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REVIEW

A review of the effectiveness of memory interventions in mild cognitive impairment (MCI)

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ABSTRACT

Background: Mild cognitive impairment (MCI) is commonly associated with memory impairment. There have been a number of studies attempting to ameliorate this through memory interventions including memory rehabilitation and training. The current paper reviews the evidence for the effectiveness of such interventions in enhancing learning of specific information, their impact on untrained material, compensation for memory impairment and improving everyday functioning.

Methods: The literature was systematically searched for studies focusing on interventions targeting memory impairment in MCI using relevant search terms. Studies were screened for inclusion or exclusion using a priori criteria and, once identified, studies were examined for quality using pre-specified criteria.

Results: A total of 226 studies were identified in the search, ten of which were included in the final review. Only one study was an RCT of "adequate" methodology. It was tentatively suggested that people with MCI can learn specific information, although there was little evidence to suggest that memory training can generalize. There was some limited evidence of ability to learn to compensate for memory difficulties and contradictory findings regarding improvement in everyday life.

Conclusions: The poor methodological quality of the included studies implies that the ability to draw conclusions is limited. MCI is a controversial concept and there is a need for good quality trials examining the efficacy of memory interventions. There are some indications that memory impairment in MCI might best be targeted by interventions developing compensatory strategies and targeting the learning of specific information relevant to the individual.

Key words: MCI, dementia, cognitive disorders, memory

Introduction

The growing emphasis on the importance of early identification of and interventions in dementia has led to attempts to define intermediate states between normal aging and dementia (Chertkow *et al.*, 2007). Mild cognitive impairment (MCI) is predominantly used to categorize this stage. To be diagnosed with MCI, an individual must not meet DSM-IV or ICD-10 criteria for a dementia syndrome, must have self- or informant report of cognitive decline, and should also show evidence of decline over time on objective cognitive tasks and preserved basic activities of daily living, with minimal impairment in complex instrumental functions (Petersen, 2004). Definition of objective impairment is not consistently agreed upon but it has been defined as being one to one-and-a-half standard deviations below the mean (Petersen *et al.*, 2001; Petersen, 2004). Subgroups of MCI have also been described: "amnestic type", where memory alone is affected; "amnestic multiple type", where memory and other cognitive functions are affected; and "non-amnestic type", where cognitive functions other than memory are affected (Petersen *et al.*, 2001; Lopez, *et al.*, 2002). These ambiguities in definition are perhaps also why it is difficult to arrive at a clear estimate of prevalence and incidence of MCI. Indeed, in individuals aged 75 years and over, Busse *et al.* (2003) found that prevalence rates ranged from 3% to 20%, depending on the definition applied.

However MCI is defined, there is a high conversion rate to dementia in people with MCI

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(Grundman *et al.*, 1996). In dementia, there have been a number of studies examining the efficacy of interventions directly targeting cognition such as cognitive training or rehabilitation (e.g. Farinal *et al.*, 2002). Cognitive training involves guided practice on a set of standard cognitive tasks, designed to reflect specific cognitive functions (such as memory), with the aim that practice will restore the underlying impaired function. Cognitive rehabilitation is a collaborative approach that involves developing individualized goals and devising strategies for addressing these. The emphasis is not on improving performance on cognitive tasks *per se*, but on enhancing functioning in an everyday context. For people with dementia, there is limited evidence for the effectiveness of both approaches (Clare *et al.*, 2003). Consequently, there has been a shift towards studying the impact of such interventions in MCI (Cipriani *et al.*, 2006; Talassi *et al.*, 2007). Given the primacy of memory in most cases of MCI (Lopez *et al.*, 2002), most intervention studies have concentrated exclusively or largely on amelioration of memory difficulties (e.g. Rapp *et al.*, 2002; Belleville *et al.*, 2006; Troyer *et al.*, 2008) and this work is the focus of the current review.

