = 1.53$, $p = .002$, 95% CI: [1.64, 7.63], $d = 0.27$, and a small to medium difference for strategy-use in daily life, $B = 6.78$, $SE = 1.50$, $p < .001$, 95% CI: [3.82, 9.73], $d = 0.40$, in favor of the intervention group (see Figures 4, 5, and 6, respectively). Similarly, there was a small significant group difference at follow-up for memory satisfaction, $B = 4.26$, $SE = 1.43$, $p = .003$, 95% CI: [1.46, 7.05], $d = 0.27$, and strategy-use, $B = 5.63$, $SE = 1.51$, $p < .001$, 95% CI: [2.66, 8.61], $d = 0.33$, but not for ratings of memory ability, $B = 2.70$, $SE = 1.53$, $p = .08$, 95% CI: [-0.30,5.71], $d = 0.16$. Within the intervention group, there was no significant change in scores from postintervention to follow-up for memory satisfaction, $B = 0.78$, $SE = 1.47$, $p = .59$, 95% CI: [-2.10, 3.67], $d = 0.05$, memory ability, $B = -1.94$, $SE = 1.57$, $p = .22$, 95% CI: [-5.03, 1.16], $d = 0.11$, or memory strategy-use, $B = -1.15$, $SE = 1.56$, $p = .46$, 95% CI: [-4.21, 1.92], $d = 0.07$.

Healthy Lifestyle Behaviors

There was a small significant main effect of time, with scores on the HPLPII increasing at posttest, $B = 3.57$, $SE = 1.46$, $p = .01$, $d = 0.21$, and follow-up, $B = 2.99$, $SE = 1.47$, $p = .04$, $d = 0.19$, for both groups. However, there were no significant group by time interactions detected for the total frequency of reported healthy lifestyle behaviors at posttest, $B = -0.94$, $SE = 2.17$, $p = .66$, $d = 0.04$, or at follow-up, $B = 2.32$, $SE = 2.17$, $p = .29$, $d = 0.09$ (see Figure 7). Similarly, no interactions were detected within the six domains: health responsibility, physical activity, nutrition, spiritual growth, interpersonal relations, and stress management.

Sensitivity Analyses

Intention-to-Treat (ITT) Analyses

A total of 105 participants in the intervention group and 97 participants in the control group were included in the ITT analyses for the outcome measures assessed through the online questionnaires. Sixty-four participants had baseline telephone data and were included in the ITT for the Memory Knowledge Quiz for a total of 89 participants in the intervention group and 86 participants in the control group.

Memory and Brain Health Knowledge. There was a significant group by time interaction for the Memory Knowledge Quiz, $F(1, 174) = 20.96$, $p < .01$, partial $\eta^2 = 0.108$. Subsequent post-hoc analyses indicated a significant difference in favor of the intervention group at posttest, characterized by a medium to large effect size ($d = 0.68$), and at follow-up, with a medium effect size ($d = 0.51$).

Memory Strategy Application. There was a significant group by time interaction for the Memory Strategy Toolbox questionnaire, $F(1, 200) = 14.59$, $p < .01$, partial $\eta^2 = 0.068$. Subsequent post-hoc analyses indicated a significant difference in favor of the intervention group at posttest, characterized by a small to medium effect size ($d = 0.43$), and at follow-up, with a small effect size ($d = 0.34$).

Memory Satisfaction, Ability, and Strategy Use in Daily Life. There was a significant group by time interaction on metamemory scores within two domains of the MMQ including satisfaction, $F(1, 200) = 4.25$, $p = .04$, partial $\eta^2 = 0.021$, and the use of strategies in daily life, $F(1, 200) = 6.10$, $p = .014$, partial $\eta^2 = 0.03$. Although the difference between groups at posttest and follow-up is not statistically significantly different for memory satisfaction, there is a small effect size in favour of the intervention group at posttest and follow-up ($d = 0.10$ and $d = 0.12$ respectively). For strategy use in daily life, there is a small significant difference between groups at posttest ($d = 0.33$) and at follow-up ($d = 0.28$). There

was no significant interaction on the ability domain of the MMQ, $F(1, 200) = 1.71$, $p = .19$, partial $\eta^2 = 0.008$.

Healthy Lifestyle Behaviours. There was no significant group by time interaction on the HPLPII, $F(1, 200) = 0.37$, $p = .55$, partial $\eta^2 = 0.002$.

Number Needed to Treat (NNT)

For one successful outcome (an increase of one standard deviation or greater from baseline to posttest) in terms of increased knowledge for both memory and brain health (NNT = 1.59), as well as the application of memory strategies (NNT = 2.33), the rounded NNT is 2. Overall, for every two people who participate in the e-learning program, one additional successful outcome is expected relative to the control group. For metamemory outcomes, the reliable change index for the satisfaction domain was 13.32, which resulted in an NNT of 11.49. The reliable change index for the ability domain was 9.40 and the NNT was 6.23. The third domain of the MMQ of strategy use had a reliable change index of 8.39 and an NNT of 3.34. For the total frequency score of the HPLPII, the reliable change index was 15.2 and the NNT was 37.22.

Exploratory Analysis: COVID-19 Pandemic

An exploratory analysis was undertaken to assess whether the findings regarding the null interaction were influenced by the COVID-19 pandemic, particularly in relation to changes in healthy lifestyle behaviors. It was considered that the imposed restrictions could potentially impact participants' capacity and motivation to engage in physical activities and social interactions, both of which are domains directly evaluated by the HPLPII. Participants were categorized based on whether they completed the online questionnaire before or after the onset of the pandemic, marked by the implementation of restrictions in Ontario, Canada,

beginning in March 2020. All participants completed baseline outcome measures before the pandemic's onset, with the latest completion date being February 6, 2020. In the per protocol sample, 5 participants in the control group completed the questionnaire at follow-up post-pandemic onset, and an additional one participant completed both the posttest and follow-up post-pandemic. In the intervention group, only one participant completed the questionnaire at both the posttest and follow-up post-pandemic and one additional participant completed the questionnaire at follow-up post-pandemic. Overall, there is insufficient power to conduct analyses to determine the impact of the COVID-19 pandemic on healthy lifestyle behaviours. In the context of the current study, it appears unlikely that the imposed restrictions significantly contributed to the absence of a treatment effect.

Attrition

A total of 16 (of 87) participants completed the attrition survey, representing a response rate of 18%. An additional three participants began the survey but did not go beyond indicating their study ID and were not included in the attrition analyses. All 16 participants were originally randomized into the intervention condition of the trial. Six individuals indicated having participated in an online research study prior to their participation in the current trial. Of the eight participants who indicated working or volunteering, the mean number of hours per week was 8.7 (SD = 11.4). No participant expressed concern about confidentiality issues regarding their personal information during their study participation.

The most common responses for dropping out of the study were a communication breakdown and personal circumstances. The next most common reasons for dropping out were related to the intervention content and technical/instructional problems. One participant

indicated that the program was too time-consuming. Results are presented in Figure 8; Table 5 provides details of each category and excerpts from participant data.

Participants were asked about their sentiments related to their study participation. Seventy-five per cent of participants (n = 12) indicated that they felt like the research study was meaningful, 56% of participants (n = 9) indicated that they felt their participation was important, and 75% (n = 12) indicated *A lot* for the statement, *I was interested in the study topic*. These findings are graphically presented in Figure 9. Lastly, six participants provided a suggestion for improvement in the open-ended question of *What could be done to improve the online study experience*? The most common suggestion was related to improved communication and included clearer communication of study goals, expectations, and reasons for withdrawal (n = 4). One participant had recommendations related to the intervention content, and one participant recommended shortening the research study length. Four participants indicated that nothing needed to be improved, it was not applicable, or that they had a good experience with the study. The remaining six participants left this question blank.

Chapter 5

Discussion

Using a randomized controlled trial design, the present study showed that a self-guided, e-learning program has a meaningful effect on memory knowledge, strategy application, and metamemory in healthy older adults. Consistent with the study hypotheses, participants in the intervention group demonstrated significant improvements in knowledge of memory and brain health as well as the application of effective memory strategies, with effect sizes ranging from medium to large (Cohen, 1988) and an NNT of 2. This was the most robust and consistent finding documented during evaluations of the in-person version of the Memory & Aging Program (Troyer et al., 2001; Vandermorris et al., 2020; Wiegand et al., 2013) as well as during initial piloting of the current e-learning program (Yusupov et al., 2022). In addition, participants in the intervention group made significant gains in metamemory outcomes, with NNTs ranging from 3 to 11 across MMQ domains (Troyer & Rich, 2002). Specifically, intervention participants indicated greater satisfaction with their memory, fewer everyday memory mistakes, and an increased frequency of memory strategy use in daily life relative to the control group. The size of the effect ranged from small to medium in the current study, whereas the gains in metamemory from the most recent in-person evaluation ranged from medium to large (Vandermorris et al., 2020). Notably, in an early evaluation on the in-person program (Troyer, 2001), participants did not report an increase in daily strategy use. This highlights the program's evolution as research findings continually inform program modifications to meet the needs of participants and achieve targeted benefits.

