NEUROPSYCHOLOGICAL REHABILITATION
https://doi.org/10.1080/09602011.2020.1841656

Initiation and maintenance of behaviour change to support memory and brain health in older adults: A randomized controlled trial

Susan Vandermorris [a], April Au [b], Sandra Gardner [c,d] and Angela K. Troyer [a,b]

[a]Neuropsychology and Cognitive Health Program, Baycrest, Toronto, Canada; [b]Department of Psychology, University of Toronto, Toronto, Canada; [c]Kunin-Lunenfeld Centre for Applied Research and Evaluation, Baycrest, Toronto, Canada; [d]Biostatistics Division, Dalla Lana School of Public Health, University of Toronto, Baycrest, Toronto, Canada

ABSTRACT

The implementation of healthy lifestyle and memory behaviours has the potential to mitigate the impact of age-related memory changes on the lives of older adults. The objective of this study was to examine whether a 10–hour multi-component memory intervention improves the initiation and maintenance of targeted, adaptive behaviour changes. Sixty-seven cognitively-normal, community-dwelling older adults, age 50–91 (72% female) participated in a randomized controlled trial with outcomes assessed at baseline, post-intervention, and six-week follow-up. Participants were allocated to a five-week, in-person, facilitator-led group intervention ($n = 34$) versus treatment as usual ($n = 33$). The intervention was associated with significant changes in participant-reported primary outcomes, including increased initiation and maintenance of health-promoting lifestyle behaviours (personal health responsibility, stress management, physical activity, and nutrition) and use of evidence-based behavioural memory strategies in everyday situations. Individualized goals were attained in both the intervention and control conditions. Secondary outcomes replicated prior findings (increased knowledge and improved memory-related confidence, affect, and self-rated ability), but were null with respect to benefits on general health and well-being. Group interventions that target positive adaptation to age-related cognitive decline via behaviour change are a promising avenue to enhance the health and wellness of our aging population.

Trial registration: ClinicalTrials.gov identifier: NCT02087137.

ARTICLE HISTORY
Received 7 May 2020
Accepted 16 October 2020

KEYWORDS
Cognitive aging; Behavior change; Clinical trials; Memory and Aging Program

Introduction

Healthy aging is associated with cognitive change, with some abilities improving, some remaining stable, and others normally declining with age (Anderson &

CONTACT Susan Vandermorris svandermorris@baycrest.org Neuropsychology and Cognitive Health Program, Baycrest, 3560 Bathurst Street, Toronto ON, Canada M6A 2E1

Supplemental data for this article can be accessed https://doi.org/10.1080/09602011.2020.1841656.

Craik, 2017). Age-related decline in certain aspects of memory increases the frequency of everyday memory mistakes such as misplacing keys, having trouble retrieving a name, or forgetting why one came into a room (Ossher et al., 2013). These memory mistakes can be a source of frustration and anxiety and a hindrance to optimal functioning (Parikh et al., 2016). They can also cause apprehension about the possibility of developing dementia, one of the most feared health conditions among older adults (Patterson, 2018).

Fortunately, there is a growing body of evidence suggesting that specific behaviours can mitigate the extent and functional impact of age-related memory changes. Longitudinal cohort studies have identified a number of lifestyle behaviours – including smoking, physical inactivity, and social isolation – that are modifiable risk factors for dementia (Livingston et al., 2020). Furthermore, the use of behavioural memory strategies such as note taking, repeating information to be remembered, and creating visual images is associated with better everyday functional memory in older adults (e.g., Frakenmolen et al., 2018; Weakley et al., 2019).

The implementation of key lifestyle and memory behaviours, therefore, has the potential to produce significant, meaningful changes in brain health and functioning for older adults. Effecting behavioural change can be a challenge, however, and requires an understanding of the factors that promote behaviour change. Theories of self-regulation and behaviour change posit that different factors guide the decision to initiate versus maintain behaviours (Rothman, 2000; Rothman et al., 2011). Individuals may decide to initiate new behaviours when they appreciate the potential benefits of those behaviours and create favourable expectations about their outcomes. Decisions to maintain new behaviours, on the other hand, are based on satisfaction with the outcomes of the behaviour. Group interventions can be used to enhance these decision-making processes by, for example, providing evidence that supports the effectiveness of the behaviours, affording opportunities to practice new behaviours, promoting self-efficacy, facilitating cost–benefit analysis, and ensuring that participants have successful experiences with the new behaviours. A variety of behaviour change strategies, therefore, are needed to ensure the success of interventions in producing lasting behavioural change.

These principles can be readily applied to memory interventions for older adults to increase both the initiation and maintenance of lifestyle and memory strategy behaviours that promote brain health. To date, however, most studies evaluating the efficacy of memory interventions have focused on objective memory outcomes and have used research designs with some inherent risk of bias towards favourable results (for reviews, see Gross et al., 2012; Hudes et al., 2019; Verhaeghen et al., 1992). A few randomized controlled trials (RCTs) have examined participant-reported outcomes such as perceived memory ability, self-efficacy, and memory related affect, but very few report lifestyle and memory strategy behaviour outcomes (Hudes et al., 2019).

Previous research using the intervention under evaluation herein (Wiegand et al., 2013) has provided limited evidence of behaviour change by participants in an intervention incorporating behaviour change strategies. That is, a single-item measure indicated that programme participants reported the implementation of more lifestyle changes than matched controls, and programme participants endorsed using more strategies from a pre-specified list of memory strategies than controls. In the current research, we examine this issue in more depth, exploring the impact of intervention on both the initiation and maintenance of behaviour changes that are related to specific lifestyle factors (e.g., physical activity, cognitive engagement, stress management) and the self-generated use of evidence-based behavioural memory strategies in everyday memory situations.

Objectives

In the present study, we report a methodologically rigorous evaluation of a 10-hour group intervention that incorporates multiple behaviour-change techniques and provides brain health lifestyle coaching and memory strategy training for cognitively normal, community dwelling older adults. The goals of the intervention are to increase knowledge about memory and aging, reassure participants with normal memory changes, provide practical tools to manage memory changes, and enable lifestyle changes to maximize brain health (Troyer & Vandermorris, 2012). Of note, the intervention is compensatory in nature. As such, objective improvement on memory test scores is not included among programme goals. Our primary research objectives were to examine whether the intervention positively impacts initiation and maintenance of (a) brain health-promoting lifestyle behaviours and (b) adaptive memory strategy use. Secondary outcomes targeted replication of prior findings and exploration of distal outcomes such as generalized benefits to health and well-being.