No previous review has focused exclusively on the effects of interventions targeting memory in MCI. Three previous reviews have touched on questions of effectiveness of interventions aimed at general cognition in MCI (Massoud *et al.*, 2007; Belleville, 2008; Jean *et al.*, 2010). A non-systematic review of the effects of cognitive training in MCI (Belleville, 2008) concluded that there was some evidence for the approach in reducing impairment, but that better quality studies needed to be done. However, this review had methodological weaknesses including no detail of inclusion/exclusion criteria and no criteria for evaluation of study quality, meaning that poorly designed and executed studies received the same weight as better designed studies. A systematic review which included cognitive interventions for MCI (Massoud *et al.*, 2007) found that the evidence was insufficient to conclude that organized cognitive intervention was beneficial. However, the review included both pharmacological and non-pharmacological interventions and there were methodological weaknesses. For example, studies that did not distinguish between mild dementia and MCI (e.g. Olazaran *et al.*, 2004) and those which used the category of "cognitive impairment no dementia" rather than MCI (Tuokko and Frerichs, 2000), were included.

Pertinent to this review is a recent review of cognitive interventions in MCI (Jean *et al.*, 2010). This study found improvement in just under half of the included studies in objective measures of memory and subjective measures of memory/mood and quality of life. This current review builds upon the work of Jean and colleagues in two main ways. First, whilst addressing many methodological issues, the review by Jean *et al.* did not include a systematic method for evaluating study quality and did not exclude studies on methodological grounds. In our review, single case studies were excluded and studies were systematically rated for quality. In addition, Jean *et al.* included studies that evaluated more general cognitive stimulation approaches (e.g. Spector *et al.*, 2003). These often stimulate memory more implicitly and have other, more generalized aims (such as improving quality of life). Interventions that are not directly and specifically aimed at improving memory were excluded in this review.

Given the difference in focus of these reviews and their methodological weaknesses, this review aimed to examine the current evidence-base for memory-based interventions for people with MCI. The review focuses only on interventions that are designed to target memory problems, and/or associated activities of daily living. The research questions address the following in people with MCI:

(1) Can memory interventions help people to learn specific information?
(2) Can memory interventions have an impact on objective untrained measures of memory (can they generalize)?
(3) Can memory interventions help compensate for memory impairment?
(4) Can memory interventions improve functioning in everyday life?

Methods

The methodology of Pettigrew and Gilbody (2002) for conducting a systematic review was used as a framework. As the literature concerning the efficacy of memory interventions with MCI is sparse, the inclusion criteria were broad.

Inclusion criteria

- All participants met specific, published MCI criteria (e.g. Petersen *et al.*, 2004).
- Interventions were described as cognitive / memory training, cognitive / memory rehabilitation or memory interventions.
- Interventions were designed to reduce memory impairment or develop compensatory strategies.
- Designs included were RCTs, controlled trials and uncontrolled pre-post studies.
- Articles were published in the English language.

Exclusion criteria

- The sample included participants with dementia.
- MCI sample not distinguished from other ways of defining intermediate cognitive states, such as 'cognitive impairment no dementia'
- Interventions involved a more generalized "cognitive stimulation" type approach.

Search strategy

The Cochrane database, Medline and Psychinfo were searched in September 2009. The search terms used were ("mild cognitive impairment and cognitive rehabilitation") or ("mild cognitive impairment and memory rehabilitation") or ("mild cognitive impairment and memory training") or ("mild cognitive impairment and cognitive training"). As a second step, potential papers, reports and book chapters were identified from reference lists and a Google search on "Mild cognitive impairment memory cognitive training rehabilitation" was conducted. Finally, titles/abstracts or excerpts were read from all identified studies to ensure they met the inclusion criteria.

Papers which fit the inclusion criteria were examined for quality using criteria appropriate to the study design. For RCTs, the Jadad *et al.* (1996) scale was used. Using this methodology, RCTs were scored according to performance in three domains, randomization, blinding and withdrawals and dropouts. The minimum score was 0 and the maximum score 5. Jadad *et al.* (1996) found that 99% of poor quality studies score 2 points or less and 71% score more than 2 (Jadad *et al.*, 1996). Therefore a study was designated as good/excellent if it scored above 3, adequate if it scored 3, poor to adequate if it scored 2 and poor if it was below 2.

