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One of the defining differences between mild cognitive impairment (MCI) and dementia is the degree of independence in everyday activities. Effecting memory-related behavioural change in MCI could help maintain daily function and prolong the time before onset of dependency. However, it is well known that changing previously well-established behaviours is difficult to achieve. We conducted a randomised controlled trial to evaluate the effectiveness of a multidisciplinary group-based intervention programme in changing everyday memory behaviour in individuals with amnestic MCI. The intervention provided evidenced-based memory training and lifestyle education to optimise memory behaviour. Fifty-four participants were randomly assigned to treatment or waitlist-control conditions. Consistent with our primary goal, treatment participants showed an increase in memory-strategy knowledge and use from pre-test to immediate post-test, and these gains were maintained at three-month

post-test relative to waitlist controls. There were no group differences in memory beliefs or on laboratory tests of objective memory performance. The increase in memory-strategy knowledge and use was associated with the degree of participation in the programme. Individuals with MCI, therefore, can acquire and maintain knowledge about memory strategies and, importantly, can change their everyday memory behaviour by putting this knowledge into practice. This incorporation of practical memory strategies into daily routines could potentially provide the means for maintaining functional independence by individuals with MCI, an issue to be addressed in future research.

INTRODUCTION

Mild cognitive impairment (MCI) is characterised by cognitive decline in the context of normal daily functioning (Petersen, 2004). MCI can be diagnosed following a decline in any cognitive domain, although most research has focused on the amnestic subtype (aMCI), which involves isolated memory decline. The presence of MCI constitutes a high risk factor for dementia, as the majority of individuals with MCI develop dementia within 3–6 years (Fisk & Rockwood, 2005; Petersen, 2004).

One of the primary differences between MCI and dementia is the individual's ability to perform his or her usual daily activities. By definition, MCI is associated with independence in functional activities, although there may be minor inconveniences associated with the memory or other cognitive impairment (Petersen, 2004). Dementia, on the other hand, is diagnosed only when cognitive deficits are sufficient to cause impaired social or occupational functioning (American Psychiatric Association, 1994).

Given this defining difference between MCI and dementia, it is conceivable that interventions aimed at helping individuals with MCI maintain their independence in daily functioning could prolong the period before which they are diagnosed with dementia. For those with aMCI, maintenance of functional independence could be promoted by teaching and implementing the use of practical memory strategies aimed at everyday activities, such as getting to appointments, taking medications properly, and remembering what needs to be done during the day.

Often overlooked in intervention programmes and research is whether the strategies that are learned are actually used by participants in their daily lives. Obviously, such behavioural change is critical in order for the training to have any practical consequence. Unfortunately, effecting behavioural change is complex and often difficult to achieve. Simply teaching individuals how to engage in new behaviours does not always result in actual behavioural change, and this is true even for behaviours for which a failure to change would have serious consequences. For example, large-scale studies of

behavioural interventions in high-risk populations frequently show that only a small proportion of individuals change relevant health-related behaviours, such as improving diet and exercise habits in individuals at risk of developing diabetes (Tuomilehto et al., 2001), engaging in regular self-screening in women with a family history of breast cancer (Bloom, Stewart, Chang, & You, 2006), and smoking cessation during pregnancy (e.g., de Vries, Bakker, Mullen, & van Breukelen, 2006; Tappin et al., 2005). Regarding memory behaviours, previous research (e.g., Scogin & Bienias, 1988; Troyer, 2001; Verhaeghen & Marcoen, 1996) indicates that many individuals who learn new memory strategies do not use them outside of the training situation. Current research and theory show that behavioural change is more likely to be achieved when the individual has acquired a positive analysis of the costs and benefits associated with the behaviour, is able to form and articulate the intended behavioural change, has positive experiences with the new behaviour, and is satisfied with the outcome of the behaviour (e.g., Rothman, Baldwin, & Hertel, 2004).

In addition to these factors important for achieving behavioural change, individuals with memory problems may require extra help with the actual learning of new memory behaviours. A previously published study examining the usefulness of a 6-week memory intervention programme in aMCI (Rapp, Brenes, & Marsh, 2002) found that self-reported use of memory strategies did not increase among participants relative to controls. This lack of demonstrated behavioural change could have been related to reduced ecological validity of some memory strategies or a failure to train participants how to apply appropriate strategies to specific memory problems. Other interventions with this population did not measure behavioural change (Belleville et al., 2006).

There are several theory-based memory strategies, including both external aids and internal strategies, that have been shown to be effective in a variety of memory-impaired populations. In general, the use of external aids such as calendars, timers, and dated pill boxes are the most effective means of accomplishing everyday prospective memory tasks such as getting to appointments and remembering to take medications on time (West, 1995). Internal memory strategies are appropriate when acquisition of new information is desired. Although not as directly related to functional independence, learning new information such as a name or telephone number is often convenient and can be important for social interactions. Several internal memory techniques require minimal cognitive effort and are applicable to everyday memory tasks. For example, spaced retrieval, which involves recalling information multiple times at increasingly longer intervals (Landauer & Bjork, 1978), has been shown to be an effective memory strategy in a number of memory-impaired populations (Davis, Massman, & Doody, 2001; McKitrick, Camp, & Black, 1992; Schacter, Rich, & Stamp, 1985; Sohlberg, White, Evans, & Mateer, 1992). Semantic orienting, which encourages the

processing of information in a meaningful way (Butters, Soety, & Becker, 1997), is based on the theory of levels of processing (Craik & Tulving, 1975), and has been shown to be an effective method for learning a variety of information, including face-name associations (Troyer, Häfliger, Cadieux, & Craik, 2006). Forming implementation intentions (Gollwitzer, 1999) involves having individuals visualise and state out loud their intention to perform a particular task such as turning off the stove or locking the door at night; this simple technique has been shown to increase the likelihood that intentions are later accomplished (Chasteen, Park, & Schwartz, 2001).

In order to intervene effectively in the aMCI population, the first step will be to apply knowledge from the behaviour-change literature in order to determine whether memory-related behaviour change can be achieved in this population. To do this, we developed and evaluated a 10-session multi-disciplinary intervention programme for aMCI. Our intervention provided extensive practice and application of memory strategies, was designed to ensure that participants had successful experiences using the strategies, and focused on ecologically valid practical memory problems (e.g., remembering names, appointments, and locations of household objects; Best, Hamlett, & Davis, 1992; Leirer, Morrow, Sheikh, & Pariante, 1990). The primary goal of our intervention was to enable behavioural change by helping individuals learn, implement, and maintain memory strategies applicable to everyday situations. Accordingly, we measured knowledge of memory strategies and use of strategies immediately following the intervention and again several months later. Although not central to our purpose of achieving behavioural change, as a consequence of acquiring new memory behaviours, we anticipated changes in memory beliefs and actual memory ability. Consequently, we also administered measures of these variables.