Evaluating the results within the context of an ITT provides insights into the effectiveness of the intervention more closely reflecting the practical reality of clinical

intervention studies. The ITT analysis includes all randomized participants, regardless of whether they were lost to attrition or completed the study protocol. This captures the common experience of nonadherence to health interventions in real-world circumstances. Within this context, the gains in knowledge of memory and memory strategies remain robust. Findings associated with metamemory outcomes are somewhat attenuated due to the conservative nature of the ITT approach. Group by time interactions remain significant for both the Satisfaction and Strategy domains, whereas the effect is lost for the Ability domain. Participants demonstrated small gains in their memory satisfaction and use of memory strategies in daily life. Nonetheless, when comparing mean scores across MMQ domains for all participants within the study, these scores are associated with average-range performance as compared to the questionnaire's established normative data (Troyer & Rich, 2002). Thus, even a small gain can produce a meaningful clinical difference. Further investigation of inter-individual differences may offer additional insights as to whether participants with lower normative scores produce larger gains in contrast to those who are already exhibiting feelings about their memory within the normal range.

We did not replicate health-promoting behavior change findings seen in the in-person study (Vandermorris et al., 2020). There are several possible explanations for this result when considering differences between in-person and online interventions. Participation in in-person intervention programs involves inherent behavioral activation components that may serve as a catalyst for greater behavior change. For example, participants must physically travel to the location and may gain access to new social opportunities, such as going for a coffee after the program. These activities may directly impact scoring reported on the HPLPII's physical activity and interpersonal relations subdomains. Further, behavior change can be facilitated

through the expectation of sharing one's experience in a social interaction (Oussedik et al., 2017). In other words, there is a greater sense of accountability when participating in an intervention with regular meetings with an in-person facilitator. Given the limited number of participants who completed study measures subsequent to the onset of the COVID-19 pandemic, it is unlikely that the pandemic influenced the results in the current study. This notion is further supported by the observation that both the intervention and control group significantly increased their frequency of engaging in health-promoting activities over time. With an NNT of 37, this number is substantial when considered within the realm of in-person interventions, where constraints such as group size and logistical resources, including physical space and facilitator availability must be considered. Yet, when contextualized within the framework of an e-learning platform with substantial potential for scalability, engaging 37 participants to produce a positive impact in their healthy lifestyle behaviours becomes markedly more manageable. Nevertheless, this is an area of focus for future development, and researchers, clinicians, and developers of online intervention programs can consider additional options that may encourage health-promoting lifestyle change. For example, to improve nutrition, it may be beneficial for some to have access to healthy meal plans, motivational reminders, or a points-based incentive system in addition to the psychoeducation on nutrition presented in the program (Robert et al., 2021).

An emerging field of research focuses on evaluating the acceptability and utility of wearable tracking technologies to monitor and improve various aspects of health such as physical activity and sleep. Recent findings demonstrate that older adults may benefit from such technology (Roberts et al., 2019; Zaslavksy et al., 2019; Zhang et al., 2022; Zhu et al., 2020). This provides the opportunity to explore the incorporation of wearables to evaluate

whether it can be a complement to e-learning programs to further encourage healthy lifestyle changes in future research. Emerging best practices in e-health interventions encourages multicomponent features to achieve improvements in health outcomes (Robert et al., 2021; Sweet et al., 2010).

Attrition and Missing Data

An inherent challenge in conducting online research is managing attrition and addressing missing data. Despite taking several measures to mitigate attrition, such as conducting pilot testing with older adults to ensure a user-friendly design (Yusupov et al., 2022) and screening for computer use and comfort (Hurmurz et al., 2021), the attrition rate in the current study was 43%. This attrition rate is notably higher than those observed in previous randomized controlled trials of the in-person Memory & Aging Program. Specifically, the most recent trial reported an attrition rate of 15% (Vandermorris et al., 2020), and an earlier trial had a 5% attrition rate (Wiegand et al., 2013). In the initial pre-post evaluation of the in-person program (Troyer, 2001), participants were self-selected to the intervention and control conditions. Of these, a total of 21% of participants did not complete one of the testing sessions and were consequently excluded from the final analyses.

Within the scope of the present study, discernible differences emerged between participants who were lost to attrition and those who completed the study. Participants who completed the study were significantly younger, more educated, and had greater memory knowledge at baseline than individuals lost to attrition. Similarly, in investigations of attrition in a web-based physical health intervention for community-dwelling older adults, the only predictor of attrition was lower educational attainment (Boekhout et al., 2019; Ratz et al., 2021). Education and knowledge pertaining to the e-learning topic may be further explored as

potential predictors of attrition. We also experienced a numerically lower rate of missing data on online questionnaires than in telephone interviews. Some challenges with telephone data collection included scheduling difficulties, travel plans, and hesitation by participants in answering unknown telephone numbers. In contrast, the online questionnaires offered greater flexibility and accessibility in that participants could access them from any location at any time.

We followed up with the 87 participants who were lost to attrition from the current trial to better understand their experience and received 16 individual responses. When asked for their main reason for withdrawing from the study, the most common response was a communication breakdown in which participants were unaware they had withdrawn or did not receive a follow-up contact, a reason that is largely in the control of researchers. The next most common reason was a personal circumstance, similar to what is seen with attrition from in-person programs (Bonk, 2010; Slymen et al., 1996). Further, some participants listed reasons related to dissatisfaction with the e-learning program. It is likely that intervention content is of greater importance in online studies considering the endless online alternatives that compete for participants' attention (Lumsden et al., 2017) and facility of opting out compared to in-person programs (Birnbaum, 2004).

There are a host of other potential reasons for attrition that may have not been reported in the current study due to its design. Specifically, previous online studies with older adults indicated that poorer perceived computer abilities were associated with greater attrition (Hurmuz et al., 2021). In our trial, computer familiarity was included as an eligibility criterion. Research on attrition of older adults from in-person studies indicates that greater attrition is associated with poorer health outcomes, independence, and cognitive status (Heid

et al., 2021; Jacomb et al., 2002; Slymen et al., 1996). Participants in our study were healthy older adults and thus were stringently screened for unimpaired cognitive status, disorders potentially affecting cognition, and independence in daily living. From a clinical perspective, a variety of potential contributors may exist for the observed disparities in attrition rates between the in-person Memory & Aging Program studies and the present study. Participating in person likely facilitates more robust social bonds and richer learning interactions both from the program facilitator and the other participants (Vandermorris et al., 2017). This environment possibly cultivates a greater sense of accountability and motivation to fulfill participation commitments within the context of a research study.

Overall, the majority of the 16 survey respondents reported feeling as though the research was meaningful and their participation was important, and they were interested in the study topic. This may in part be attributable to the fact that the majority of healthy older adults will experience normal age-related changes in cognition, and older adults are proactive in finding ways to keep their brains active (Parikh et al., 2016), although these factors were not sufficient to retain these particular participants in the current study. Further, although older adults may commonly express concerns related to privacy of information over the internet (Chang et al., 2015; Pike et al., 2018), none of the survey respondents felt worried about the confidentiality of their personal information. This may be because some participants were recruited from the volunteer pool of the host institution, and study materials included the logo of the institution. In turn, this emphasizes the credibility, reliability, and highest ethical standard of research associated with the institution. Lastly, the most common participant-reported suggestions for improving the online study experience were related to clearer communication of study goals, expectations, and reasons that would lead an individual to be

withdrawn from the study. In addition to providing this information explicitly and potentially through various channels (e.g., telephone and email), researchers may consider advance notification of scheduled testing sessions, which has been shown to support retention in studies with older adults (Lacey et al., 2017).