For other study designs, the York Centre for Systematic Reviews (2001) criteria were used to define a study as poor, adequate or good. This is a list of criteria that non-RCT type studies (e.g. controlled, non-randomized trials and pre-post designs) should meet. The criteria are as follows: (1) Was there adequate description of participants? (2) Was there adequate description of an intervention and who received it? (3) Is measurement likely to be reliable and valid? (4) Are the measures used the most relevant ones for answering the research question? (5) What was the dropout rate and has this introduced bias? (6) Is the length of time long enough to identify changes in the outcome of interest? (7) In studies where two groups are compared, are the groups similar? Were they treated similarly? And if not were there attempts to control for those differences (matching or statistical control)? (8) Was outcome assessment blind to exposure status? In the current review, if a study met all of the criteria it was rated as "good". If it met half or more it was rated as "adequate", and if it met fewer than half it was rated as "poor".

Results

The search identified 226 studies, of which ten were included in the review. The remaining 216 studies were excluded because (a) on reading the abstract/excerpts they were unrelated to the topic for review, (b) they related to MCI but were not intervention studies, (c) they included people with dementia in the MCI sample, (d) they were case studies, or (e) they used categories other than MCI to define the sample, such as "cognitive impairment no dementia". Of the ten included studies, six were rated as "adequate", three as "poor" and one as "poor- adequate". All ten studies are described in Table 1.

Results were organized according to the focus of change in an intervention, as specified in the review questions above (i.e. learning specific information, generalization to untrained measures,, compensation for memory impairment, effect on everyday life). Where different aspects of a study were pertinent to two or more questions, the different aspects of the study are recorded under the appropriate questions.

(1) Can memory interventions help people learn specific information?

Two studies (Akhtar *et al.*, 2006; Hampstead *et al.*, 2008) looked at the ability of people with MCI to learn specific new information and the conditions under which this was best achieved. These studies did not examine generalization to other non-trained measures and were thus not looking at reducing impairment.

There is adequate evidence that people with MCI can learn new verbal information (Akhtar *et al.*, 2006) and faces (Hampstead *et al.*, 2008), despite showing poorer learning than controls. This learning is aided by using errorless learning (Akhtar *et al.*, 2006) and mnemonics such as visual imagery and nicknames (Hampstead *et al.*, 2008). This learning effect may last up to one month (Hampstead *et al.*, 2008). These findings suggest that implicit learning strategies such as errorless learning can aid recall of specific information. This is perhaps unsurprising as people with dementia can also learn new pieces of information using these techniques (Clare *et al.*, 2000). The results of the study by Hampstead *et al.* (2008) suggest that, unlike in studies with an Alzheimer's disease sample, the use of compensatory mnemonic strategies can also be used to aid learning of specific information.

Table 1. Details of the ten included studies

AUTHORS (YEAR)	DESIGN	INTERVENTION	FREQUENCY/ DURATION	POPULATION	OUTCOME MEASURES DISCUSSED IN REVIEW	RESULTS	STUDY QUALITY
Troyer *et al.* (2008).	Single blind RCT with 3-month follow-up	Group intervention: memory training combined with information regarding lifestyle factors	Ten 2-hour sessions over 6 months	54 MCI (Petersen *et al.*, 2001 criteria): 27 = intervention 27 = wait list controls	Memory toolbox (Troyer, 2001); Multifactorial Memory Questionnaire (MMQ) (Troyer and Rich, 2002); measures of "objective memory" (face/name association and list learning) designed specifically for study	Change in memory toolbox (memory strategy use) (p = 0.001) for intervention versus controls, maintained at follow-up. No change in MMQ (p = 0.23 or in objective memory learning (p = 0.74).	Adequate (Jadad score)
Rapp *et al.* (2002).	Single blind RCT, 6 month follow-up	Group intervention: education and training about memory skills	Six 2-hour weekly meetings	19 MCI (Petersen *et al.*, 2001 criteria): 10 = intervention 9 = wait list controls	List learning and face name association (Scogin *et al.*, 1998); Story recall (Wechsler, 1987); Memory Functioning Questionnaire (Zelinski *et al.*, 1990); memory controllability inventory (Lachman *et al.*, 1995)	For intervention vs control MFQ improved (p = 0.0008), maintained at follow-up. Memory controllability inventory improved (p = 0.005), not maintained at follow-up. Trend towards list learning improving (p = 0.06). No significant effects on other relevant outcomes.	Poor – adequate (Jadad score)