METHODS

Participants

Sixty-eight individuals with aMCI were recruited from physician referrals and from newspaper advertisements. Clinical evaluation and consensus were used to classify individuals with aMCI according to criteria establish by Petersen (2004). These criteria include the presence of a new memory complaint, objective evidence of memory impairment, normal general cognitive functioning, no substantial interference with normal activities, and no dementia. Presence of a new memory complaint and absence of substantial interference with normal activities were determined by interview with the individual and, whenever possible, a family member. Evidence of an objective memory impairment was obtained by cognitive testing with the Hopkins

Verbal Learning Test (HVLT; Brandt & Benedict, 2001), Wechsler Memory Scale–Revised Verbal Paired Associates (Wechsler, 1987), Brief Visuospatial Memory Test (BVMT; Benedict, 1997), and Rey-Osterreith Complex Figure Recall (Spreen & Strauss, 1998). As recommended by Petersen (2004), memory impairment was considered present when an individual obtained memory scores judged to be lower than expected based on age, education, and intellectual function. As seen in the first columns of Table 1, as a group, mean memory scores were approximately 1–1.5 standard deviations below age norms (i.e., scaled scores of 5–7), and this is lower than expected based on above-average verbal intelligence estimates (i.e., Vocabulary scaled scores of 13). Normal general cognitive functioning was confirmed with the Mini-Mental State Examination (MMSE: Folstein, Folstein, & McHugh, 1975) and the Dementia Rating Scale–II (Jurica, Leitten, & Mattis, 2001), on which participants were required to score in the normal range for their age and education. For descriptive purposes, we also tested naming to confrontation (i.e., Boston Naming Test: Kaplan, Goodglass, & Weintraub, 1983), attention and working memory

TABLE 1
Demographic and descriptive cognitive and mood variables for eligible individuals

	Eligible (n = 68)		Intervention (n = 24)		Control (n = 24)		
	Mean	SD	Mean	SD	Mean	SD	d
Age	75.4	6.8	76.0	5.6	74.8	7.7	0.18
Education years	14.5	3.3	15.2	3.3	14.3	3.1	0.28
Sex (males:females)	32:36		11:13		11:13		
MMSE score	27.7	1.7	27.2	1.9	28.5	1.0	−0.90*
Dementia Rating Scale score	134.5	5.4	133.6	5.4	135.2	5.8	−0.29
HVLT immediate recall SS	6.7	2.4	7.0	2.3	6.9	2.7	0.04
HVLT delayed recall SS	5.3	3.3	5.1	3.2	6.1	3.7	−0.29
BVMT immediate recall SS	5.1	2.6	4.3	1.3	6.0	3.4	−0.72*
BVMT delayed recall SS	5.8	3.0	4.7	2.3	7.1	3.5	−0.83*
Vocabulary SS	13.1	2.9	12.8	3.0	13.2	3.1	−0.13
Boston Naming SS	10.1	3.0	9.8	3.1	9.7	2.8	0.03
Digit Span total SS	11.7	3.1	10.8	3.1	12.9	3.4	−0.65*
Rey-Osterreith Figure copy SS	8.1	2.4	8.5	2.1	7.9	2.3	0.27
Trail Making: Switching SS	10.7	2.5	10.4	3.1	10.7	2.4	−0.11
HADS total score	9.1	5.9	10.3	5.4	8.1	6.3	0.38

SS = age-corrected scaled score; MMSE = Mini-Mental State Examination; HVLT = Hopkins Verbal Learning Test; BVMT = Brief Visuospatial Memory Test; HADS = Hospital Anxiety and Depression Scale; d = effect size for difference between intervention and control groups. *significant group difference, $p < .05$

(i.e., Digit Span: Wechsler, 1997), visual construction (i.e., Rey-Osterreith Complex Figure Copy), and alternation of attention (Trail Making Test Number-Letter Switching: Delis, Kaplan, & Kramer, 2001). As seen in Table 1, group performance was within the average range on these tests (i.e., scaled scores of 8–12). The final criterion of "no dementia" was determined by taking into consideration all of the previous criteria and hinged on the criterion of no significant impairment in daily functioning (Petersen, 2004). In addition, a careful review of each participant's background information, current medical conditions, self-reported mood (including assessment with the Hospital Anxiety and Depression Scale; Snaith & Zigmond, 1994), and the cognitive assessment were used to ascertain that no medical or psychiatric condition (other than possible incipient AD) accounted for the memory impairment.

Study design

Two pilot intervention programmes were conducted. The first involved a group of four individuals with aMCI and their families and resulted in several modifications to the intervention based on feedback from the participants and the experience of the leaders. A second pilot intervention tested the revised procedure with five additional individuals and their families. All sessions of this second pilot were audiotaped and transcribed in order to produce a handbook for the leader to use during subsequent programmes. No further modifications were made after the second pilot intervention or at any other time over the two years in which the clinical trial was conducted.

A randomised waitlist-control group design was used. After recruitment into the study, each participant was randomised by coin toss to treatment or waitlist. We continually recruited participants over a two-year period, and conducted the intervention on five occasions, as soon as we had five or six participants in each group.

Each individual participated in three outcome testing sessions. For the treatment groups, testing was done during intervention sessions (see Table 2): (1) pre-testing occurred during the first session, immediately before the intervention began; (2) immediate post-testing occurred on the last session of the main intervention; and (3) longer-term post-testing occurred three months later, at the beginning of the final session, before any further review. Testing for the waitlist groups was conducted at the same time points as for the treatment groups. Participants in each waitlist-control group were provided the opportunity to participate in the intervention immediately after completing their final testing session.