Method

Participants and procedure

Study procedures and participant flow are detailed in the CONSORT flow chart in Figure 1. This single-site, parallel-groups trial with balanced randomization (1:1) was registered prospectively at clinicaltrials.gov (NCT02087137) and took place at an academic geriatric medical centre. The study was approved by the host institution Research Ethics Board. Sample size was determined based on prior evaluations of the intervention that resulted in medium to large average effect sizes of 0.6–0.7 when comparing change scores between participants and controls. Using Cohen's (1988) sample size tables and an effect size of 0.6, we estimated that, with a desired power of 0.8, 30 subjects per group

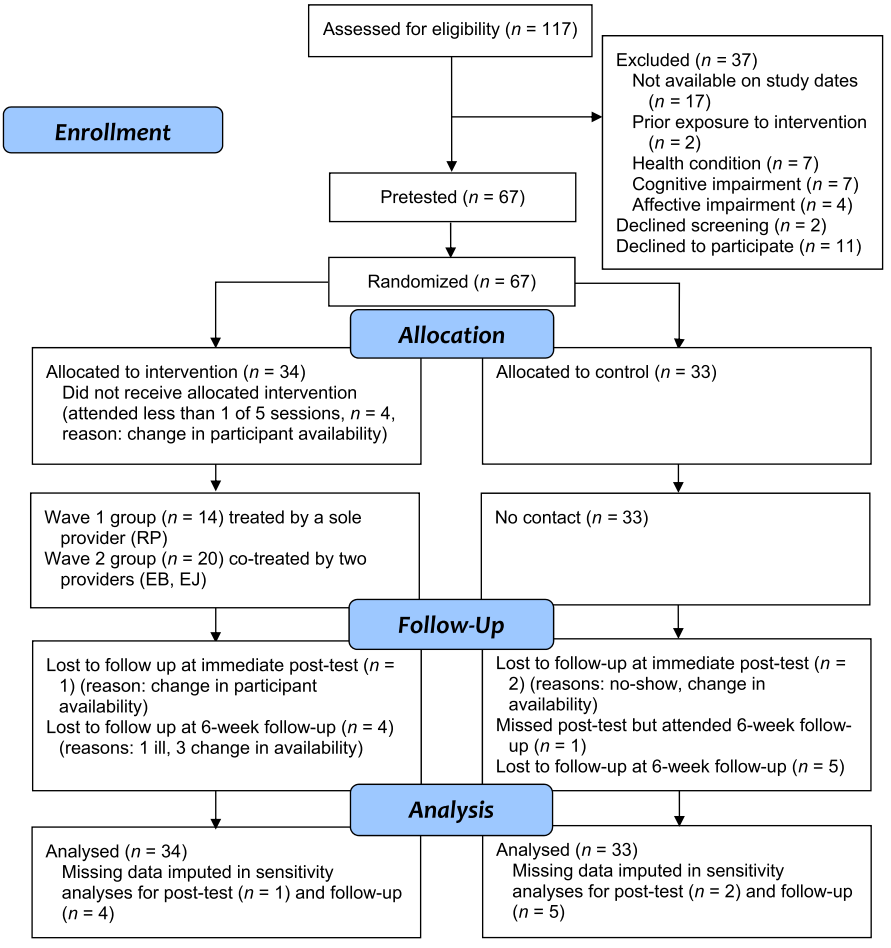

Figure 1. CONSORT 2010 Flow Diagram (non-pharamcologic extended version).

were needed to obtain group differences significant at $p = .05$. Data were collected in two waves for logistical reasons.

Healthy, community-dwelling older adults ($n = 117$) were recruited between March 2014 and June 2015 by newspaper advertisements, flyers, and an institutional volunteer pool. Prospective participants were screened by telephone for inclusions (i.e., age 50+, available to participate) and exclusions. Exclusion criteria included (a) health conditions with major effects on cognition (e.g., stroke, brain surgery, or other neurological disorder), (b) dependence in instrumental activities of daily living, (c) cognitive impairment (i.e., score below 30 on the Telephone Interview for Cognitive Status; Brandt et al., 1988), or (d) affective impairment (i.e., score above 1 on a 5-item Geriatric Depression Scale; Hoyl et al., 1999). For descriptive purposes, additional information about demographics and memory concerns was also collected.

Sixty-seven eligible and interested participants completed written informed consent and pretesting. A computer-generated list of random numbers was

Table 1. Participant demographics by group.

	Control ($n = 33$) M (SD)	Intervention ($n = 34$) M (SD)
Age, in years	72 (8.3)	71 (8.8)
Education, in years	15 (3.2)	16 (2.3)
TICS total score	35 (2.4)	34 (2.0)
	Proportion	Proportion
Female	68%	77%
Concerned about memory	70%	79%

Note. TICS = Telephone Interview for Cognitive Status. Groups do not differ significantly on any variables in the table. Race/ethnicity data were not collected.

used to randomly assign participants to either an intervention or no contact control group according to a blocked randomization scheme stratified on age created by a statistician not otherwise involved in the study. Data were then reviewed for spousal pairings, and a coin toss was used to re-allocate any separated spouses to the same condition ($n = 2$ pairings). A final list of participant allocations was given to the intervention staff who contacted participants by telephone to advise them of their allocation. Participant demographics by condition are provided in Table 1.

The manualized intervention, the Memory and Aging Program (Troyer & Vandermorris, 2012), was delivered by predoctoral interns in clinical neuropsychology under the supervision of the lead author. The intervention consists of five weekly, 2-hour sessions, and was run in July 2014 and July 2015. Content includes education about normal memory change and health/lifestyle factors that affect memory and practical training in evidence-based memory strategies. Format includes interactive lectures, structured discussions, in-class exercises, and homework assignments (see Table 2 for details). Guided by self-regulation theory (Cameron & Levanthal, 2003; Vohs & Baumeister, 2011), behaviour change techniques (i.e., analysis of costs-benefits, self-monitoring, accountability, successful experiences, generalization, goal setting and review) are used

Table 2. Schedule of intervention content.