Table 1. Continued

AUTHORS (YEAR)	DESIGN	INTERVENTION	FREQUENCY/ DURATION	POPULATION	OUTCOME MEASURES DISCUSSED IN REVIEW	RESULTS	STUDY QUALITY
Rozzini *et al.* (2007)	Single blind RCT.	Individual intervention: computer training on tasks of memory, attention, language and other cognitive functions	Three blocks of sessions spaced by 2 months. Each block = 1-hour sessions, 5 days a week for 4 weeks.	59 MCI (Petersen *et al.*, 2001) criteria: 15 = intervention and medication 22 = medication alone 22 = no treatment	Short story recall (Novelli *et al.*, 1986); Rey Osterrieth Complex figure test (ROCFT) recall (Osterreith, 1944); Geriatric Depression Scale (GDS) (Sheikh andYesavage, 1986); Basic Activities of Daily Living (BADL) (Lawton and Brody, 1969)	The intervention group improved in short story recall ($p = 0.01$) and GDS ($p = 0.02$). The medication-only group improved in GDS ($p = 0.05$). No significant effects on other relevant outcomes.	Poor (Jadad score)
Belleville *et al.* (2006)	Non randomized pre-post controlled study	Group intervention: training on episodic memory enhancement techniques/ attentional training	Eight weekly 2-hour sessions.	25 MCI (Petersen *et al.*, 2001): 17 = intervention 8 = controls Also 19 healthy older adults: 11 – intervention 8 – controls	Name to face associations designed for the study; list learning (Belleville *et al.*, 1992); story recall (Gély-Nargeot *et al.*, 1997); well-being (Bravo *et al.*, 1996); Questionnaire d'autoévaluation de la mémoire (QAM) (van der Linden *et al.*, 1989)	Improvements in MCI intervention group on name to face associations ($p = 0.004$) and for delayed list learning ($p = 0.0001$). Improvement in well-being ($p = 0.05$) and one subscale of the QAM ($p = 0.04$). The MCI control group did not show these improvements. No significant effects on other relevant outcomes.	Adequate (York criteria)

Talassi *et al.* (2007)	Non-randomized pre-post controlled study	Individual intervention – computer training (same as Rozzini *et al.*, 2007) combined with occupational therapy (OT) and physical rehabilitation. Active control group received only OT and physical rehabilitation.	Four 45-minute sessions a week for 3 weeks	37 MCI: 30 = intervention 7 = controls Also 30 mild dementia: 24 = intervention 6 = controls.	ROCFT; Short story recall (Novelli *et al.*, 1986); GDS; BADL	MCI group improved on ROCFT recall ($p = 0.033$) and GDS ($p = 0.012$). Mild dementia group improved in GDS ($p = 0.03$). No significant effects on other relevant outcomes at $p = 0.05$ level.	Poor (York criteria)
Greenaway *et al.* (2008)	Pre-post uncontrolled study, 8-week follow-up	Individual intervention – training in use of memory support system (MSS) – use of calendar, journal etc.	12 1-hour sessions	24 MCI (Petersen criteria) and their carers.	Record of Independent Living (Weintraub, 1986); compliance with MSS (measure developed for study); Everyday cognition scale (Farias *et al.*, 2006) (9 participants)	Participants significantly more compliant with MSS after intervention ($p < 0.0001$) and at follow-up ($p < 0.001$). No significant effects on other relevant outcomes.	Adequate (York criteria)
Londos *et al.* (2008)	Pre-post uncontrolled study, 6 month follow-up	Group intervention – Cognitive rehabilitation program connected to specific goals	Eight sessions, 2.5 hours, twice a week	15 MCI (Petersen criteria)	ROCFT; Quality of life-Alzheimer's disease scale (QoL-AD, (Logsdon *et al.*, 1999); Canadian Occupational Performance Measure (COPM) (Wressle *et al.*, 1999)	COPM performance improved after intervention ($p = 0.003$) maintained at follow-up ($p = 0.0002$). Satisfaction with performance improved after intervention ($p = 0.0002$) maintained at follow-up ($p = 0.001$). QoL-AD improved after intervention (0.037) and at follow-up (0.04). No significant effects on other relevant outcomes.	Adequate (York criteria)