TABLE 2
Intervention schedule

Session	Week	Content of hour 1	Content of hour 2	At-home assignment
1	1	*Testing*: Pre-test	*Information:* MCI, what it is, how it relates to normal aging and dementia	
2	2	*Information*: Overview of memory strategies	*Intervention:* Memory for future events, memory book rationale	Creating a memory book
3	3	*Information:* Relaxation and stress management	*Intervention:* Memory for future events, memory book practice	Relaxation exercise and using the memory book
4	4	*Information:* Relaxation follow-up	*Intervention:* Memory for names, spaced retrieval	Memory for names using spaced retrieval
5	5	*Information:* Nutrition	*Intervention:* Memory for numbers and names, spaced retrieval and semantic processing	Memory for numbers and names using semantic processing
6	6	*Information:* Community resources	*Intervention:* Memory for actions, implementation intentions, consistent logical locations	Memory for actions
7	7	*Information:* Recreation	*Intervention:* Strategy review and selection of appropriate strategies	Selecting strategies
8	9	*Review:* Strategy use and appropriate selection	*Testing*: Immediate post-test	
9	13	*Review:* Strategy use and appropriate selection	*Review:* Lifestyle information	
10	25	*Testing*: Long-term post-test	*Review:* Strategy use and appropriate selection	

Intervention

The intervention consisted of 10 2-hour sessions presented over 6 months, as outlined in Table 2. Sessions were conducted in groups and consisted of: (1) presentation of information regarding a lifestyle factor (e.g., nutrition) that can affect memory function, (2) focused memory intervention training, (3) review of information or intervention, and/or (4) outcome testing. All memory interventions were provided by a registered psychologist (KM);

presentations of lifestyle information were provided by KM or another health professional, as indicated subsequently. Participants were given weekly assignments to complete at home. To assess compliance, they were asked to document when they completed each exercise and to hand in assignment sheets the following week. Any participants completing fewer than half of the exercises from the first assignment were telephoned during subsequent weeks to provide a reminder and assistance with the assignment.

   Lifestyle information.   The first hour of each session typically consisted of an information lecture, focused on a lifestyle factor that can affect memory ability (see Table 2). The presentation style facilitated group discussion by encouraging participants to ask questions and make comments. These sessions were multidisciplinary and were led by a psychologist, dietician, or social worker.

   Session 1 included an introductory lecture and group discussion on the topic of MCI, how it differs from normal aging and dementia, and the associated risk of Alzheimer's disease.

   Session 2 provided an overview of the memory strategies covered in the programme and the types of everyday memory situations to which these strategies could be successfully applied. The importance of routine use of the memory strategies in daily life was emphasised.

   Sessions 3 and 4 focused on relaxation and stress management and was presented by a registered clinical psychologist. Information was provided about definitions and causes of stress, the impact of stress on memory (e.g., Lupien et al., 1998), and the importance of relaxation for managing stress. Participants discussed their own experiences of stress and relaxation. A deep-breathing relaxation technique (Lichstein, 1988) was taught and practised.

   Session 5 was presented by a registered dietician experienced in the dietary needs of older adults. Dietary recommendations were provided (Health Canada, 2004), and the relation between diet and memory was discussed (e.g., Greenwood & Winocur, 1999; Kaplan, Greenwood, Winocur, & Wolever, 2000, 2001).

   Session 6 was presented by a geriatric social worker. Information was provided about community resources, recreational and educational programmes, legal issues, transportation services, housing, counselling for emotional issues, and support services for medical and personal care.

   Session 7 focused on the importance of recreation. Information was provided about the role of physical and mental activities in maintaining memory ability (Hultsch, Hertzog, Small, & Dixon, 1999; Kramer et al., 1999) and decreasing the risk of dementia (e.g., Crowe, Andel, Pedersen, Johansson, & Gatz, 2003; Laurin, Verreault, Lindsay, MacPherson, & Rockwood, 2001).

No lifestyle information was presented during sessions 8 or 10 in order to allow for post-testing. Session 9 provided an overview of the information regarding MCI and lifestyle factors affecting memory.

Memory intervention.   Each of Sessions 2–6 focused on an everyday memory problem. In each session, relevant memory strategies were introduced, and participants discussed and practised the strategies. To support the learning process in these memory-impaired individuals, strategies from previous sessions were reviewed in later sessions. In order to increase the likelihood of achieving behavioural change, consistent with current theory (e.g., Rothman et al., 2004), each intervention session included: (1) discussion of the minimal costs (e.g., time commitment) and the potential benefits (i.e., improved ability to complete memory tasks) of using memory strategies; (2) guided instruction to assist individuals in forming and articulating the expected behavioural changes; and (3) gradual progression from simple to more difficult memory tasks during the training sessions and in the at-home assignments to ensure that participants' experiences with the strategies were positive and successful.

The first intervention sessions focused on *memory for future events*, with an emphasis on developing and using a portable "memory book" consisting of a calendar, list of things to do, frequently used telephone numbers, a blank "scratch pad", and a record of any other important information that is used frequently. In Session 2, the rationale and content of the memory book were discussed, with an emphasis on increasing participants' current use of the memory aid. In Session 3, participants practised using their memory books in specific exercises in which the facilitator presented future events or information to be remembered and participants generated ways of using their memory books to assist in remembering that information. Discussion focused on how this can be successfully integrated into daily life.

Session 4 targeted *memory for names*, with an emphasis on spaced retrieval. The rationale, benefits, and procedures for spaced retrieval were presented. Specific exercises included presenting names and providing cues to repeat the name after spaced intervals (i.e., immediately and again after 5, 10, 20, 40, 60, 90, 120, 150, and 180 seconds; based on Davis et al., 2001). Overt cuing was gradually reduced, and exercises continued until most participants were able to recall the name after the final 3-minute delay and were able to report that they understood the procedures.

Session 5 focused on *remembering numbers* such as telephone numbers or personal identity numbers (PIN). Spaced retrieval was reviewed and applied to the task of learning new numbers, as in the previous session. Training using semantic association strategies followed, first for numbers and then for names. Semantic orienting, verbal elaboration, and creating personal associations (Butters et al., 1997) were explained. Then, participants were given

names and numbers and were asked to provide semantic associations. This continued until participants were able to generate several associations fluently.

The focus of Session 6 was *memory for actions*, such as remembering where things were placed, whether something was done (e.g., the stove was turned off), and what one was about to do (e.g., why one came into a room). One memory strategy was to establish logical locations for items and to use them consistently. Participants were asked to share examples of frequently-used items that have been misplaced (e.g., keys, reading glasses, umbrella), and the group generated meaningful locations to put those items (e.g., night stand, hall closet). Another strategy focused on increasing attention. A technique involving visualising and verbally mediating actions was devised based on the idea of implementation intentions (Gollwitzer, 1999) and was applied to remembering completed actions and intended actions. Participants were requested to perform simple tasks in class (e.g., stand up and stretch at 10.30 a.m.) and were guided to visualise carrying out the task and to state out loud their intention. Cueing was gradually decreased on subsequent exercises. These exercises continued until participants were able to describe accurately how to apply the strategy to various everyday scenarios and were able to remember to do the specified tasks within the session.