Considerations for Clinical Practice

The present results provide evidence of metamemory benefits for participants who completed a self-guided, e-learning program that were similar to outcomes from previous evaluations of a well-established in-person program. Although there are substantial start-up costs for e-learning programs, once established, they can provide cost savings for both the provider and the participant. For example, there are no requirements for a physical space or a clinician facilitator. Participants can also minimize travel costs (monetary and time) associated with attending in-person programming. General benefits of online memory programs include greater accessibility, flexibility, increased participant self-efficacy, and a larger reach than in-person programs (Pike et al., 2018). Some individuals who are able to access in-person programs may prefer them over online programs for a variety of reasons such as greater social engagement or lack of access to computers. A logical client-centered approach is to offer participants the choice between e-learning or in-person programs to emphasize participant autonomy in personalizing their healthcare according to their goals, values, and needs. Indeed, considering patient characteristics and preferences is an important element of evidence-based practice in psychology (American Psychological Association, 2006). As the field of online memory programs continues to evolve, a next step will be to conduct a synthesis (i.e., meta-analysis, systematic review) of available efficacy trials in order

to produce a comprehensive summary of existing evidence to support clinical decision-making (Haynes, 2007).

The current study highlights new directions for health care delivery, particularly for the older adult population. Researchers and clinicians alike may wish to refer to the Quintuple Aim framework when developing innovative services and identifying areas of future research (Nundy et al., 2022). The Quintuple Aim is the newest rendition of the original Triple Aim framework, which highlighted three important objectives of healthcare delivery: (a) improving population health, (b) enhancing the patient experience, and (c) reducing costs (Berwick et al., 2008). Offering online memory programs is a potentially scalable solution that can make a broad impact towards improving the health of the growing older adult population. In order to enhance the patient experience, we conducted extensive piloting and iterative rounds of modifications to tailor the program to our targeted end-users (Yusupov et al., 2022). In clinical practice, it will be important to solicit feedback from program participants to evaluate satisfaction and identify areas for continual improvement. This will ensure that services are evolving to meet the ever-changing needs of patients. In-person community memory programs have cost-savings potential when compared to the cost of consultations with healthcare professionals for a memory concern (Baker et al., 2022). A self-guided, e-learning memory program can exponentially reduce costs as previously described.

The newest objectives emphasized in the Quintuple Aim include (d) enhancing the care provider experience and (e) promoting health equity (Nundy et al., 2022). Both of these elements reflect the importance of adapting health service delivery to the sociocultural environment, namely, acknowledging the COVID-19 pandemic that placed a heavy burden on care providers as well as social justice movements that illuminated inequities within the

healthcare system. Aside from developing and evaluating novel memory programs, it is crucial to consider their integration within health systems to improve the experience of healthcare providers. For example, perhaps such a psychoeducational program can be offered as part of a health promotion campaign to alleviate future healthcare utilization and free up resources for providers to focus on caring for individuals with more complex needs. Lastly, it is a duty of all clinicians and researchers to be actively engaged in strategies to promote health equity. Although our goal was to increase accessibility of a memory program, our research sample was highly educated and likely underrepresentative of the diversity in the older adult population. It will be important to develop strategies to promote equity in program accessibility and to consider ways in which online memory programs can be offered to the public who may not have personal access to technology. Overall, psychologists are well equipped to design and execute research that is both methodologically rigorous and supports human relationships with diverse individuals to continue to advance evidence-based practice (American Psychological Association, 2006).

Conclusion

Through a randomized controlled trial, we demonstrated clinical outcomes of a self-guided, e-learning memory program similar to outcomes previously achieved within the in-person version. Healthy older adults who completed the e-learning program showed significant gains in memory and brain health knowledge, acquisition of memory strategies and application in daily life as well as memory satisfaction and perceived ability relative to a no-intervention waitlist group. There were no significant differences between groups in improvements of healthy lifestyle behaviors, which is an area of future research to inform the design of online health-promoting interventions. For older adults who are concerned about

their memory changes or who are looking to learn how to optimize brain health, self-guided, e-learning memory programming shows promise to be an effective, accessible, flexible, and cost-effective alternative to in-person programs. Exploring reasons for attrition revealed an opportunity for researchers to improve retention and the participant experience through clearer communication strategies. Important next steps are to consider how such programs may be integrated within healthcare systems to improve the patient and provider experience and to promote health equity within the older adult population.

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Table 1

Description of Individual Modules Within the Online Memory and Aging Program

	Module Description
Getting Started	Introduction to navigating the learning management system and program functions
Module 1: Introduction	Overview of content and introduction to different components of the program (e.g., discussion boards, surveys, and polls)
Module 2: What is Memory?	Explanation of what memory is, what brain regions are involved in memory, types of memory processes, normal and memory changes
Module 3: Factors Affecting Memory	A discussion of health and lifestyle factors that affect memory
Module 4: Stress and Relaxation	A discussion of the effect of stress on memory and introduction of relaxation techniques
Module 5: Memory Strategies Overview & Practice Retrieval	Explanation of the rationale, procedures, and evidence supporting five key memory strategies; in-depth practice of the spaced-retrieval memory strategy

Module 6: Memory Strategies Associations and Records	In-depth practice of the semantic association memory strategy and a discussion of the use of records as a memory aid
Module 7: Application of Memory Strategies & Goal Setting	Review of memory strategies and training on how to set effective goals
Module 8: Wrap-up & Feedback	Opportunity to participate in a content review game, goal setting, sharing final thoughts, and providing feedback

Table 2

Participant Demographics by Study Group

	Intervention (n = 52) M (SD)	Control (n = 63) M (SD)	Effect Size
Age (years)	70.0 (6.8)	70.6 (5.9)	d = 0.09
Education (years)	15.4 (2.1)	15.8 (2.3)	d = 0.19
mTICS (total score)	39.2 (4.2)	39.3 (3.6)	d = 0.04
Female (proportion)	71%	71%	w = 0.00

Note. M = mean; mTICS = Modified Telephone Interview for Cognitive Status; SD = standard deviation. Years of education was coded according to the highest level of education achieved. There were no significant differences between groups on any of the variables. Ethnicity/race data were not collected.

Table 3

Participant Demographics and Baseline Outcome Measures by Study Group and Attrition Group

	Study Group (n = 115) M (SD)	Attrition Group (n = 86) M (SD)	Effect Size
Demographics			
Age (years)	70.3 (6.3)***	73.4 (7.4)***	d = 0.45
Gender (female proportion)	71%	66%	w = 0.05
Education (years)	15.7 (2.2)*	15.0 (2.4)*	d = 0.29
mTICS	39.3 (3.9)	38.2 (4.2)	d = 0.27
Baseline Measures			
Memory Knowledge Quiz	9.4 (3.3)*	8.4 (2.8)*	d = 0.30
Memory Strategy Toolbox	14.0 (4.1)	13.0 (4.2)	d = 0.24
MMQ-Satisfaction	40.9 (13.7)	44.0(12.4)	d = 0.23
MMQ-Ability	47.4 (9.7)	50.0 (10.0)	d = 0.26
MMQ-Strategies	37.2 (10.4)	37.6 (10.1)	d = 0.05
HPLPII	144.3 (20.6)	144.1 (22.4)	d = 0.01

Note. M = mean; SD = standard deviation; mTICS = Modified Telephone Interview for Cognitive Status; MMQ = Multifactorial Memory Questionnaire; HPLPII = Health Promoting Lifestyle Profile II. *$p < .05$. ***$p < .001$

Table 4

Descriptive Statistics for Outcome Measures by Group and Time

	Intervention (n = 52)			Control (n = 63)		
	Baseline M (SD)	Posttest M (SD)	Follow-up M (SD)	Baseline M (SD)	Posttest M (SD)	Follow-up M (SD)
Memory Knowledge Quiz*	9.5 (3.4)	16.2 (5.0)	15.5 (5.5)	9.3 (3.1)	9.6 (3.6)	10.8 (3.7)
Memory Strategy Toolbox*	13.8 (4.1)	18.7 (6.6)	18.2 (6.8)	14.1 (4.1)	14.2 (5.1)	14.6 (5.4)
MMQ-Satisfaction*	40.1 (15.1)	44.8 (13.1)	45.8 (13.1)	41.6 (12.6)	43.6 (13.6)	43.1 (13.9)
MMQ-Ability*	46.8 (11.2)	51.4 (9.4)	51.4 (11.4)	47.8 (8.4)	48.4 (9.2)	50.0 (10.5)
MMQ-Strategies*	37.4 (11.2)	45.2 (10.2)	46.6 (10.1)	37.0 (9.8)	38.0 (10.6)	39.8 (10.4)
HPLPII Domains						
Health Responsibility	2.5 (0.6)	2.6 (0.6)	2.6 (0.6)	2.5 (0.4)	2.6 (0.5)	2.5 (0.5)
Physical Activity	2.7 (0.6)	2.8 (0.6)	2.8 (0.7)	2.6 (0.7)	2.7 (0.7)	2.7 (0.7)
Nutrition	3.0 (0.6)	3.0 (0.5)	3.1 (0.5)	3.0 (0.5)	3.1(0.5)	3.1 (0.5)
Spiritual Growth	2.8 (0.4)	2.9 (0.5)	3.0 (0.6)	2.9(0.7)	3.0 (0.6)	2.9 (0.7)
Interpersonal Relations	3.0 (0.5)	3.0 (0.6)	3.1 (0.6)	3.0 (0.6)	3.1(0.6)	3.0 (0.6)
Stress Management	2.7 (0.5)	2.8 (0.4)	2.9 (0.5)	2.7 (0.6)	2.8 (0.5)	2.8 (0.6)
HPLPII Total Frequency	144.5 (17.4)	147.9 (19.2)	150.6 (19.1)	144.0 (23.1)	150.0 (22.1)	147.6 (24.3)

Note. M = mean; SD = standard deviation; MMQ = Multifactorial Memory Questionnaire; HPLPII = Health Promoting Lifestyle Profile II. Presented values are means of raw scores obtained on the outcome measures. Higher scores are associated with better performance for each of the measures.