Week	Content
1	Orientation and goal setting Normal age-related memory changes
2	Factors that affect memory (e.g., medical conditions/medications, diet, exercise, cognitive engagement, attitude, stress/relaxation) Relaxation training: diaphragmatic breathing and visualization Homework: track own cognitive and physical activities
3	Overview of memory strategies (e.g., implementation intentions, spaced retrieval, semantic elaboration, habits, and external memory aids) Teaching and practice with spaced retrieval memory strategyHomework: relaxation practice
4	Teaching and practice with semantic elaboration memory strategy Teaching and discussion of external memory strategies (e.g., written and electronic aids) Homework: memory strategy practice
5	Application of memory strategies in everyday scenarios Review and evaluation of goal attainment Goal setting for future memory strategy use and lifestyle practices

throughout to empower participants to increase brain-healthy lifestyle behaviours and adopt newly learned memory strategies. Treatment adherence was monitored through attendance and homework completion.

In order to examine both initiation and maintenance of behaviour change, outcome measures were administered at pretest (one week prior to intervention), immediate post-test (one week following intervention), and a six-week follow-up session. Staff members responsible for testing were masked to participant allocation. Pretesting sessions were two hours in duration, run in small groups for logistical reasons of up to six persons. Post-test and follow-up sessions were 90 min, run in groups of up to 20 persons. Total study participation duration was 12 weeks, with an additional 5 weeks of optional intervention available to control participants. Overall study retention rate was 96% at post-test and 87% at follow-up.

Outcome measures

Primary outcomes. Healthy lifestyle behaviours were measured using the Health Promoting Lifestyle Profile II (HPLPII, Walker et al., 1987). This 52-item, well-validated instrument uses a 4-point Likert scale to measure the frequency of participant-reported behaviours across six domains: health responsibility, physical activity, nutrition, spiritual growth, interpersonal relations, and stress management. We computed an overall total score (out of 208) and mean scores for each of the six domains. Higher scores indicate greater frequency of participant-reported healthy behaviours.

Adaptive memory-strategy use was measured with a novel, participant-reported measure of strategy use in everyday memory scenarios. Six scenarios (e.g., you have met someone new and you want to remember his or her name) were taken from the Memory Strategy Toolbox (Troyer, 2001). For each scenario, participants were asked to list possible memory strategies (a measure of knowledge) and to indicate which of those strategies they currently use when that situation arises in their day-to-day lives (a measure of behaviour). Each strategy was rated from zero to two – with higher scores indicating greater degree of specificity, effectiveness, and self-reliance – and multiple strategies were allowed for each scenario. A total strategy-use score was calculated as the sum of the behaviour-based scores from the six scenarios.

Personal goals for lifestyle and memory behaviour change were measured with Goal Attainment Scaling (GAS, Gordon et al., 2000; Kiresuk et al., 1994). Participants were individually interviewed to establish goals for lifestyle change, memory strategy use, and functional outcomes of memory strategy use. Details of this protocol and intervention-related outcomes captured by the GAS measure were reported previously (Herdman et al., 2019). Additional analyses of the primary composite scores were undertaken in the present study to facilitate presentation of all primary study outcomes on a common metric.

Secondary outcomes. Several of our secondary outcome measures were used to examine replicability of prior findings (as per Troyer, 2001; Wiegand et al., 2013). We administered a 13-item fill-in-the-blank memory knowledge quiz, the original 6-item Memory Strategy Toolbox (utilizing the knowledge score, as described above), a 12-item free-recall name-learning task, a single open-ended question to determine the number of lifestyle changes made in the past month, and a single-item using a 5-point Likert scale to assess intention to seek medical treatment for memory concerns (from Wiegand et al., 2013). We also administered a 57-item participant-reported measure of satisfaction with memory, everyday memory ability, and memory strategy use (Multifactorial Memory Questionnaire, MMQ, Troyer & Rich, 2002).

To explore previously identified benefits to prospective memory in more detail (Troyer, 2001), we administered a paper-and-pencil naturalistic prospective memory task where participants were assigned eight hypothetical tasks to remember per day for five days (Actual Week, Au et al., 2018). The proportion of tasks that were recorded as on time and accurate was used as the outcome variable.

To explore evidence for possible benefits distal to treatment targets, we administered two 10-item self-rated assessments of affect (Positive and Negative Affect Schedule, Watson et al., 1988), a 10-item self-efficacy scale (Generalized Self-Efficacy Scale, Schwarzer & Jerusalem, 1995), and a 36-item self-report measure of physical and mental health (Short Form Health Survey, SF-36; Ware & Sherbourne, 1992). To measure potential effects on stereotypes related to aging, we administered a 5-item scale about self-perceptions of aging (Attitude Toward Own Aging, Lawton, 1975) and rated responses to an open-ended question about the first five words that come to mind when thinking of someone old (Negative Age Stereotypes, Levy & Langer, 1994).

Statistical analyses

Primary outcomes were modelled separately, longitudinally, using linear regression models with an unstructured correlation structure for R-side random effects to adjust for the repeated measures within person across time. There is no group fixed effect. There are fixed effects for the post and follow up time points with the baseline measure as the reference time point. The fixed time effects estimate the common change from baseline for both groups. The interaction between the fixed effects for time and group estimate the additional change from baseline attributed to the intervention group. The main effect for group was excluded from all models because this was an RCT with pretest outcomes measured prior to randomization and confirmed to not be significantly different across groups (Fitzmaurice et al., 2011). Contrasts were used to evaluate within-group change over time and between-group differences in change over time. Models were adjusted for repeated measures

using an unstructured covariance structure. Mean centred age was included in all models. Sensitivity analyses were conducted to assess the potential impact of pretest covariates and missing values. Pretest covariates (e.g., cognitive screening score, sex, memory concerns, and recruitment wave) were considered for inclusion as were their interactions with time. Participants were analyzed as randomized. Missing values (e.g., incomplete questionnaire, missed time point) were imputed according to recent recommendations for RCTs (Jakobsen et al., 2017) using the fully conditional specification method (Berglund & Heeringa, 2014; Van Buuren, 2007) and outcome scale totals were recalculated. Ten imputation data sets were generated for each model and results were combined.