Table 1. Continued

AUTHORS (YEAR)	DESIGN	INTERVENTION	FREQUENCY/ DURATION	POPULATION	OUTCOME MEASURES DISCUSSED IN REVIEW	RESULTS	STUDY QUALITY
Cipriani *et al.* (2006)	Pre-post uncontrolled study	Individual intervention: computerized training of cognitive functions (same as Rozzini *et al.*, 2008)	Two 4-week training blocks with four sessions a week for 30 minutes	10 MCI, 10 mild dementia, 3 multiple system atrophy	Rivermead Behavioral Memory Test (RBMT) (Wilson *et al.*, 1985); GDS	MCI group improved on RBMT post intervention ($p = 0.017$). No significant effects on other relevant outcomes.	Poor (York criteria)
Akhtar *et al.* (2006)	Within-subjects experimental design	Individual intervention: practiced learning lists of words using errorful or errorless learning techniques	One session lasting 40–60 minutes	16 MCI (Petersen criteria). 16 healthy older adults.	Cued and free word list recall (adapted from Rubin and Friendly, 1986); awareness of memory problems assessed by Judgment of Learning task (JOL) (adapted from Mazzoni and Nelson, 1995)	MCI and healthy older adults recall more using errorless learning than errorful learning ($p < 0.05$). MCI have lower JOLs than healthy older adults ($p < 0.05$) (suggesting awareness of problems) and judge learning to be better in errorless learning ($p < 0.001$).	Adequate (York criteria)
Hampstead *et al.* (2008)	Within-subjects experimental design	Individual intervention: face name associations trained using mnemonics on one set of faces and compared to performance on untrained set of faces.	Three training sessions over 2 weeks	8 MCI (Petersen criteria)	Measure designed for the study: recognition memory for face name associations.	Significantly better recognition memory performance on the trained than the untrained list ($p < 0.001$).	Adequate (York criteria)

Key for general terms
RCT = randomized controlled trial; MCI = mild cognitive impairment; MMQ = Multifactorial Memory Questionnaire; MFQ = Memory Functioning Questionnaire; ROCFT = Rey Osterrieth Complex Figure Test; GDS = Geriatric Depression Scale; BADL = basic activities of dialing living; QAM = Questionnaire d'autoévaluation de la mémoire; OT = occupational therapy; MSS = memory support system; QoL-AD = Quality of life – Alzheimer's disease scale; COPD = Canadian Occupational Performance Measure; RBMT = Rivermead Behavioral Memory Test; JOL = Judgment of Learning.
Key for study quality
For RCTs: Jadad score 3/5 = adequate; Jadad score 2/5 = poor–adequate; Jadad score 1/5 = poor (Jaded *et al.*, 1996).
For other study types: Four or more of the York Centre criteria met = adequate; fewer than four of the York Centre criteria met = poor.

The study by Akhtar *et al.* (2006) also suggested that people with MCI were both aware of their impairment and of the positive effects of errorless learning. This may be important in rehabilitation. As Clare *et al.* (2000) pointed out in their work with mild dementia, a key component of effective rehabilitation is awareness of difficulty and motivation to change, and knowledge of the effectiveness of an intervention may be an important component of this. Such findings suggest that it may be clinically useful to work individually with people using mnemonics and errorless learning strategies to learn specific pieces of information relevant to them, for example the names of people at a day center they attend.