*Overall test of the group-by-time interaction was statistically significant ($p < .05$), with results favouring the e-learning memory intervention group.

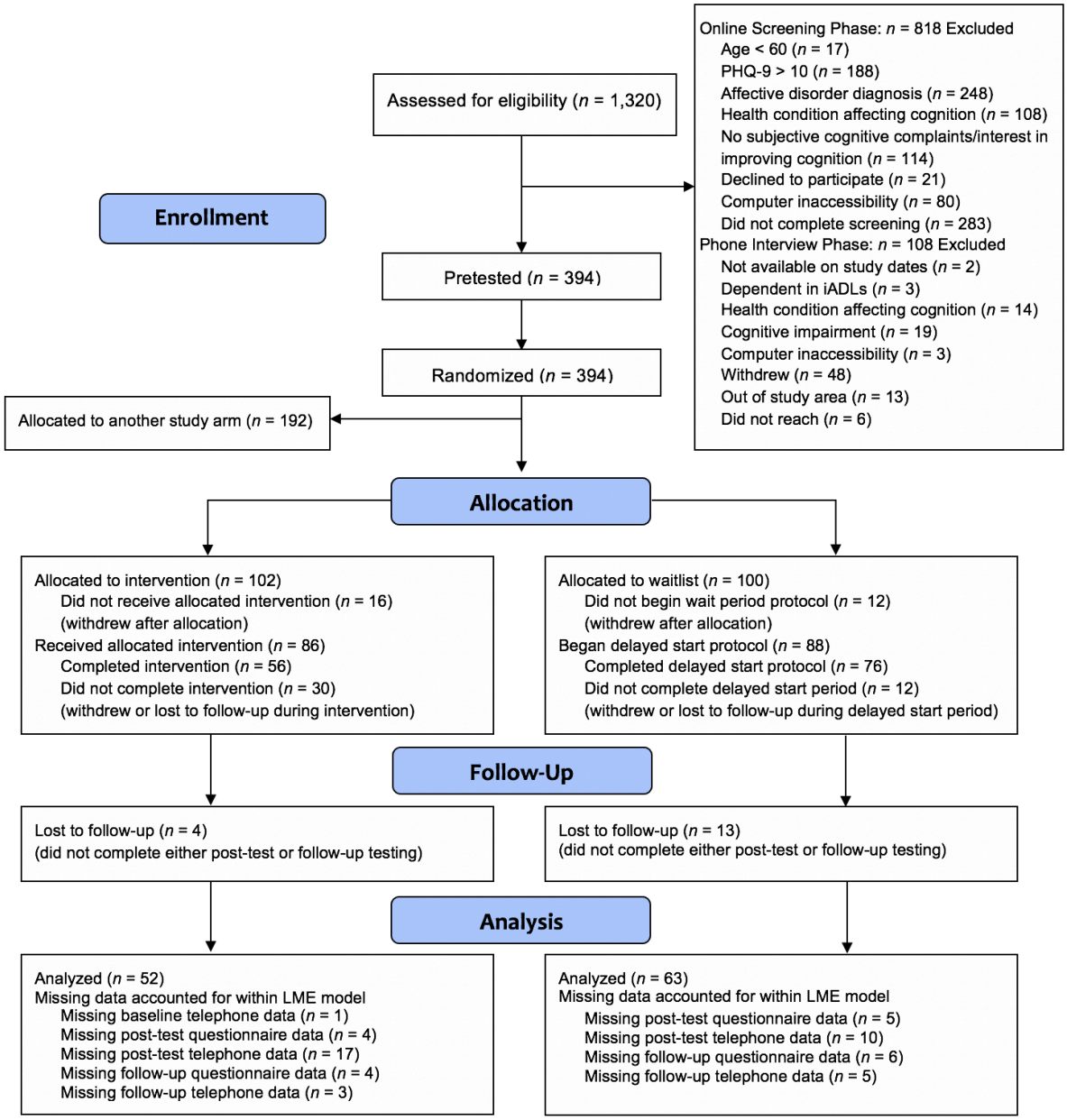
Table 5

Main Reason for Attrition Category Details and Excerpts from the Data

Category	Details	Participant Quote
Communication breakdown	Unaware that they were withdrawn, did not receive any follow-up	*"I was not aware that I had withdrawn from the study"* *"I was never followed up to participate"*
Personal circumstance	External life event, personal health issues, personal issues with technology	*"I withdrew due to other pressing commitments happening in my life* *"I kept forgetting to check email"*
Intervention content-related	Boring, too repetitive, lack of relevance of content to one's life	*"Got bored."* *"The questions seemed repetitive"*
Technical/instructional issues	Difficulty with instructions, technical problems	*"[Phone survey] questions that sounded very academic and jargonistic, I bailed"* *"I found it a nuisance to access the pages I needed"*
Too time consuming		*"Didn't expect it to be such a long involved course"*

Figure 1

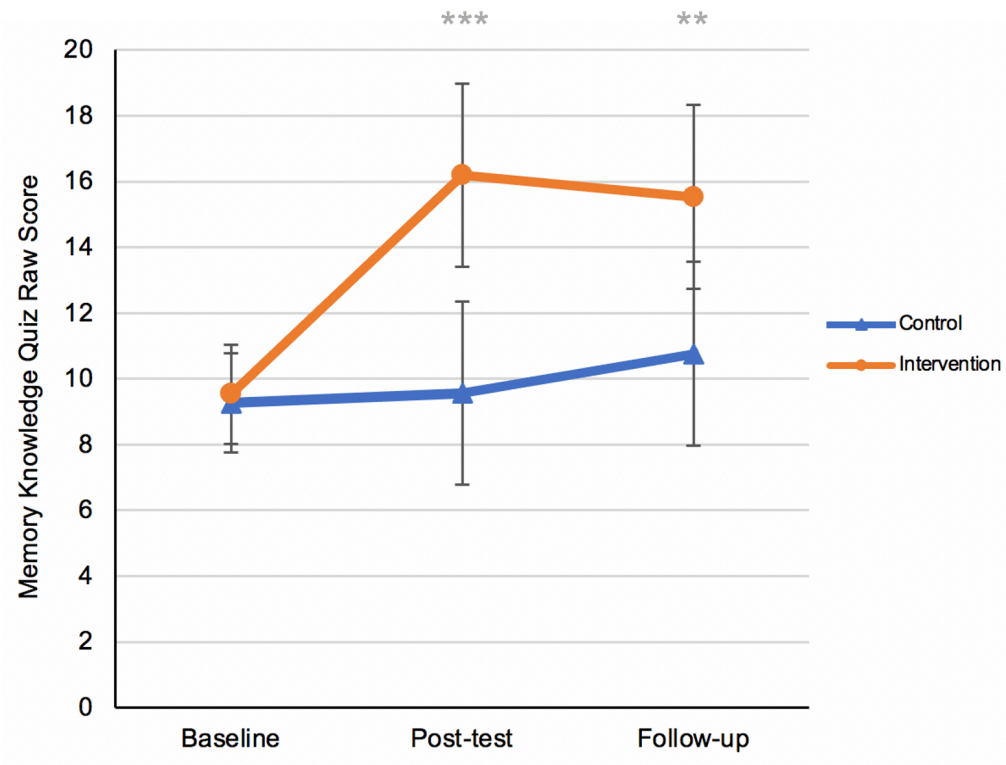
CONSORT Flow Diagram



Note. PHQ-9 = Patient Health Questionnaire-9. iADLs = instrumental activities of daily living.