Session 7 involved *review and application* of the strategies taught in the programme. Sample scenarios of everyday memory tasks were presented to allow participants to practise selecting appropriate strategies. The facilitator encouraged participants to generate multiple strategies based on the intervention sessions and added to participants' answers when necessary to ensure that multiple possibilities were considered. Additional review of strategy use and selection was provided in follow-up sessions 8, 9, and 10.

Outcome measures

Outcome testing was conducted during the programme sessions. Testing consisted of pre-testing during Session 1, immediate post-testing during Session 8, and longer-term post-testing during Session 10 (see Table 2).

Memory-strategy knowledge and behaviour.   To measure knowledge of memory strategies, we used a previously developed questionnaire (Memory Toolbox; Troyer, 2001). Six memory situations requiring the application of a memory strategy (e.g., learning a new name, remembering to attend appointments, remembering locations of items) were listed on paper. Participants wrote down strategies that would be useful for each situation. Responses were scored according to the number and quality of strategies listed. Two points were awarded for each strategy that was effective, specific to the situation, and required self-reliance (e.g., visualise the name, write

down an appointment in a memory book); one point was awarded for each strategy that was less effective, nonspecific, or involved reliance on others (e.g., pay attention, ask someone else); no points were awarded for responses that were not memory strategies (e.g., look up a telephone number in the telephone book). To determine inter-rater reliability for scoring this test in this population, a subset of 20 questionnaires was scored by two individuals. These scores were very highly correlated, $r(20) = .97$, indicating good inter-rater reliability.

As measures of the use of memory strategies, we examined self-reported strategy use both during memory testing and at home. Immediately following each memory task administered during outcome testing, we asked participants to write down all of the memory strategies they used on that task. Responses were scored similar to the strategy knowledge measure, with 2 points for each effective strategy and 1 point for each less effective strategy listed. Scores were summed over all memory tests administered during that testing session. To measure at-home strategy use, we administered the Strategy subscale of the Multifactorial Metamemory Questionnaire (MMQ; Troyer & Rich, 2002) to assess self-reported use of 19 different memory aids and strategies (i.e., writing on a calendar, repeating information, creating a rhyme). Participants indicated the frequency with which each strategy was used over the past two weeks on a 5-point scale, and possible scores ranged from 0 to 76.

Memory-related affect and thoughts.   The MMQ Contentment subscale was used to assess participants' satisfaction with their memory ability, with 18 items assessing memory-related emotions (e.g., confidence, concern, embarrassment, irritation) and perceptions of one's own memory (e.g., comparison to peers, presence of a serious memory problem). The MMQ Ability subscale was used to assess self-reported everyday memory functioning. Twenty different everyday memory mistakes (e.g., forgetting to run an errand, not being able to recall a name) were rated based on the frequency with which they occurred. The Impact Rating Scale (modified from the Illness Intrusiveness Scale, Devins et al., 1983) was used to measure illness-induced disruptions to lifestyle and activities that negatively impinge on quality of life. Participants ranked the degree to which their memory problems interfere with each of 13 different aspects of their life (e.g., recreation, relationships, community involvement). We developed a questionnaire (Lifestyle Importance) to measure participants' thoughts about the relationship between lifestyle factors (i.e., stress/relaxation, nutrition, physical activity, and participation in cognitively-stimulating activities) and memory. Twelve statements regarding the effects of these factors on memory and participants' intentions to change these behaviours were rated.

Objective memory ability.   We created memory tests to be administered in groups by projecting stimuli onto a screen and requiring written responses. We made three versions of each task, and these were counterbalanced for use during pre-testing and immediate and longer-term post-testing.

To measure face-name learning, participants were shown a 3-by-2 array of six faces, each paired with a first and last name, for six minutes. Approximately 30 seconds after presentation, each face was presented individually in random order, and participants were instructed to write down the corresponding name. One point was awarded for each first and last name.

To measure number learning, random digits were arranged into a 7-digit telephone number, a 4-digit PIN number, and a 6-digit locker combination. At presentation, each item was preceded by a label (i.e., telephone number, PIN number, locker combination), and all three items with their labels were presented simultaneously for four minutes. Approximately 30 seconds after presentation, participants were given a response sheet with the label of each item and a series of underlined spaces for each digit in the sequence. One point was given for each correct digit produced in the correct order.

To measure wordlist learning, 10 two-syllable nouns (from Thorndike and Lorge, 1944) were presented individually and simultaneously read aloud for 2 seconds each. Approximately 30 seconds after presentation, participants were asked to write down as many words as they could remember, in any order.

Statistical analyses

To determine treatment outcome, three repeated-measures multivariate analyses of variance (MANOVAs) were conducted (for each of the three groups of outcome tests, including strategy, affect/thoughts, and objective memory) at each outcome interval (i.e., pre-test vs. immediate post-test and pre-test vs. 3-month post-test). For each MANOVA, there was one between-group variable (group membership: intervention and control), one within-group variable (time of testing: pre-test and post-test), and three or four measures (individual outcome tests). For all analyses, we looked at interactions between group and time of testing; for those with significant multivariate effects, we examined univariate tests of group differences on individual measures.

Ancillary analyses were conducted to determine individual characteristics that were associated with the degree of benefit received from the programme. Three regression analyses were conducted with demographic/mood variables, cognitive variables, and participation variables as predictors of outcome. We had no a priori hypotheses about the directionality of the first two groups of variables; we expected participation to be a positive predictor of outcome. The number needed to treat (NNT) was calculated as a measure of clinical efficacy (Cook & Sackett, 1995).