(2) Can memory interventions have an impact on objective untrained measures of memory (can they generalize)?

Three studies examined performance on neuropsychological tests before and after computerized general cognitive (not memory specific) training. Two were case control studies (Cipriani *et al*, 2006; Talassi *et al*, 2007) and a third was an RCT (Rozzini *et al.*, 2007). All studies used similar computerized general cognitive training packages (although Rozzini *et al.* combined it with anticholinesterase inhibitors) and showed improvement on at least one of their measures of memory in the group who received this intervention. Such improvements in memory were not found in MCI groups who did not receive the intervention or in groups with dementia who did receive the intervention.

Previous meta-analyses with Alzheimer's patients (Sitzer *et al.*, 2006) have shown a greater impact on learning (acquisition of information) versus memory (recall of previously learned information over a delay). In the current study, a consistent pattern was not noted with most studies not clearly separating these processes. Where memory, as opposed to learning, was examined (e.g. delayed recall); it should be noted that one study (Rozzini *et al.*, 2008) found no improvement and another (Talassi *et al.*, 2007) found improvements.

Although this may appear to provide reasonable evidence for computerized training in improving memory in people with MCI, all studies were rated as being of poor methodological quality. In general, drop-outs were not discussed, raters were not blinded, practice effects were not taken into account, and in the case of the two case control studies, participants were not well defined. There is evidence that in healthy older adults, cognitive training is useful (Verhaeghen *et al.*, 1992) and all studies reviewed here showed effects on at least one measure of memory impairment in MCI following cognitive training. However, it is not possible to conclude that there is any good evidence for computerized cognitive training in improving memory in MCI, as the methodological problems in these studies particularly bias them towards detecting a difference when none exists (type-1 error). Thus the implication for rehabilitation is that, until further research is done using good quality RCTs, there is no reason to recommend these interventions in clinical practice.

The computerized interventions all focused on general cognitive training and looked at effects on memory. Three other studies took a slightly different approach and looked at the impact of memory focused group interventions for people with MCI. Troyer *et al.* (2008) and Rapp *et al.*, (2002) were both reasonably conducted RCTs and Bellville *et al.*, (2006) was a case control study.

Rapp *et al.* (2002) reported no changes in objective memory in an MCI group which participated in a group-based memory training intervention, in relation to a waiting list control group, after the intervention or at six-month follow-up, although there was a self-perceived improvement in memory. While this study was an RCT rated "poor to adequate", the small sample size and consequent low power made it vulnerable to type-2 error. However, the study's findings were replicated in an RCT by Troyer *et al.* (2008), rated as "adequate". They found no difference in memory immediately or at three-month follow-up, following a 12-session group focused on memory strategy learning when compared to a waitlist control group.

It is important to note that despite randomization, the groups in the study by Troyer *et al.* (2008) were not matched at baseline. One possible reason for the lack of significant findings may be that the control group had significantly higher Mini-mental State Examination scores (Folstein *et al.*, 1975) at baseline.

In contrast to the results above, Belleville *et al.* (2006) reported medium to large effect sizes for improvement in memory in an MCI group following group-based memory training when compared to a control group. One of the measures that improved (name/face associations) was a learning (acquisition) measure and another of these (delayed list learning) a memory measure. Thus, unlike in the meta-analysis performed by Sitzer *et al.* (2006), there was not clear evidence of a differential effect on acquisition as opposed to memory. In any case, whilst this study had some strengths methodologically – for example, the authors corrected for type-1 error when using multiple outcome measures – it was a case control study (and it was not clear how well matched the control and intervention groups were). As Rapp *et al.* (2002) and Troyer *et al.* (2008) were adequate RCTs, greater weight should be given to these null results, suggesting little effect of group intervention on memory impairment.

(3) Can memory interventions help compensate for memory impairment?