Two statistical approaches were taken to provide clinical context for significant results of the above longitudinal models. First, standardized response mean effect sizes were computed for each measure using raw unimputed data for (a) within-group change across time (i.e., mean change across time divided by the standard deviation of the change; Cohen, 1988) and (b) retest-adjusted intervention group change across time (i.e., intervention minus control difference in mean change across time, divided by the pooled standard deviation of the change; Requena et al., 2016). Second, number needed to treat (NNT) values were computed. Cut scores were defined by computing reliable change indices for each measure (Jacobson & Truax, 1991). Persons with missing outcome data were categorized as showing no change.

Analyses were conducted using SAS/STAT software version 14.1, SAS System for Windows version 9.4, and IBM SPSS Statistics 25 For Windows.

Results

Primary outcomes

Descriptive statistics for primary outcomes are shown in Table 3. Standardized effect sizes capturing relative gain in the intervention group compared to the control group for all three primary outcomes over study interval are plotted in Figure 2.

Healthy lifestyle behaviours. The mean HPLPII scores (see supplementary Table 1) for the control group did not change significantly over time, while the mean for the intervention group increased significantly by 6.1 points at post study ($p = .004$, 95%CI: 2.0, 10.2) and did not show further significant change at follow-up. The overall group-by-time interaction was significant ($\chi^2 = 19.3$, $p < .001$) and the improvement in HPLPII in the intervention group compared to the control group was significant at post study and follow-up. Sensitivity analysis indicated similar results.

Raw score-based standardized response mean effect sizes for the pretest/post-test and pretest/follow-up gain in the intervention group were medium

Table 3. Descriptive statistics for primary outcomes by group.

	Control ($n = 33$)						Intervention ($n = 34$)					
	Pretest		Post-test		Follow-up		Pretest		Post-test		Follow-up	
Health Promoting Lifestyle Profile II*	140.9	(17.2)	138.6	(18.7)	139.2	(16.9)	141.2	(19.7)	146.1	(18.2)	147.4	(19.7)
Health Responsibility*	2.6	(0.5)	2.4	(0.4)	2.5	(0.5)	2.5	(0.6)	2.6	(0.6)	2.6	(0.6)
Physical Activity*	2.4	(0.7)	2.4	(0.7)	2.5	(0.6)	2.3	(0.6)	2.5	(0.6)	2.4	(0.6)
Nutrition*	2.9	(0.4)	2.9	(0.4)	2.8	(0.4)	3.0	(0.4)	3.1	(0.5)	3.1	(0.4)
Spiritual Growth	2.8	(0.6)	2.7	(0.6)	2.8	(0.5)	2.9	(0.6)	2.9	(0.5)	3.0	(0.6)
Interpersonal Relations	3.0	(0.6)	3.0	(0.5)	2.9	(0.5)	3.1	(0.5)	3.1	(0.6)	3.1	(0.6)
Stress Management*	2.6	(0.5)	2.5	(0.5)	2.5	(0.5)	2.5	(0.6)	2.5	(0.5)	2.7	(0.5)
Memory strategy use*	11.0	(4.2)	11.7	(4.7)	11.9	(4.7)	9.2	(4.8)	13.7	(6.5)	14.5	(6.2)
Goal Attainment Scaling	37.2	(1.0)	50.0	(10.4)	51.7	(10.5)	37.0	(1.6)	52.3	(9.5)	52.3	(7.8)

Note. Values are means and standard deviations of obtained raw score primary outcome measures by group and time point. On all measures, higher scores represent better performance. There were no significant group differences observed on any primary outcomes at pretest. Nine participants were lost to follow-up during the study as detailed in the CONSORT flow chart. Overall study retention rate was 96% at immediate post-test and 87% at six-week follow-up.

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

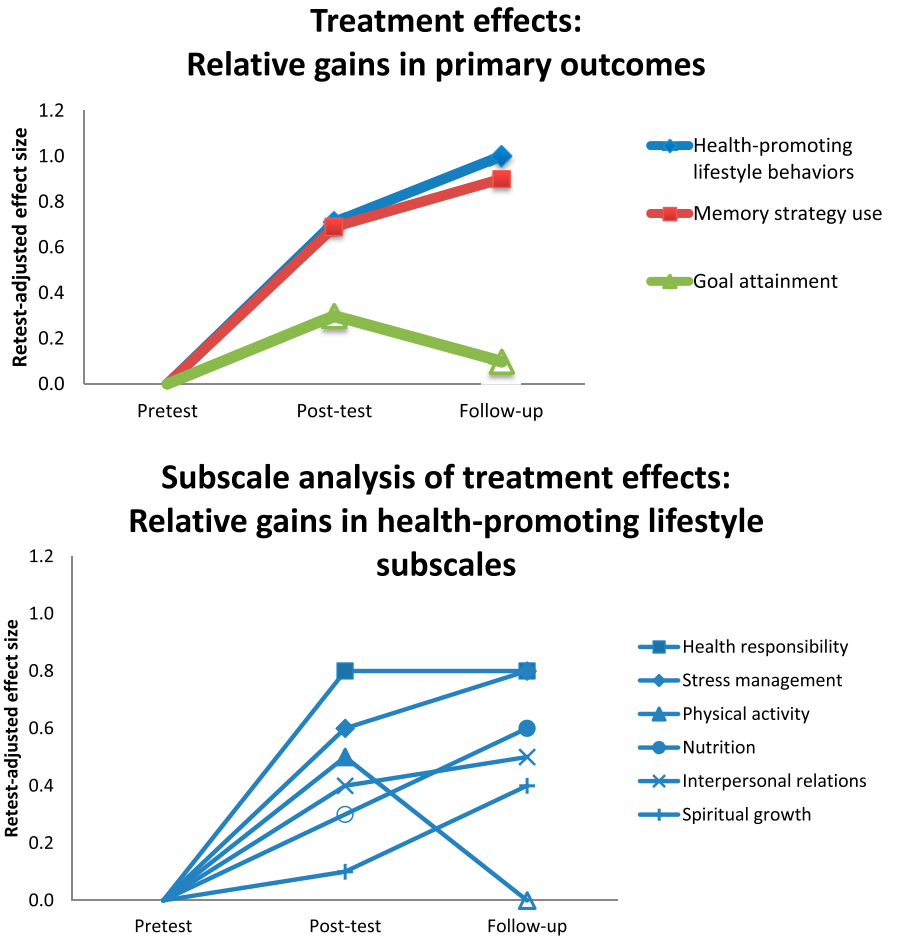

Figure 2. Plot of treatment effects on primary outcome measures using standardized, retest-adjusted effect sizes. Values plotted represent standardized ($M = 0$, $SD = 1$) change from pretest on the primary outcome measures in the intervention group after adjusting for the retest effect in the control group. Statistically significant intervention effects are shown with filled data markers.

in size, at 0.5 and 0.6, respectively. Figure 2 shows the medium to large relative gains in the intervention group compared to the control group on the HPLPII (pretest/post-test $ES = 0.7$, pretest/follow-up $ES = 1.0$). The reliable change index for the HPLPII total score was 17.6. Post-test NNT was 4.9 and follow-up was 8.5.