Figure 2

Memory and Brain Health Knowledge Group Mean Scores

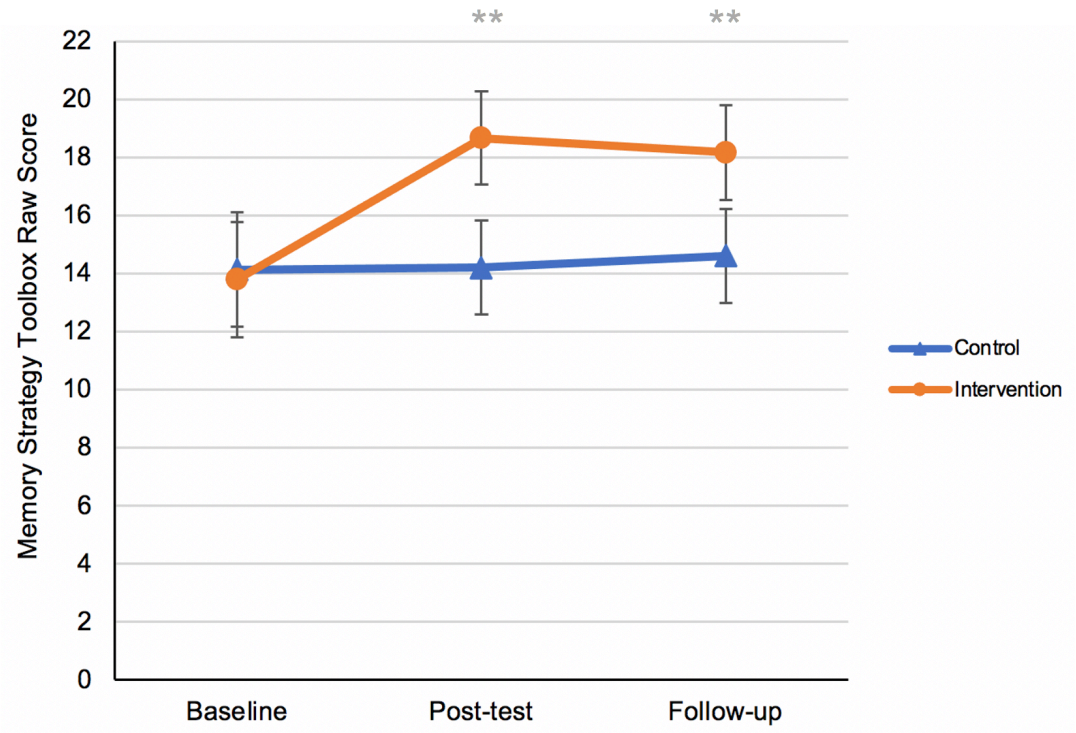


Note. Raw scores on this measure are out of a maximum possible 25 points; in this sample, scores ranged from 2 to 25. See CONSORT flow chart (Figure 1) for a breakdown of missing data in each group. Error bars represent 95% CI

* = small effect size, ** = medium effect size, *** = large effect size.

Figure 3

Memory Strategy Application Group Mean Scores

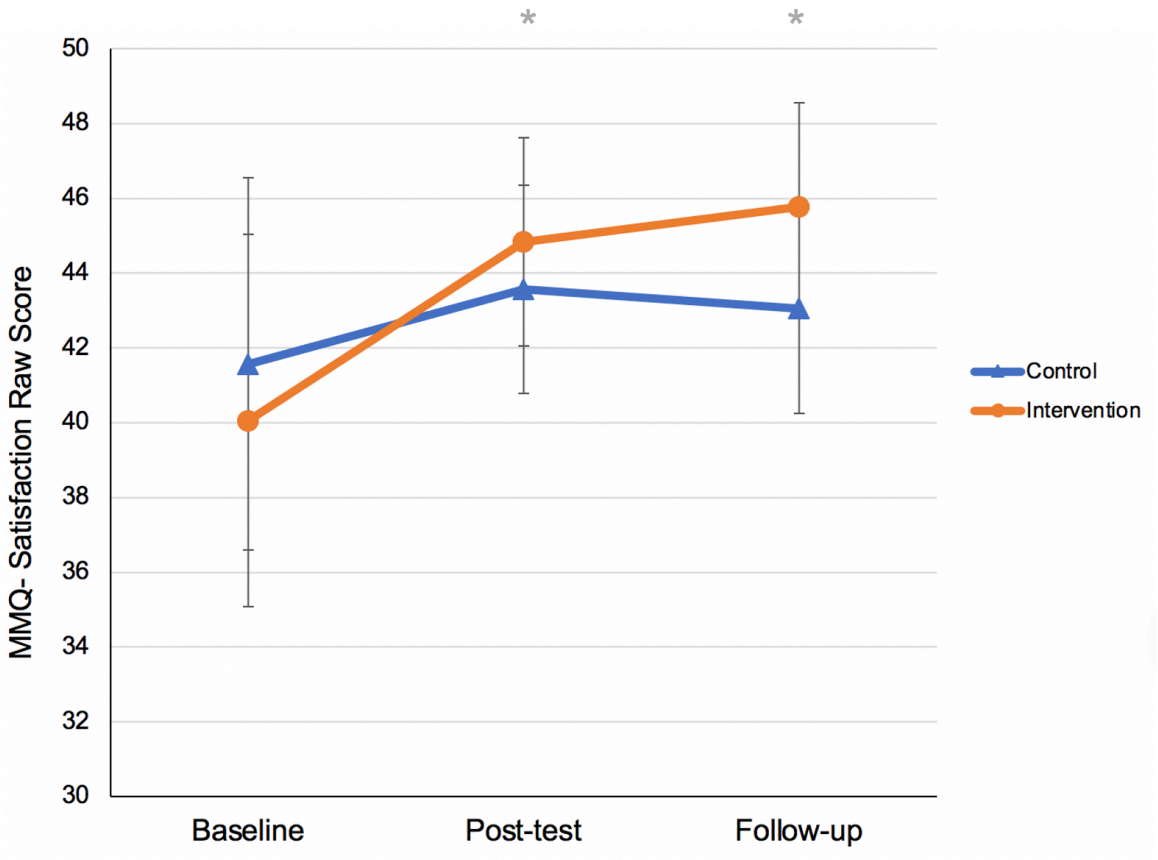


Note. Raw scores on this measure have no maximum; in this sample, scores ranged from 5 to 40. Error bars represent 95% CI

* = small effect size, ** = medium effect size, *** = large effect size.

Figure 4

Memory Satisfaction Group Mean Scores

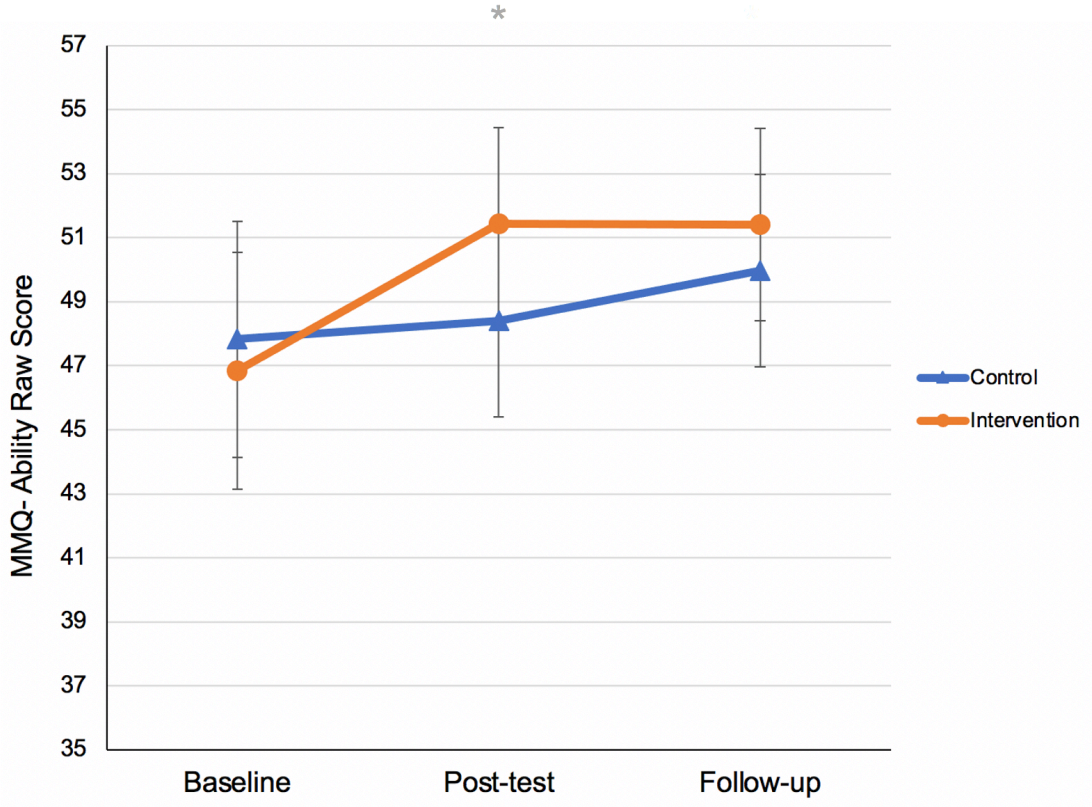


Note. Y-axis scale does not begin at zero. Raw scores on this measure are out of a maximum of 72; in this sample, scores ranged from 7 to 71. Error bars represent 95% CI

* = small effect size, ** = medium effect size, *** = large effect size.