RESULTS

Participant characteristics

The flow of participants through the clinical trial is shown in Figure 1. Individuals were considered eligible for the clinical trial if they completed our clinical evaluation and met criteria for aMCI. Of 68 eligible individuals, nine participated in pilot programmes and thus were not included in the evaluation, and 14 did not participate in the entire evaluation because they declined or withdrew ($n = 13$) or died ($n = 1$) before the 3-month follow-up testing. All individuals who withdrew did so at their own request and reported as
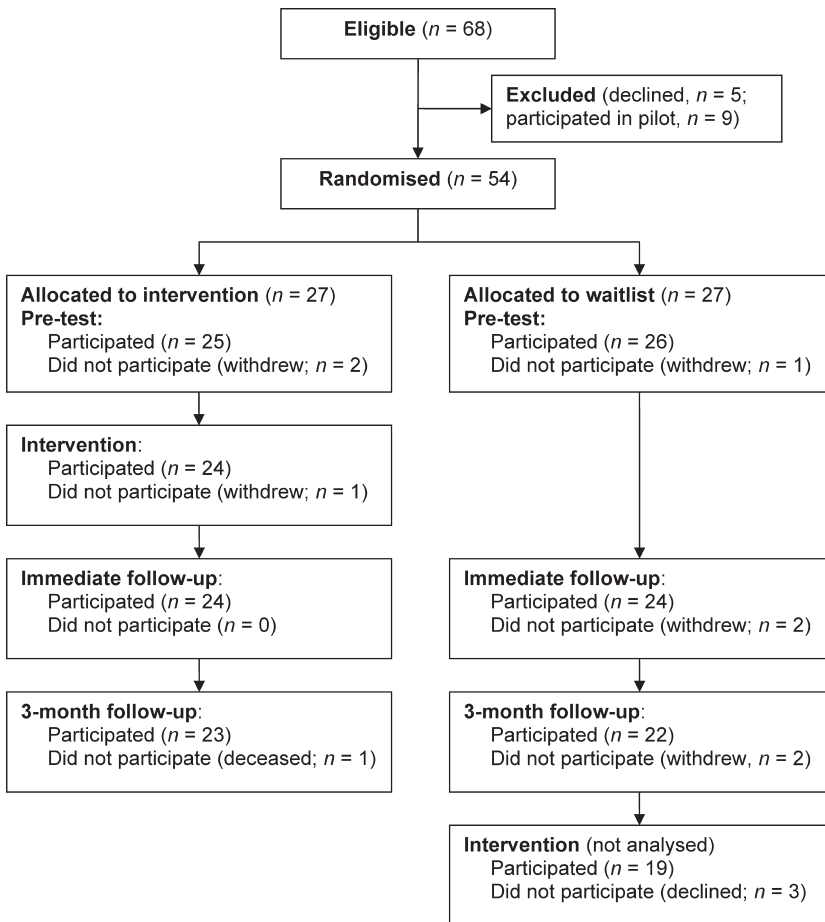
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                        ┌──────────────────────────┐
                        │  Eligible (n = 68)        │
                        └──────────────────────────┘
                                    │
                                    │      ┌──────────────────────────────────┐
                                    ├─────→│ Excluded (declined, n = 5;        │
                                    │      │ participated in pilot, n = 9)      │
                                    │      └──────────────────────────────────┘
                        ┌──────────────────────────┐
                        │  Randomised (n = 54)      │
                        └──────────────────────────┘
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┌───┐   ┌───┐
│ **Allocated to intervention** ($n = 27$)   │   │ **Allocated to waitlist** ($n = 27$)   │
│ **Pre-test:**   │   │ **Pre-test:**   │
│   Participated ($n = 25$)   │   │   Participated ($n = 26$)   │
│   Did not participate (withdrew; $n = 2$) │ │   Did not participate (withdrew; $n = 1$) │
└───┘   └───┘

┌───┐
│ **Intervention:**   │
│   Participated ($n = 24$)   │
│   Did not participate (withdrew; $n = 1$) │
└───┘

┌───┐   ┌───┐
│ **Immediate follow-up:**   │   │ **Immediate follow-up:**   │
│   Participated ($n = 24$)   │   │   Participated ($n = 24$)   │
│   Did not participate ($n = 0$)   │   │   Did not participate (withdrew; $n = 2$) │
└───┘   └───┘

┌───┐   ┌───┐
│ **3-month follow-up:**   │   │ **3-month follow-up:**   │
│   Participated ($n = 23$)   │   │   Participated ($n = 22$)   │
│   Did not participate (deceased; $n = 1$) │ │   Did not participate (withdrew, $n = 2$) │
└───┘   └───┘

                                                    ┌───┐
                                                    │ **Intervention** (not analysed)   │
                                                    │   Participated ($n = 19$)   │
                                                    │   Did not participate (declined; $n = 3$) │
                                                    └───┘

Figure 1. Flow diagram of the progress of aMCI participants through the randomised clinical trial.

reasons a lack of interest in the programme and/or testing ($n = 7$) or inconvenience (i.e., too far to travel or time conflict; $n = 6$).

Participants versus drop-outs.   To determine the representativeness of the participant sample, we compared the demographic, cognitive, and mood variables of the individuals who participated in the entire clinical trial (excluding pilots, $n = 45$) versus those who dropped out at any time before the 3-month follow-up testing ($n = 14$). There were no group differences in sex, $\chi^2(1, \ N = 59) = 0.56$, $p = .76$, or in age, years of education, memory scores (HVLT and BVMT immediate and delayed memory), any non-memory cognitive tests (described in Methods section), or HADS mood scores, all $ts < 1.6$, $ps > .13$. All effect sizes were small or negligible, with the exception of a moderate effect size, $d = 0.51$, for the HADS total score, which was lower in the drop-out group ($M = 6.7$) than in the participant group ($M = 9.8$), indicating somewhat better mood in those who dropped out.

Intervention versus waitlist control participants.   Forty-eight individuals completed the immediate post-test and were thus included in the immediate outcome analyses; 45 individuals completed the 3-month post-test and were thus included in the longer-term outcome analyses. We compared differences in demographic and descriptive cognitive and mood variables between the intervention and waitlist participants for those who completed immediate post-test, as shown in Table 1. Despite random assignment, there were significant group differences favouring the control group on the MMSE, $t(42) = 2.85$, $p = .007$, Digit Span total score, $t(45) = 2.23$, $p = .031$, and BVMT immediate and delayed recall, $t(39) = 2.14$, $p = .038$, $t(39) = 2.62$, $p = .013$. There were no group differences in sex, $\chi^2(1, \ N = 48) = 0$, $p = 1.0$, or any other demographic, descriptive cognitive, or mood variable, all $ts < 1.2$, $ps > .20$. Importantly, as seen in Table 3, there were no significant group differences on any of the baseline outcome measures, all $ts < 1.4$, all $ps > .17$.