The above analyses were repeated for each of the HPLPII subscales. There was a significant overall group-by-time interaction for the health responsibility ($\chi^2 = 13.9$, $p = .001$), stress management ($\chi^2 = 11.7$, $p = .003$), physical activity ($\chi^2 = 6.8$, $p = .03$), and nutrition ($\chi^2 = 9.3$, $p = .01$) subscales, but not the interpersonal relations ($\chi^2 = 5.3$, $p = .07$) or the spiritual growth subscale ($\chi^2 = 3.6$, $p = .17$). Contrasts revealed that the intervention group performance significantly exceeded that of controls at post-test on the health responsibility, stress

management, and physical activity subscales. At follow-up, contrasts favoured the intervention group on the health responsibility, stress management, and nutrition scales. As seen in Figure 2, effect sizes for statistically significant contrasts ranged from medium to large, 0.5–0.8.

Memory strategy use. Memory strategy use scores (see Supplementary Table 2) did not change significantly in the control group, while the mean for the intervention group increased significantly by 3.8 points at post-test ($p < .001$, 95%CI: 1.7, 5.8) and did not show further significant change at follow-up. The overall group-by-time interaction was significant ($\chi^2 = 8.7$, $p = .01$) and the improvement in the strategy use score in the intervention group compared to the control group was significant at follow-up only. Sensitivity analysis indicated similar results.

Raw score-based effect sizes for the pretest/post-test and pretest/follow-up gain in the intervention group were medium to large, at 0.7 and 0.9, respectively. Effect sizes capturing the relative gain in the intervention group compared to the control group over the same intervals were also medium to large, 0.7 and 0.9, as seen in Figure 2. The reliable change index for the memory strategy use was 8.9. Post-test NNT was 4.9 and follow-up was 6.9.

Goal attainment. Longitudinal modelling results associated with the Goal Attainment Scaling measure were congruent with our previously reported multivariate analysis of variance results (Herdman et al., 2019). That is, the GAS scores showed very large, significant increases comparably in both groups at post-test, and these gains were sustained at follow-up (see supplementary Table 3). Raw score-based effect sizes for the pretest/post-test and pretest/follow-up gain in the control group were 1.2 and 1.4, respectively, and 1.7 and 1.9 in the intervention group. The overall group-by-time interaction was not significant. Effect sizes capturing the relative gain in the intervention group compared to the control group over the same intervals were small and negligible, at 0.3 and 0.1, respectively (Figure 2). Given the non-significant effects of longitudinal modelling, NNTs were not computed.

Secondary outcomes

Descriptive statistics for secondary outcomes are shown in Table 4, and effect sizes and NNTs are summarized in supplementary Table 4.

Consistent with previous research, there were large intervention-related gains in general factual knowledge about memory, knowledge of memory strategies (Troyer, 2001; Wiegand et al., 2013), and increases in the number of lifestyle changes made to improve health and memory (Wiegand et al., 2013). Medium to large intervention-related gains in satisfaction with memory, participant-reported memory ability, and memory strategy use were observed on the Multifactorial Memory Questionnaire. Similar findings have been reported in prior trials, but not consistently.

Table 4. Descriptive statistics of secondary outcomes by group.

	Control						Intervention					
	Pretest		Post-test		Follow-up		Pretest		Post-test		Follow-up	
Replication of prior findings												
Memory knowledge *	7.0	(3.7)	7.6	(4.9)	9.2	(3.8)	6.7	(4.8)	11.9	(7.1)	14.8	(6.3)
Strategy toolbox (knowledge) *	15.2	(5.4)	15.7	(5.3)	14.3	(5.7)	14.2	(5.4)	18.5	(8.0)	18.5	(7.4)
Name learning	6.7	(1.6)	7.1	(1.8)	7.4	(1.9)	6.7	(2.3)	6.9	(1.9)	7.5	(2.3)
Healthy lifestyle changes *	0.6	(0.9)	0.7	(0.9)	1.1	(1.6)	1.0	(1.7)	2.4	(1.7)	1.6	(1.5)
Intention to seek medical care	3.9	(1.1)	4.2	(1.0)	4.0	(0.9)	3.9	(1.0)	4.0	(0.9)	4.1	(0.9)
MMQ Satisfaction *	41.9	(13.5)	43.8	(13.4)	43.0	(12.4)	34.1	(12.0)	41.9	(14.9)	43.0	(12.0)
MMQ Ability *	49.6	(11.6)	51.9	(11.3)	52.6	(9.3)	45.6	(12.5)	48.5	(11.8)	51.6	(9.2)
MMQ Strategy *	39.5	(8.4)	39.2	(8.9)	42.9	(9.0)	35.9	(10.1)	43.4	(9.0)	43.1	(9.4)
Experimental memory test												
Actual Week (% correct)	55.4	(26.6)	61.3	(26.3)	66.6	(26.4)	51.9	(23.7)	62.8	(23.2)	62.0	(28.6)
General outcomes												
Positive affect (PANAS)	35.8	(6.5)	34.1	(9.2)	35.0	(7.0)	35.8	(7.5)	34.7	(8.1)	35.3	(7.3)
Negative affect (PANAS)	15.9	(5.6)	16.2	(5.0)	15.3	(4.8)	17.0	(6.1)	16.0	(6.1)	14.7	(4.1)
General self-efficacy (GSEC)	30.9	(5.0)	31.1	(5.0)	32.4	(3.7)	30.9	(4.3)	31.1	(4.0)	31.4	(4.0)
General health (SF-36)	65.6	(22.5)	67.3	(23.4)	68.2	(20.0)	67.2	(17.5)	67.5	(15.9)	67.5	(18.8)
Attitude toward own aging	3.3	(1.2)	3.2	(1.4)	3.2	(1.5)	3.0	(1.6)	3.2	(1.7)	3.1	(1.6)
Negative age stereotypes	3.2	(0.8)	3.0	(0.9)	3.0	(0.9)	3.0	(0.9)	3.0	(1.0)	3.0	(1.0)

Note. Values are means and standard deviations of obtained raw scores by group and time point. On all measures, higher scores represent better performance. MMQ = Multifactorial Memory Questionnaire.