Figure 5

Memory Ability Group Mean Scores

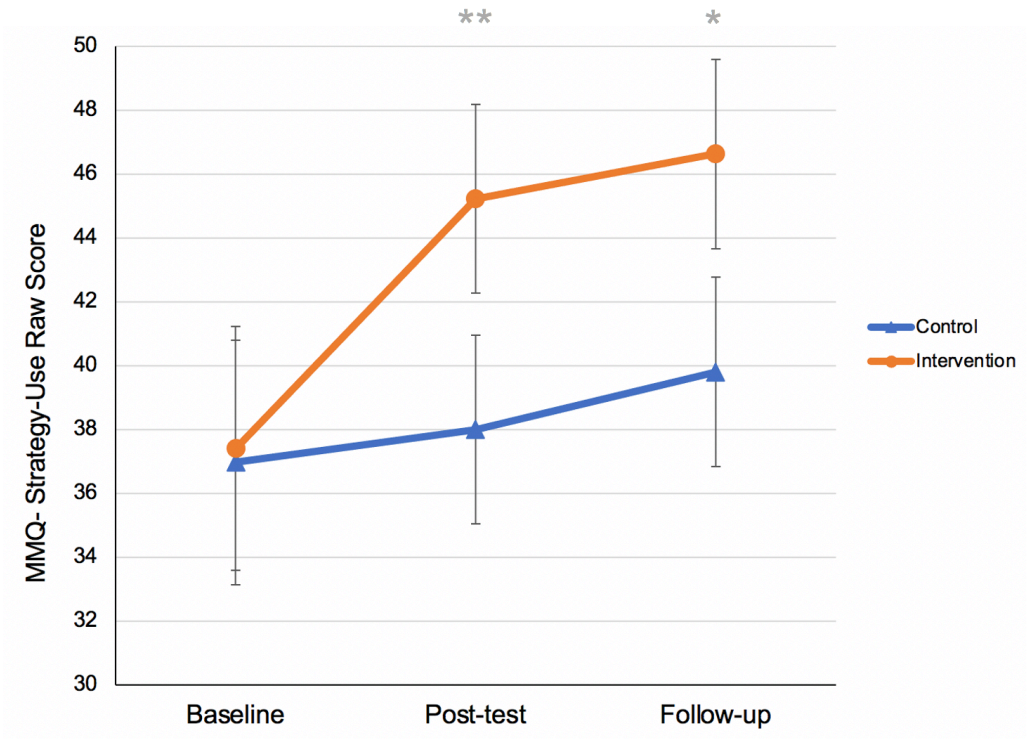


Note. Y-axis scale does not begin at zero. Raw scores on this measure are out of a maximum of 80; in this sample, scores ranged from 21 to 75. Error bars represent 95% CI

* = small effect size, ** = medium effect size, *** = large effect size.

Figure 6

Memory Strategy-Use Group Mean Scores

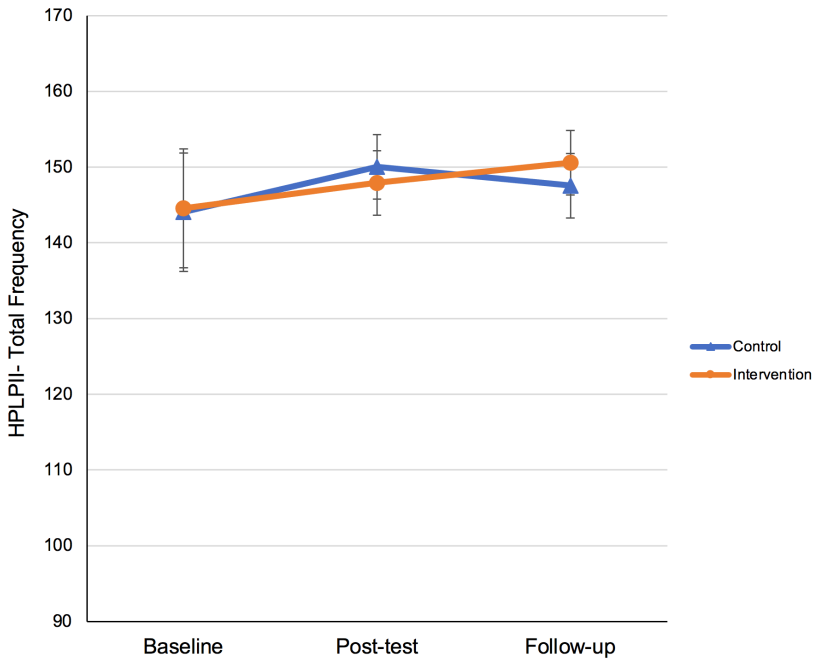


Note. Y-axis scale does not begin at zero. Raw scores on this measure are out of a maximum of 76; in this sample, scores ranged from 16 to 72. Error bars represent 95% CI

* = small effect size, ** = medium effect size, *** = large effect size.

Figure 7

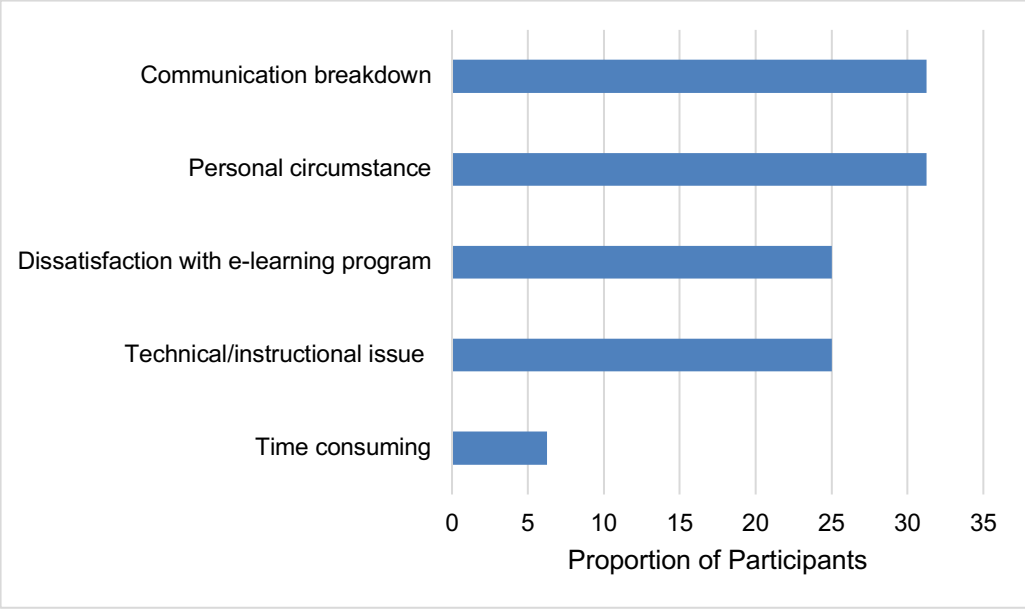
Total Frequency of Health-Promoting Lifestyle Behaviors Group Means



Note. Y-axis scale does not begin at zero. Raw scores on this measure are out of a maximum of 208; in this sample, scores ranged from 93 to 198. Error bars represent 95% CI.