Outcome

An analysis by intention to treat was not conducted because false inclusions (i.e., participants determined after randomisation not to meet aMCI criteria) were low (i.e., $n = 2$) and were equally distributed across the groups, and because individuals who dropped out of the intervention were also lost to follow-up. Under these conditions, analysis by intention to treat is generally not recommended (Hollis & Campbell, 1999).

To simplify visual presentation of the data in the figures, we calculated change scores for all measures. Means and standard deviations obtained by the entire group at pre-testing were used to calculate z-scores at pre-test,

TABLE 3
Baseline test scores for individuals completing pre-testing and immediate post-testing

	Intervention (n = 24)		Control (n = 24)		
	Mean	SD	Mean	SD	d
Strategy Toolbox (knowledge; (0+)	11.3	3.0	12.3	3.2	−0.32
Strategy use on memory tasks (0+)	3.7	2.1	4.5	2.1	−0.38
MMQ-Strategy (use at home; 0−76)	34.4	8.2	32.0	8.9	0.28
MMQ-Contentment (0−72)	32.6	13.7	31.9	10.6	0.06
MMQ-Ability (0−80)	47.5	11.0	46.1	10.0	0.13
Impact Rating Scale (0−91)	64.9	9.9	62.5	13.7	0.20
Lifestyle importance (0−48)	34.9	6.4	32.0	6.2	0.46
Name recall (0−12)	5.4	3.4	6.7	3.8	−0.36
Number recall (0−17)	10.4	4.0	11.9	3.9	−0.40
Wordlist recall (0−10)	3.0	1.4	3.4	1.6	−0.27

MMQ = Multifactorial Metamemory Questionnaire. For all measures, higher scores represent better performance. Possible score ranges are shown in parentheses following each measure. There were no significant group differences at baseline on any outcome measure

immediate post-test, and 3-month post-test. Change scores were calculated as the difference between the pre-test and post-test z-scores. These change scores were used in the figures and in the ancillary analyses of benefit derived from the programme. All other statistical analyses were conducted on raw scores.

Strategy knowledge and use.   Analysis of immediate outcome (i.e., pre-test vs. immediate post-test) across the three measures of memory-strategy knowledge and use indicated a significant multivariate group-by-time interaction, $F(3, 43) = 6.97$, $p = .001$, $\eta_p^2 = 0.33$. As seen in the left panel of Figure 2, there was greater improvement over time in the intervention than the control group. Examination of individual measures indicated similar group-by-time interactions on all three measures, including strategy knowledge as measured by the toolbox questionnaire, $F(1, 45) = 14.27$, $MSE = 178.93$, $p < .001$, $\eta_p^2 = 0.24$, strategy use at home as measured by MMQ-Strategy, $F(1, 45) = 5.74$, $MSE = 168.62$, $p = .021$, $\eta_p^2 = 0.11$, and strategy use on objective memory testing, $F(1, 45) = 4.08$, $MSE = 12.61$, $p = .049$, $\eta_p^2 = 0.08$.

Similar to immediate outcome testing, multivariate testing for longer-term outcome (i.e., pre-test vs. 3-month post-test) on these measures indicated a significant group-by-time interaction, $F(3, 40) = 5.18$, $p = .004$, $\eta_p^2 = 0.28$. As seen in the right panel of Figure 2, there was greater change over time in the intervention than the control group. Examination of individual
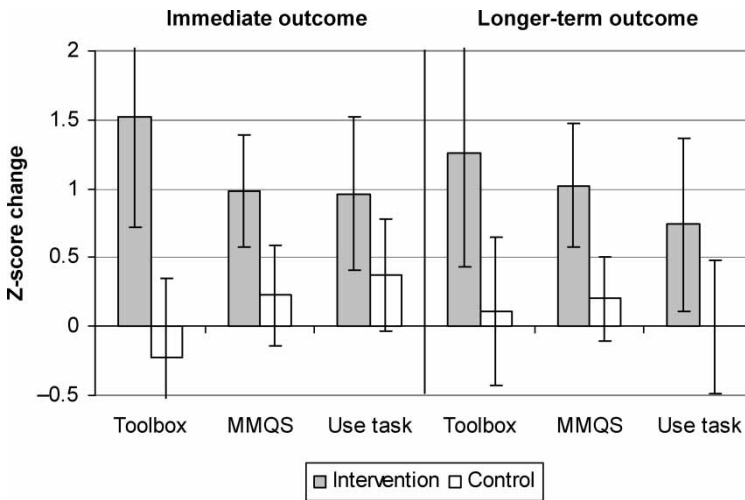
Figure 2. Change scores on measures of strategy knowledge and use. MMQS = Multifactorial Metamemory Questionnaire Strategy subscale. Error bars show the 95% confidence intervals.

measures indicated similar group-by-time interactions on strategy knowledge as measured by Toolbox, $F(1, 42) = 6.25$, $MSE = 67.38$, $p = .016$, $\eta_p^2 = 0.13$, and strategy use at home as measured by MMQ-Strategy, $F(1,42) = 9.05$, $MSE = 232.38$, $p = .004$, $\eta_p^2 = 0.18$. The group-by-time interaction on the measure of strategy use during objective memory testing was no longer statistically significant, $F(1, 42) = 3.32$, $MSE = 11.64$, $p = .076$, $\eta_p^2 = 0.07$.

Memory-related affect and thoughts. Analysis of immediate outcome (left panel of Figure 3) indicated no multivariate group-by-time interaction on these measures, $F(4, 42) = 1.48$, $p = .23$, $\eta_p^2 = 0.12$. Similarly, analysis of longer-term outcome (right panel of Figure 3) indicated no multivariate group-by-time interaction, $F(4, 39) < 1$, $p = .86$, $\eta_p^2 = 0.03$.

Objective memory ability. Analyses of immediate and longer-term outcome indicated no multivariate group-by-time interactions on the objective memory measures, $F(3, 41) < 1$, $p = .74$, $\eta_p^2 = 0.03$, and $F(3, 37) < 1$, $p = .82$, $\eta_p^2 = 0.03$, respectively (Figure 4).