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

The remaining secondary analyses showed negligible to small effects that were not significant. A prior null result related to an objective test of name learning was replicated. There was no significant group-by-time interaction on an experimental measure of applied everyday prospective memory. A previously significant overall group-by-time interaction on a measure of intention to seek medical care specifically for memory concerns was not replicated. Probing of this result revealed a similar overall pattern of findings, but smaller effect sizes in the present dataset (0.27 vs. 0.18). There were no significant group-by-time interactions for any outcomes selected to explore possible benefits distal to treatment targets (i.e., positive and negative affect, general self-efficacy, general health, stereotypes related to aging).

Discussion

The present trial was designed to evaluate whether a 10-hour multi-component group memory intervention can facilitate lifestyle and memory behaviour change in community-dwelling older adults with normal age-related memory functioning. The intervention incorporates a variety of behaviour change techniques – including self-efficacy, cost–benefit analysis, and ensuring successful experiences – for the purpose of facilitating decisions related to both the initiation and maintenance of behaviour change, consistent with current theories of self-regulation and behaviour change (Rothman, 2000; Rothman et al., 2011). As predicted, the intervention was associated with significant increases in participant-reported health-promoting lifestyle behaviours and everyday use of evidence-based memory strategies. These findings were evident immediately post-intervention and sustained at six-week follow-up, with retest-adjusted effect sizes ranging from medium to large (Cohen, 1988) and NNTs ranging from 5 to 9. As discussed elsewhere (Herdman et al., 2019), our finding of comparable goal attainment in intervention and control participants suggests a possible therapeutic contribution of setting and rating goals with GAS. Secondary outcomes replicated previously documented gains in participant-reported outcomes related to memory ability, self-efficacy, and affect, but did not show benefit on exploratory outcomes including measures of global psychological well-being, health, age-related stereotypes, and name-learning and prospective memory tests.

With respect to health-promoting behaviours, it is notable that there were specific, targeted, intervention-associated increases observed in participant-reported behaviours related to personal health responsibility, stress management, physical activity, and nutrition. Increasing attention to potentially modifiable risk factors for dementia (e.g., hypertension, depression, physical inactivity) and the relatively limited success of large-scale single-factor secondary prevention trials has led to increasing interest in interventions that target multiple risk factors (Livingston et al., 2020). The present findings demonstrate the efficacy of

a relatively brief intervention to foster positive behaviour change. These changes were maintained for at least six weeks following participation, with the exception of physical activity, for which scores returned to baseline levels. It is unclear why this particular behaviour differed from the others, but it is possible that it takes longer than 5 weeks to obtain satisfactory physical activity outcomes that would foster behaviour maintenance (Rothman, 2000; Rothman et al., 2011) and that a longer intervention or more direct support with exercise is required.

With respect to memory behaviours, the present study is a methodologically rigorous evaluation that minimizes the risk of bias present in many similar studies (as reviewed in Hudes et al.). As such, it provides high quality evidence that practical, compensatory, memory-strategy training for healthy older adults can translate to the initiation and maintenance of participant-reported adaptive strategies in everyday life. Future study is needed to evaluate the longer-term sustainability of these findings, particularly among those individuals who go on to show non-normative memory decline. There is evidence that the same types of memory-strategy training employed within the present study can lead to similar positive behaviour change in persons with mild cognitive impairment (Gates et al., 2011; Troyer et al., 2008), and that some benefits are maintained for up to several years (Kinsella et al., 2015; Matthews et al., 2020). Given the relative preservation of procedural memory, or habits, in memory disorders such as Alzheimer's disease (van Halteren-van Tilborg et al., 2007), it is possible that establishing good habits around compensatory memory behaviours prior to the onset of notable memory loss could delay functional losses associated with these conditions.

Our use of an age-diverse sample, a manualized intervention, and different group facilitators enhance the generalizability of our results to other settings. Other features of the present study impose some limitations. The sample comprised a relatively mobile, highly-educated group recruited from a single site in an urban setting. It remains to be studied to what degree results would hold in persons with restricted mobility, lower education, or in non-urban settings. Multi-site evaluation research would help to address some of these limitations. Racial/ethnic data were not collected in the present study, and this is important to address in future studies. The masking of study staff to participant condition was a methodological improvement relative to prior studies, but participants could not be fully masked to their assignment to the immediate treatment versus no contact control conditions. In the context of participant-reported primary outcomes, this partial masking carried a risk of favourable bias due to demand characteristics. While this risk could have been mitigated to some degree by using an active control design, we elected to optimize clinical relevance by employing a no contact control as the "treatment-as-usual" for persons who are concerned about normal age-related memory change. That is, current management recommendations for older adults who present with

subjective memory complaints but are found to have normal cognition on exam suggest that no treatment is indicated (Petersen et al., 2018), though re-assessment in 1–2 years may be reasonable (McDade & Petersen, 2019). Because participant-reported outcome measures are susceptible to social desirability and other biases, another avenue for future study could be to complement these with passive measures such as fitness trackers or masked observational reports.

Taken together, the present study demonstrates that a relatively brief group memory intervention that incorporates a variety of behaviour-change techniques can foster both the initiation and maintenance of positive health and memory behaviour change in cognitively normal older adults. With the use of available facilitator's materials (Troyer & Vandermorris, 2012, 2017), the programme can be implemented in a variety of settings. An economic evaluation, such as a cost–benefit analysis, would be useful in identifying any economic benefits of the programme to the provider and the health care system. Memory intervention that fosters positive behaviour change may be a promising avenue to reduce the impact of age-related memory changes, optimize health and everyday functioning, and preserve independence in later adulthood.