Figure 8

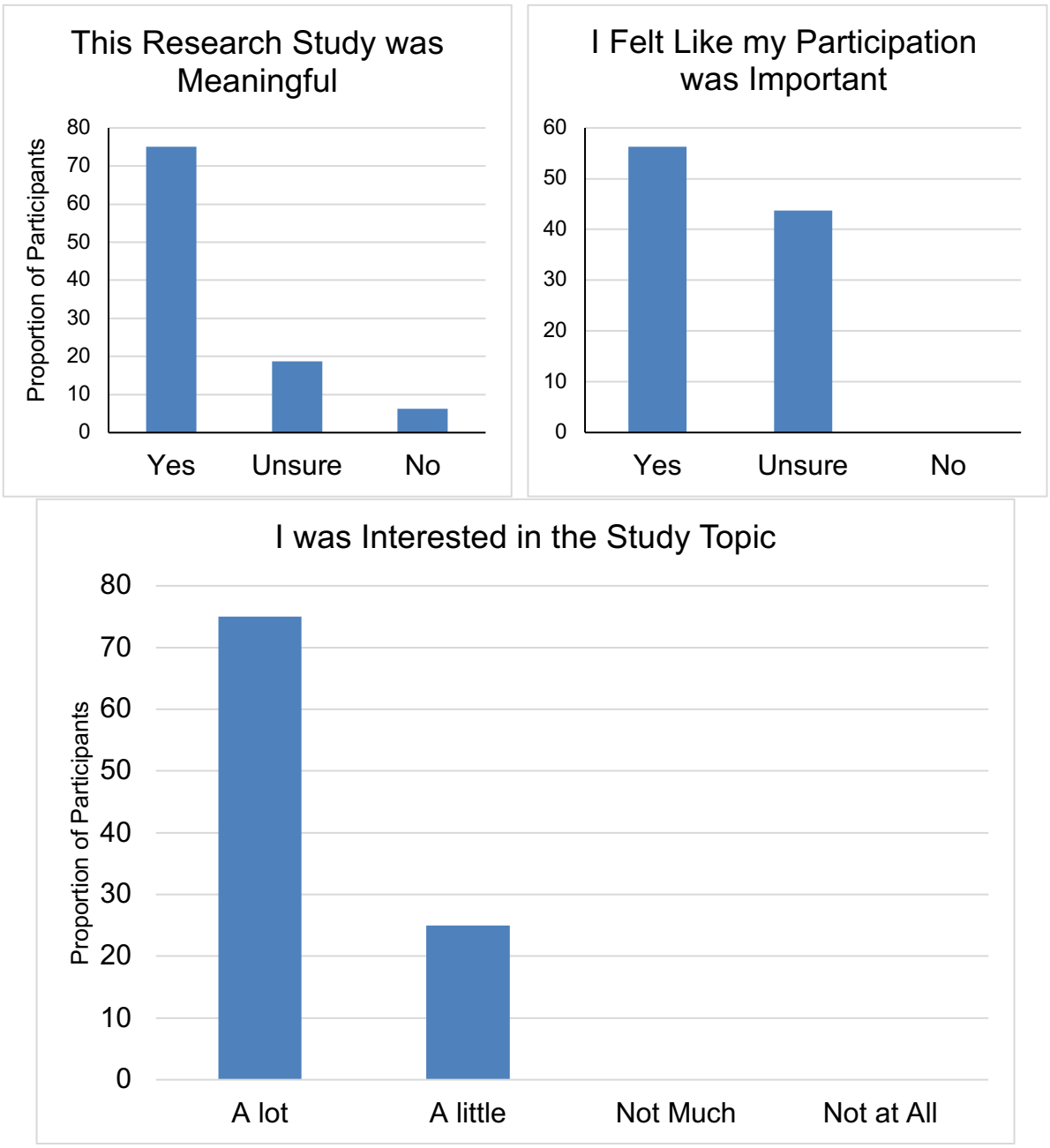
Participant-Reported Main Reason for Attrition



Note. Proportions are reported based on n = 16 feedback survey respondents. Most participants provided one reason for attrition (n = 13), two participants provided two reasons, and one participant provided three reasons

Figure 9

Sentiments Related to Research Participation Among Withdrawn Participants



Note. Proportions are reported based on n = 16 feedback survey respondents for each statement.

Appendix A: Study Recruitment Advertisement

Seeking research participants interested in cognitive fitness, aging, and brain health.

At Baycrest, we have developed online programs that target common age-related cognitive changes. These online programs are based on well-validated, in-person offerings that have been delivered at Baycrest and other sites for many years.

The programs consist of modules composed of videos, slides, activities, memory and thinking exercises, discussion boards, and small homework assignments. We are presently recruiting research participants to for a study evaluating the online program from the comfort of their homes.

You will be asked to:

- Complete a set of questionnaires and tasks on three occasion online and over the phone (each testing session is approximately 2 hours but can be completed at your own pace)
- Participate in the online cognitive fitness programs (approximately 10-20 hours over 5-9-weeks)

If you are 60 years old and older, have to access and feel comfortable using a computer, and would like to learn about how to optimize cognitive fitness and brain health, please email us at **onlinetraining.info@research.baycrest.org** for more information.

Appendix B: Informed Consent Form

Title of project: Evaluation of online cognitive fitness programs

Investigators: Dr. Susan Vandermorris, Dr. Angela Troyer, Dr. Jill Rich, Ms. Iris Yusupov, Ms. Komal Shaikh, Ms. Erica Tatham, Dr. Brian Levine, Dr. Jordan Lass

Study description:
At Baycrest, we have developed online programs that target common age-related cognitive changes. These online programs are based on well-validated, in-person offerings that have been delivered at Baycrest and other sites for many years. The aim of this study is to evaluate whether the online programs help people achieve the same outcomes as the in-person programming.

Procedures:
Participation in the study will involve completing online programming in your own home using your own computer or tablet. You will be randomly assigned to one of four programming groups. The programs consist of modules composed of videos, slides, activities, memory and thinking exercises, discussion boards, and small homework assignments. Some groups include some brief telephone interviews with a member of the study team. You may complete most of the programming at your convenience, on your own schedule. The programs are designed to take approximately 10-20 hours of your time over 5-9 weeks. These programs will be provided to you free of charge.

You will also be asked to complete three online assessment sessions consisting of questionnaires and tasks pertaining to your memory and aspects of your daily life. These assessment sessions will take place three times over the course of the study, approximately 5-9 weeks apart. The sessions are about 1-2 hours in duration and may be completed in multiple shorter sittings. You will be compensated $30 per testing session.

Benefits and risks:
Persons who complete our in-person programs have shown increased confidence in everyday memory and thinking ability. You may also experience these benefits. In addition, participants who have tried earlier versions of the online programs have expressed that the programs are enjoyable to them. There are no known risks associated with participation in this study. If new information related to the risks of the study is obtained, you will be informed.

Confidentiality:
If you agree to join this study, we will collect the data from questionnaires and tasks you complete. **Your data will be identified with a study number only and will never be identified by name.**

The information that is collected will be kept in a password protected electronic file. Only the researchers listed at the top of this form will be allowed to look at the data. Data collected in this study may be used for future, related studies by the research team. Baycrest's Research Ethics Committee may also examine collected data to ensure adherence to ethical standards.

All information collected during this study will be kept confidential and will not be shared with anyone outside the study unless required by law. If you decide to withdraw from the study, the information about you that was collected to that point will not be used.

Voluntary participation:
Your participation in this study is completely voluntary. You may decide not to be in this study, or to be in the study now and then change your mind later. You may leave the study at any time without affecting the nature of your relationship with York University or Baycrest Health Sciences either now or in the future. You may refuse to answer questions you do not want to answer. In no way does signing this consent form waive your legal rights nor does it relieve the investigators, sponsors or involved institutions from their legal and professional responsibilities. It is suggested that you print a copy of this consent form for your own records.

Questions about the study:
If you have any questions, concerns or would like to speak to the study team for any reason, please contact Iris Yusupov at iyusupov@baycrest.org or Dr. Susan Vandermorris at svandermorris@baycrest.org or 416-785- 2500 x2686.

If you wish to contact someone not connected with the project about your rights as a research participant, please call Dr. Ron Heslegrave, Chair of the Research Ethics Board at (416) 785-2500 ext. 2440.

Signature section:

I have read the preceding information, and I understand the purpose of my participation, the procedures involved and the potential risks to myself, as stated in this document. All my questions have been answered to my satisfaction. I understand that I can ask further questions during any stage of the study.

I understand that my participation in the study is voluntary. I may withdraw from the study at any point in time. I am aware that the study will not benefit me specifically, but knowledge will be gained that will benefit others. It has been explained to me that the results of the study are confidential. Neither my identity nor any personal information will be available to anyone other than the investigators. No personal information will be disclosed in any resulting publication or presentation.

Check one:
_ I agree
_ I disagree

Appendix C: Online Pre-Screening Questions (Computer Access and Familiarity)

Baycrest

The following page contains some questions about your upcoming availability and computer experience. Please answer them to the best of your ability.