Ancillary analyses

To look at individual differences in the degree to which memory-behaviour change was achieved, we examined the mean *z*-score change obtained on the three strategy knowledge/use measures at the 3-month post-test in
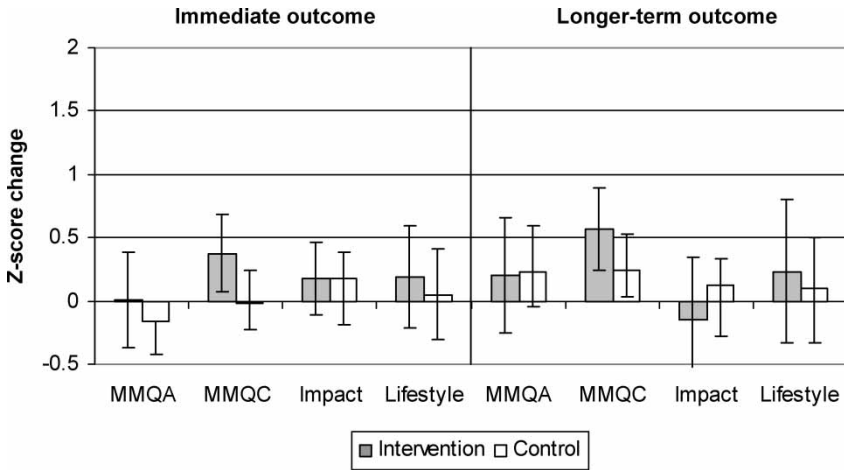
Figure 3. Change scores on measures of metamemory. MMQA = Multifactorial Metamemory Questionnaire Ability subscale; MMQC = Multifactorial Metamemory Questionnaire Contentment subscale. Error bars show the 95% confidence intervals.

comparison to pre-test. The mean benefit score was 0.99 ($SD = 0.95$) for the intervention group and 0.13 ($SD = 0.64$) for the control group, $t(42) = 3.53$, $p = .001$, $d = 1.08$.

Prior to performing regression analyses, an intercorrelation matrix of possible predictor variables was produced. To avoid problems of multicollinearity,
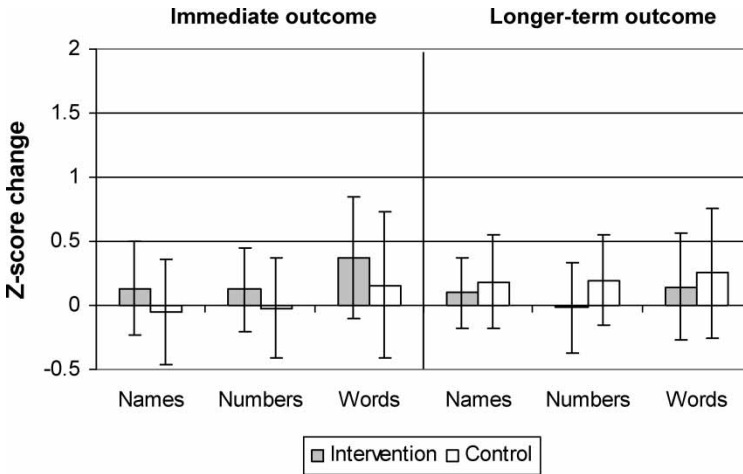
Figure 4. Change scores on objective memory measures. Error bars show the 95% confidence intervals.

variables with correlation coefficients greater than .40 were not included as predictors in the same regression equations. This resulted in the exclusion of HVLT and BVMT immediate recall scores and the combination of attendance and assignment completion measures as a single predictor (i.e., sum of proportions). Three separate multiple regression analyses were conducted. Results indicated that no demographic or mood variable was a significant predictor of behavioural change: age, $\beta = .21$; education, $\beta = .24$; sex, $\beta = .11$; or HADS total score, $\beta = -.20$; all $ts < 1.0$, all $ps > .35$. None of the following cognitive measures was a significant predictor of behavioural change: MMSE, $\beta = -.28$; Vocabulary, $\beta = .58$; HVLT delayed recall, $\beta = .13$; BVMT delayed recall, $\beta = .35$; and Trail Making Switching, $\beta = -.25$; all $ts < 1.0$, all $ps > .16$. In contrast, Digit Span was a significant predictor of behavioural change, with lower scores predicting greater change, $\beta = -.89$, $t = -2.23$, $p = .042$. An analysis of the scatterplot between these two variables indicated that the negative prediction was due to three outliers with Digit Span scores in the Superior ranges; reanalysis with individuals obtaining average scores (i.e., SS's ranging from 7 to 13) indicated that Digit Span was not a significant predictor of behavioural change, $\beta = -.19$, $t = -0.41$, $p = .695$. An examination of participation variables indicated that the combined measure of sessions attended by the participant and at-home assignments completed was a positive predictor of behavioural change, $\beta = .39$, $t = 1.86$, one-tailed $p = .039$, but the number of sessions attended by a family member was not, $\beta = -.07$, $t = -0.35$, one-tailed $p = .37$.

To provide additional information about the clinical utility of the intervention, we calculated the number needed to treat (NNT) in order to have one successful outcome in terms of behavioural change. We defined successful behavioural change as an increase of one SD or more between pre-testing and 3-month post-testing on the combined memory-strategy measures (i.e., strategy knowledge, strategy use on objective memory tasks, and strategy use at home). Using the mean z-score change across these memory-strategy measures, we found that of the 22 participants in the intervention who completed 3-month post-testing, 11 had successful outcomes and 11 did not. Of the 22 control participants who completed 3-month post-testing, 2 had successful outcomes and 20 did not. Intervention participants were more likely to show successful behavioural change than control participants, $\chi^2 (1, N = 44) = 8.84$, $p < .001$, and the NNT was 2.4. Using the same criteria for the memory affect/thought measures (i.e., satisfaction, self-rated ability, impact of memory impairment, lifestyle importance), we found that two of the intervention participants and none of the control participants had successful outcomes. Intervention participants were not more likely to have a successful outcome than control participants, $\chi^2 (1, N = 44) = 1.91$, $p = .170$. Regarding objective memory, 1 intervention participant and 2 control participants had a successful outcome, and this was not significantly different, $\chi^2 (1, N = 44) = 0.36$, $p = .546$.

DISCUSSION

The main purpose of this randomised controlled trial for individuals with amnestic mild cognitive impairment (aMCI) was to explore the efficacy of a memory intervention programme in effecting memory-related behavioural changes as measured by the acquisition and application of everyday memory strategies. Our findings show that the intervention was successful in meeting this goal. That is, in comparison to the waitlist-control group, individuals who participated in the intervention showed significantly better knowledge and use of appropriate memory strategies, both in the laboratory and in their everyday lives. The benefit of the programme was evident both immediately after the intervention and at a 3-month follow-up, indicating successful maintenance of the newly learned behaviours. As a direct measure of clinical efficacy, we determined that the number needed to treat (NNT) was 2.4, indicating that in order to have one individual benefit from the intervention by increasing his or her knowledge and use of memory strategies, we needed to treat just over two individuals.