Acknowledgements

The authors acknowledge Dr. Rosanne Aleong and Rosalind Sham from the Baycrest KL-CARE team for project management and participant recruitment; Dr. Ronak Patel, Dr. Elsa Baena, and Dr. Eliyas Jeffay for delivering the intervention; Dr. Joanna Sue, Dr. Cameron Clark, Dr. Emilie Crevier-Quintin, Wajiha Afaq, Sabrina Scarcello, Areeba Adnan, Luna Taguchi, and Jennifer Pritzker for assistance with participant testing; Dr. Rebecca Levy for guidance regarding assessment of age stereotypes; and Dr. Shafagh Fallah for randomizing participants to groups.

Disclosure statement

Drs. Vandermorris and Troyer have co-authored a leader's manual, participant workbook, and clinical guide for the Memory and Aging Program and have presented train-the-trainer workshops on delivering the Memory and Aging Program. Under Baycrest's Intellectual Property Policy, they are eligible to receive a percentage of the royalties collected on the net profit generated from these ventures.

Funding

The authors acknowledge named donor support for the Memory and Aging Program within the Mira & Saul Koschitzky Neuropsychology Treatment Programs at Baycrest. This work was supported by internal funding from the host institution.

ORCID

Susan Vandermorris http://orcid.org/0000-0002-6187-9077
April Au http://orcid.org/0000-0001-9047-5904
Sandra Gardner http://orcid.org/0000-0002-3855-4899
Angela K. Troyer http://orcid.org/0000-0001-5660-4127

References

Anderson, N. D., & Craik, F. I. M. (2017). 50 years of cognitive aging theory. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *72*(1), 1–6. https://doi.org/10.1093/geronb/gbw108

Au, A., Vandermorris, S., Rendell, P. G., Craik, F. I. M., & Troyer, A. K. (2018). Psychometric properties of the actual week test: A naturalistic prospective memory task. *The Clinical Neuropsychologist*, *32*(6), 1068–1083. https://doi.org/10.1080/13854046.2017.1360946

Berglund, P., & Heeringa, S. (2014). *Multiple imputation of missing data using SAS*. SAS Institute.

Brandt, J., Spencer, M., & Folstein, M. (1988). The telephone Interview for cognitive status. *Neuropsychiatry, Neuropsychology, & Behavioral Neurology*, *1*(2), 111–117.

Cameron, L. D., & Levanthal, H. (2003). *The self-regulation of health and illness behavior*. Routledge.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Routledge Academic.

Fitzmaurice, G. M., Laird, N. M., & Ware, J. H. (2011). *Applied longitudinal analysis* (2nd ed.). John Wiley & Sons.

Frakenmolen, N. L., Overdorp, E. J., Fasotti, L., Claasen, J. A. H. R., Kessels, R. P. C., & Oosterman, J. M. (2018). Memory strategy training in older adults with subjective memory complaints: A randomized controlled trial. *Journal of the International Neuropsychological Society*, *24* (10), 1110–1120. https://doi.org/10.1017/S1355617718000619

Gates, N. J., Sachdev, P. S., Fiatarone Singh, M. A., & Valenzuela, M. (2011). Cognitive and memory training in adults at risk of dementia: A systematic review. *BMC Geriatrics*, *11*(1), 55. https://doi.org/10.1186/1471-2318-11-55

Gordon, J., Powell, C., & Rockwood, K. (2000). Assessing patients' views of clinical changes. *JAMA: The Journal of the American Medical Association*, *283*(14), 1824–1825. https://doi.org/10.1001/jama.283.14.1824

Gross, A. L., Parisi, J. M., Spira, A. P., Kueider, A. M., Ko, J. Y., Saczynski, J. S., Samus, Q. M., Rebok, G. W. (2012). Memory training interventions for older adults: A meta-analysis. *Aging & Mental Health*, *16*(6), 722–734. https://doi.org/10.1080/13607863.2012.667783

Herdman, K. A., Vandermorris, S., Davidson, S., Au, A., & Troyer, A. K. (2019). Comparable achievement of client-identified, self-rated goals in intervention and no-intervention groups: Reevaluating the use of goal attainment scaling as an outcome measure. *Neuropsychological Rehabilitation*, *29*(10), 1600–1610. https://doi.org/10.1080/09602011.2018.1432490

Hoyl, M. T., Alessi, C. A., Harker, J. O., Josephson, K. R., Pietruszka, F. M., Koelfgen, M., Mervis, J. R., Fitten, L. J., & Rubenstein, L. Z. (1999). Development and testing of a five-item version of the geriatric depression scale. *Journal of the American Geriatrics Society*, *47*(7), 873–878. https://doi.org/10.1111/j.1532-5415.1999.tb03848.x

Hudes, R., Rich, J. B., Troyer, A. K., Yusupov, I., & Vandermorris, S. (2019). The impact of memory-strategy training interventions on participant-reported outcomes in healthy older adults: A systematic review and meta-analysis. *Psychology and Aging*, *34*(4), 587–597. https://doi.org/10.1037/pag0000340

Jacobson, N. S., & Truax, P. (1991). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting and Clinical Psychology*, *59*(1), 12–19. https://doi.org/10.1037/0022-006X.59.1.12

Jakobsen, J. C., Gluud, C., Wetterslev, J., & Winkel, P. (2017). When and how should multiple imputation be used for handling missing data in randomised clinical trials – a practical guide with flowcharts. *BMC Medical Research Methodology*, *17*(1), 162. https://doi.org/10.1186/s12874-017-0442-1

Kinsella, G. J., Ames, D., Storey, E., Ong, B., Pike, K. E., Saling, M. M., Clare, L., Mullaly, E., & Rand, E. (2015). Strategies for improving memory: A randomized trial of memory groups for older people, including those with mild cognitive impairment. *Journal of Alzheimers Disease*, *49* (1), 31–43. https://doi.org/10.3233/JAD-150378

Kiresuk, T. J., Smith, A., & Cardillo, J. E. (1994). *Goal attainment scaling: Applications, theory, and measurement*. Lawrence Erlbaum Associates.