Please answer the following questions:

	No	Yes
Will you have access to a computer with internet over the next 17 weeks?	○	○
Are you willing and able to use a computer to participate in a cognitive fitness program that is designed to take approximately 10-20 hours of your time over a period of 5-9 weeks?	○	○
Are you willing and able to participate in 1-2 hour computer and/or telephone based cognitive assessments that will take place three times, approximately 5-9 weeks apart?	○	○

For each of the following statements, rate your agreement on a scale from "Strongly disagree" to "Strongly agree".

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I feel comfortable using a computer.	○	○	○	○	○	○	○
I feel comfortable using a computer mouse.	○	○	○	○	○	○	○
I feel comfortable using a computer keyboard.	○	○	○	○	○	○	○

How often do you use a desktop or laptop computer?

- ○ Less than once per month
- ○ About once per month
- ○ About once per week
- ○ More than once per week
- ○ Daily

Appendix D: Telephone Questions Assessing Independence of Activities of Daily Living

Baycrest

Now I am going to be asking you about some of your activities of daily living. Are you receiving any help with...

	Are you receiving any help with...		(if yes) have you always received help with this activity?		Are you receiving help because of changes in your memory or thinking?		Details
	Yes	No	Yes	No	Yes	No	(if applicable)
Banking	○	○	○	○	○	○	
Housekeeping	○	○	○	○	○	○	
Paying bills	○	○	○	○	○	○	
Taking medication	○	○	○	○	○	○	
Cooking	○	○	○	○	○	○	
Driving/transportation	○	○	○	○	○	○	
Grocery shopping	○	○	○	○	○	○	
Managing appointments	○	○	○	○	○	○	

Appendix E: Memory Knowledge Quiz

Baycrest

What are the three stages (or processes) that need to occur in order for a person to learn and remember something?

Answer (copy verbatim)

If you named three memory processes, which process is affected most by normal aging?

Answer (copy verbatim)

Name six types of memory. These refer to the kinds of information that are remembered:

Answer (copy verbatim)

There are a number of different lifestyle and medical factors that can affect memory, either positively or negatively. Name five lifestyle or medical factors that can affect memory. Do not include memory strategies:

Answer (copy verbatim)

Name five memory strategies (i.e., strategies that help you to remember information).

Answer (copy verbatim)

Name two brain structures that are important for learning and memory:

Answer (copy verbatim)

What is the name of the hormone that is released in response to stress?:
(check all that are correct)

Answer (copy verbatim)

8. Name two types of formal relaxation techniques:

Answer (copy verbatim)

**NOTES, if applicable write any notes on issues related to the memory and knowledge quiz

Appendix F: Memory Strategy Toolbox Questionnaire

Memory Situations

Below are several different situations that involve memory. After each situation, briefly list the things you should do to improve your ability to remember. Then circle any things you have listed that you actually do.

1. You made arrangements to meet a friend. You want to be sure you remember to meet him or her.

2. A family member or friend has moved. You want to remember his or her new phone number.

3. There are a number of things that you need to remember to do today.

4. You have met someone new, and you want to remember his or her name.

5. You frequently lose your keys or your wallet because you can't remember where you put them.

6. You want to remember details about things that you have done, such as trips you have taken or books you have read.

Appendix G: Satisfaction Subscale of the Multifactorial Memory Questionnaire

Multifactorial Memory Questionnaire

How I Feel About My Memory

Name: _____ Date: _____

Below are statements about feelings that people may have about their memory. Read each statement and think about your feelings over the past *two weeks*. Then, check the box next to the response that best describes how much you agree or disagree.

1. I am generally pleased with my memory ability.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

2. There is something seriously wrong with my memory.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

3. If something is important, I will probably remember it.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

4. When I forget something, I fear that I may have a serious memory problem, like Alzheimer's disease.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

5. My memory is worse than most other people my age.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

6. I have confidence in my ability to remember things.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

7. I feel unhappy when I think about my memory ability.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

8. I worry that others will notice that my memory is not very good.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

9. When I have trouble remembering something, I'm not too hard on myself.

   ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

10. I am concerned about my memory.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

11. My memory is really going downhill lately.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

12. I am generally satisfied with my memory ability.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

13. I don't get upset when I have trouble remembering something.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

14. I worry that I will forget something important.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

15. I am embarrassed about my memory ability.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

16. I get annoyed or irritated with myself when I am forgetful.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

17. My memory is good for my age.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

18. I worry about my memory ability.

☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

Multifactorial Memory Questionnaire: Satisfaction Scale (formerly Contentment Scale)

Baycrest

Appendix H: Ability Subscale of the Multifactorial Memory Questionnaire

Multifactorial Memory Questionnaire

Memory Mistakes

Name: _____ Date: _____

Below is a list of common memory mistakes that people make. Decide how often you have done each one in the *last two weeks*. Then, check the box next to the appropriate response.

1. Forget to pay a bill on time.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

2. Misplace something you use daily, like your keys or glasses.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

3. Have trouble remembering a telephone number you just looked up.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

4. Not recall the name of someone you just met.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

5. Leave something behind when you meant to bring it with you.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

6. Forget an appointment.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

7. Forget what you were just about to do; for example, walk into a room and forget what you went there to do.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

8. Forget to run an errand.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

9. In conversation, have difficulty coming up with a specific word that you want.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

10. Have trouble remembering details from a newspaper or magazine article you read earlier that day.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

11. Forget to take medication.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

12. Not recall the name of someone you have known for some time.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

13. Forget to pass on a message.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

14. Forget what you were going to say in conversation.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

15. Forget a birthday or anniversary that you used to know well.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

16. Forget a telephone number you use frequently.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

17. Retell a story or joke to the same person because you forgot you already told him or her.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

18. Misplace something that you put away a few days ago.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

19. Forget to buy something you intended to buy.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

20. Forget details about a recent conversation.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

Multifactorial Memory Questionnaire: Ability Scale

Baycrest

Appendix I: Strategy Subscale of the Multifactorial Memory Questionnaire

Multifactorial Memory Questionnaire

Use of Memory Strategies

Name: _____ Date: _____

People often use different tricks or strategies to help them remember things. Several strategies are listed below. Decide how often you used each one in the *last two weeks*. Then, check the box next to the appropriate response.

1. Use a timer or alarm to remind you when to do something.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

2. Ask someone to help you remember something or to remind you to do something.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

3. Create a rhyme out of what you want to remember.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

4. In your mind, create an image of something you want to remember, like a name and face.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

5. Write things on a calendar, such as appointments or things you need to do.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

6. Go through the alphabet one letter at a time to see if it sparks a memory for a name or word.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

7. Organize information you want to remember; for example, organize your grocery list according to food groups.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

8. Say something out loud in order to remember it, such as a phone number you just looked up.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

9. Use a routine to remember important things, like checking that you have your wallet and keys when you leave home.

   ☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

10. Make a list, such as a grocery list or a list of things to do.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

11. Mentally elaborate on something you want to remember; for example, focus on a lot of the details.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

12. Put something in a prominent place to remind you to do something, like putting your umbrella by the front door so you will remember to take it with you.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

13. Repeat something to yourself at increasingly longer and longer intervals so you will remember it.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

14. Create a story to link together information you want to remember.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

15. Write down in a notebook things that you want to remember.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

16. Create an acronym out of the first letters in a list of things to remember, such as carrots, apples, and bread (cab).

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

17. Intentionally concentrate hard on something so that you will remember it.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

18. Write a note or reminder for yourself (other than on a calendar or in a notebook).

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

19. Mentally retrace your steps in order to remember something, such as the location of a misplaced item.

☐ All the Time ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

Multifactorial Memory Questionnaire: Strategy Scale

Baycrest

Appendix J: Attrition Feedback Survey

Baycrest

1. What was the main reason for your decision to withdraw from the study?

2. Did you experience technical difficulties

- Yes
- No

If yes, please provide a brief description:

3. Did you experience any other barriers to completing the online program?

- Yes
- No

If yes, please provide a brief description:

4. Did any personal events or circumstances influence your participation in the program?

- Yes
- No

If yes, can you please specify:

5. Were you worried about confidentiality issues regarding your personal information?

- Yes
- No

Include details here if needed:

Please choose the most applicable answer to each statement

6. This research study is meaningful.

- Yes
- No
- Unsure

7. I was interested in the study topic.

- A lot
- A little
- Not much
- Not at all

8. I felt like my participation was important.

- Yes
- No
- Unsure

9. What could have been done to improve your experience?

10. Have you participated in an online research study before?

- ○ Yes
- ○ No

11. How many hours per week do you work or volunteer?

12. Any other comments about your experience you'd like to share?

Thank you for your responses!