It is well known that effecting health-related behavioural change is not an easy task, and the efficacy of our programme is particularly notable when compared to other programmes with similar goals of changing health-related behaviours in high-risk populations. For example, recent studies have shown NNTs ranging from 5 to 12 for increasing exercise and decreasing consumption of fat, sugar, and salt in individuals at high risk of developing diabetes (calculated from data provided by Tuomilehto et al., 2001), for increasing breast-cancer self-screening in women with a positive family history (calculated from Bloom et al., 2006), and for decreasing or quitting smoking during pregnancy (calculated from de Vries et al., 2006). Regarding memory behaviours, previous memory-training research has indicated that participants do not always use learned memory strategies in their everyday lives, including healthy older adults (Scogin & Bienias, 1988; Troyer, 2001; Verhaeghen & Marcoen, 1996) and individuals with aMCI (Rapp et al., 2002). Memory-behaviour change is likely more difficult for individuals with aMCI than other populations because their memory impairments make it more difficult to learn and remember new information of any kind. Presumably, our success in effecting behavioural change was related to our theory-based approach, which helped participants acquire a positive cost-benefit analysis, guided them to form and articulate the expected behaviours, and ensured positive experiences with the new behaviours.

Theoretically, a promising approach for preventing progression of aMCI to Alzheimer's dementia would be to preserve everyday functioning, given that a key distinction between these two diagnoses is the degree of functional independence. We argue that to maintain functionality, individuals with aMCI must change their memory-related everyday behaviours – to learn new

strategies and apply them appropriately in their everyday lives. For example, it is reasonable to presume that increased use of a memory book would help individuals with aMCI better manage their appointments, increased use of consistent logical locations would decrease incidences of losing important items at home, and increased reliance on written notes would result in more successful shopping trips. Indeed, even individuals with severe amnesia experience improvements in their functional independence by learning how to use external memory aids such as memory books and pagers (Wilson, Emslie, Quirk, & Evans, 2001). Therefore, the successful initiation and 3-month maintenance of memory-strategy use may provide the basis for individuals with aMCI to maintain functional independence, thereby delaying dementia. Clearly, however, the question of whether or not increased use of memory strategies results in functional gains in this group will need to be tested directly. Future research could utilise self-reported logs of daily memory slips and family reports of participants' level of independence in various daily activities.

The main goal of our intervention, and the strongest findings we obtained, centred on changes in memory-related behaviour. Our cursory examination of metamemory did not show significant change as a result of participation in the programme. In retrospect, this is not surprising. The intervention programme provided factual information that increased participants' awareness of their diagnosis of aMCI and its implication for future development of AD. One would expect this to have a negative impact on metamemory items that measure concerns about one's memory and comparisons with one's peers. A similar memory intervention programme for healthy older adults (Troyer, 2001) did result in significant improvements in metamemory, arguably because the information provided about the differences between normal memory changes and dementia reassured participants that they were *not* dealing with a progressive disease. Interestingly, qualitative feedback from participants in our programme generally centred on an improved sense of control regarding how to manage day-to-day remembering and, contrary to questionnaire data, participants reported increased confidence in their functional memory and ability to maintain these gains into the future. Another possibility, therefore, is that our questionnaires did not tap into relevant areas of metamemory that were improved as a result of the programme.

Our intervention had positive effects on knowledge and behaviour change, but no measurable effect on objective memory ability measured with laboratory tasks. It is possible that the effects of the intervention would proceed in stages: first an increase in knowledge of what to do, next behavioural change reflecting increased use of strategies, and finally the translation of the behavioural changes into actual performance change. It could be that our participants needed more time to show any effects on actual memory ability. Effecting changes in objective memory, however, was considered to be of secondary importance in our intervention because this is not crucial for

everyday function. For example, a person could have severely impaired objective memory ability, but be able to function quite independently in everyday life by systematically using a memory book and other external memory aids (Wilson, Evans, Emslie, & Malinek, 1997). As a result, many of the strategies taught in the intervention were aimed at memory compensation (i.e., using a memory book, using consistent locations), and these would have little impact on actual ability in laboratory-type memory tasks. We did not find significant changes in objective memory ability in individuals who participated in our programme on our outcome measures of face-name, number, and word-list recall. It is not possible to apply external memory aids to these tasks, and improvement would depend solely on internal strategies such as spaced retrieval and association. Internal strategies require attention-demanding, self-initiated application, whereas external strategies may mitigate some of these attentional demands. Thus, more extensive practice may be needed for participants to master internal than external strategies. Indeed, Troyer (2001) reported that a similar intervention for healthy older adults also did not improve name or word-list learning, although performance on a prospective memory task on which participants could use external memory aids (phoning the investigator at specified times) did improve. Furthermore, the lack of objective memory change may have been related to psychometric issues, namely, the face-name and number tasks showed ceiling effects in some individuals at baseline, and this scale restriction precludes the possibility of obtaining positive change scores in those individuals.

Participants who were more likely to change their behaviours as a result of participating in the programme were those who attended more sessions and completed more at-home assignments. This finding reinforces the idea that behavioural change requires continued maintenance of new behaviours. Initial analyses raised the possibility that attention ability, as measured by Digit Span, negatively predicted behavioural changes. However, close inspection indicated that this was related to outlying data; the relationship did not hold for the large majority of individuals with attention abilities that were in the average range.

Unexpectedly, despite randomisation, there were baseline group differences on several of the cognitive tests (as shown in Table 1). All of these differences were in the direction of better performance by the control group, and it is possible that differential effects of the intervention on meta-memory and objective memory performance were obscured by these differences. However, this seems unlikely given the fact that there were no baseline group differences on the outcome measures.

In conclusion, our findings demonstrate the treatment efficacy of a memory intervention programme for individuals with aMCI. The programme we developed affected the behaviour of participants by fostering the knowledge, initiation, and maintenance of appropriate memory strategy use both in the

laboratory and in everyday life. The degree to which these behavioural changes result in practical benefit to the participant was not demonstrated in this study. Future studies will focus on whether increased use of memory strategies can have an impact on everyday functional abilities and whether this in turn delays progression to diagnosis of AD.

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