Lawton, M. P. (1975). The Philadelphia geriatric center Morale scale: A revision. *Journal Of Gerontology*, *30*(1), 85–89. https://doi.org/10.1093/geronj/30.1.85

Levy, B., & Langer, E. (1994). Aging free from negative stereotypes: Successful memory in China and among the American deaf. *Journal of Personality and Social Psychology*, *66*(6), 989–997. https://doi.org/10.1037/0022-3514.66.6.989

Livingston, G., Huntley, J., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., Brayne, C., Burns, A., Cohen-Mansfield, J., Cooper, C., Costafreda, S. G., Dias, A., Fox, N., Gitlin, L. N., Howard, R., Kales, H. C., Kivimäki, M., Larson, E. B., … Mukadam, N. (2020). Dementia prevention, intervention, and care: 2020 report of the *Lancet* Commission. *The Lancet*, *396*(10248), 413–446. https://doi.org/10.1016/S0140-6736(20)30367-6

Matthews, M. L., Wells, Y., Pike, K. E., & Kinsella, G. J. (2020). Long-term effects of a memory group intervention reported by older adults. *Neuropsychological Rehabilitation*, *30*(6), 1044–1058. https://doi.org/10.1080/09602011.2018.1544570

McDade, E. M., & Petersen, R. C. (2019). Mild cognitive impairment: Epidemiology, pathology, and clinical assessment. In P. T.W. (Ed.), UpToDate. UpToDate Inc. https://www.uptodate.com

Ossher, L., Flegal, K. E., & Lustig, C. (2013). Everyday memory errors in older adults. *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition*, *20*(2), 220–242. https://doi.org/10.1080/13825585.2012.690365

Parikh, P. K., Troyer, A. K., Maione, A. M., & Murphy, K. J. (2016). The impact of memory change on daily life in normal aging and mild cognitive impairment. *The Gerontologist*, *56*(5), 877–885. https://doi.org/10.1093/geront/gnv030

Patterson, C. (2018). World Alzheimer Report 2018: The state of the art of dementia research: New frontiers. https://www.alz.co.uk/research/WorldAlzheimerReport2018.pdf

Petersen, R. C., Lopez, O., Armstrong, M. J., Getchius, T. S. D., Ganguli, M., Gloss, D., Gronseth, G. S., Marson, D., Pringsheim, T., Day, G. S., Sager, M., Stevens, J., & Rae-Grant, A. (2018). Practice guideline update summary: Mild cognitive impairment: Report of the guideline development, dissemination, and implementation subcommittee of the American Academy of Neurology. *Neurology*, *90*(3), 126–135. https://doi.org/10.1212/WNL.0000000000004826

Requena, C., Turrero, A., & Ortiz, T. (2016). Six-year training improves everyday memory in healthy older people. Randomized controlled trial. *Frontiers in Aging Neuroscience*, *8*, 135. https://doi.org/10.3389/fnagi.2016.00135

Rothman, A. J. (2000). Toward a theory-based analysis of behavioral maintenance. *Health Psychology*, *19*(1S), 64–69. https://doi.org/10.1037/0278-6133.19.Suppl1.64

Rothman, A. J., Baldwin, A. S., Hertel, A. W., & Fuglestad, P. T. (2011). Self-regulation and behavior change. In K. D. Vohs, & R. F. Baumeister (Eds.), *Handbook of self-regulation* (2nd ed., pp. 106–122). Guilford.

Schwarzer, R., & Jerusalem, M. (1995). Generalized self-efficacy scale. In J. Weinman, S. Wright, & M. Johnston (Eds.), *Measures in health psychology: A user's portfolio. Causal and control beliefs* (pp. 35–37). NFER-NELSON.

Troyer, A. K. (2001). Improving memory knowledge, satisfaction, and functioning via an education and intervention program for older adults. *Aging, Neuropsychology, and Cognition*, *8* (4), 256–268. https://doi.org/10.1076/anec.8.4.256.5642

Troyer, A. K., Murphy, K. J., Anderson, N. D., Moscovitch, M., & Craik, F. I. M. (2008). Changing everyday memory behaviour in amnestic mild cognitive impairment: A randomised controlled trial. *Neuropsychological Rehabilitation*, *18*(1), 65–88. https://doi.org/10.1080/09602010701409684

Troyer, A. K., & Rich, J. B. (2002). Psychometric properties of a new metamemory questionnaire for older adults. *The Journals Of Gerontology. Series B, Psychological Sciences And Social Sciences*, *57*(1), 19–27. https://doi.org/10.1093/geronb/57.1.P19

Troyer, A. K., & Vandermorris, S. (2012). *Memory and aging Program: Leader's manual*. Baycrest Centre for Geriatric Care.

Troyer, A. K., & Vandermorris, S. (2017). *Memory and aging Program: Clinical guide*. Baycrest Centre for Geriatric Care.

Van Buuren, S. (2007). Multiple imputation of discrete and continuous data by fully conditional specification. *Statistical Methods in Medical Research*, *16*(3), 219–242. https://doi.org/10.1177/0962280206074463

van Halteren-van Tilborg, I. A., Scherder, E. J., & Hulstijn, W. (2007). Motor-skill learning in Alzheimer's disease: A review with an eye to the clinical practice. *Neuropsychology Review*, *17*(3), 203–212. https://doi.org/10.1007/s11065-007-9030-1

Verhaeghen, P., Marcoen, A., & Goossens, L. (1992). Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging*, *7*(2), 242–251. https://doi.org/10.1037/0882-7974.7.2.242

Vohs, K. D., & Baumeister, R. F. (2011). *Handbook of self-regulation research, theory, and applications* (2nd ed.). Guilford Press.

Walker, S. N., Sechrist, K. R., & Pender, N. J. (1987). The health-promoting lifestyle profile: Development and psychometric characteristics. *Nursing Research*, *36*(2), 76–81. https://doi.org/10.1097/00006199-198703000-00002

Ware, J. E., & Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. *Medical Care*, *30*(6), 473–483. https://doi.org/10.1097/00005650-199206000-00002

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063

Weakley, A., Weakley, A. T., & Schmitter-Edgecombe, M. (2019). Compensatory strategy use improves real-world functional performance in community dwelling older adults. *Neuropsychology*, *33*(8), 1121–1135. https://doi.org/10.1037/neu0000591

Wiegand, M. A., Troyer, A. K., Gojmerac, C., & Murphy, K. J. (2013). Facilitating change in health-related behaviors and intentions: A randomized controlled trial of a multidimensional memory program for older adults. *Aging & Mental Health*, *17*(7), 806–815. https://doi.org/10.1080/13607863.2013.789000