A distinction can be drawn between internal compensatory strategies, such as mnemonics; and external compensatory strategies, such as diaries and memory aids (Sitzer *et al.* 2006). Troyer *et al.* (2008) taught both these types of strategy. Although they found no objective memory change, their intervention group did report greater change in the use of appropriate strategies, such as mnemonics and external aids, than controls. This occurred across three settings: at home, in response to scenarios requiring strategy usage and when strategy use was reported by participants after objective testing. The improvement in strategy usage was maintained at follow up. Rapp *et al.* (2002), taught solely internal compensatory strategies and reported the opposite result: strategy usage did not improve in the intervention group. This was unlikely to be due to low power, as controls actually reported more strategy use.

Greenaway *et al.* (2008) report on a cohort study evaluating an individualized program teaching the use of a memory management system (essentially a diary and calendar) to people with amnestic MCI and their carers. Compliance with the system improved post training and this improvement was maintained at eight-week follow-up. This study lacked a control group, and intervention providers themselves rated the performance of the clients in learning, which might have biased their ratings. Results of the study by Hampstead *et al.* (2008) provide evidence that internal strategies (mnemonics) can also aid memory for specific information.

The findings of Troyer *et al.* (2008) suggest that people with MCI could learn strategies which, in theory, could help them to compensate for their memory difficulties. However, the lack of change in objective memory performance or self-reported memory performance at home, despite increased reported strategy use in both these settings, perhaps indicates that participants could not use these strategies to improve actual memory performance. Further research into the linkages between strategy development and everyday performance would be useful. The finding of Rapp *et al.* (2002) that strategy use was not aided by training was probably not due to a lack of power, but perhaps to a difference between their intervention and that of Troyer and colleagues. Rapp *et al.* (2002) did not focus as explicitly on strategy use in everyday situations and had six sessions as opposed to 12. This suggests that, while interventions to develop compensatory strategies may be clinically useful, they may need to be of sufficient duration. Although lacking a control group, the finding of Greenaway *et al.*(2008) that people with MCI could learn to use a memory management system adds to the evidence base for teaching compensatory strategies in MCI. Of note, they were the only authors to have an observer-rated measure, which may be more valid than relying on self report in cognitively impaired individuals (e.g. Clare *et al.*, 2000).

(4) Can memory interventions improve functioning in everyday life?

Londos *et al.* (2008) report on a cohort study of a group of 15 amnestic MCI patients. They enrolled in an intervention involving training on strategies for managing memory in everyday life and showed increases in self-reported performance and satisfaction with performance of everyday activities. The changes were maintained at six-month follow-up. The participants were well described, as was the intervention, and drop-outs were also discussed. The study lacked a control group, and the fact that the Canadian Occupational Performance Measure is a self-report measure is a limitation as people with cognitive impairments are often not reliable informants. Scores on self-reported measures of cognition in such populations may be more closely related to mood than cognitive function (Bolla *et al.*, 1991), and mood did improve post intervention in this study.

Three other studies examined the self-reported impact of interventions on everyday activities and found few effects. Belleville *et al.* (2006) reported a significant difference in one subscale of a measure of impact. However, other subscales did not change and the results were not corrected for multiple comparisons. Rapp *et al.* (2002) found no improvement in the impact of memory difficulties on everyday life. Troyer *et al.* (2008) reported no difference between groups in self-reported impact of memory on everyday life.

Evidence suggests that although people with cognitive difficulties may report on their own functioning, such reports may not be related to their actual functioning (e.g. Klepstad, 2000). In contrast, carer reports of functioning may be correlated with actual functioning (e.g. Ready *et al.*, 2002). Three studies included informant-reported measures. Rozzini *et al.* (2007) and Talassi *et al.* (2007) used the Basic Activities of Daily Living Scale (Lawton and Brody, 1969) and no change was reported, which was unsurprising as it is designed to assess gross changes in function which are not expected to be affected in people with MCI. Greenaway *et al.* (2008) found no change in carer report of everyday functioning on a similar measure, the record of independent living (Weintraub, 1986). They note, however, that when the E-Cog (Farias *et al.*, 2006), a more sensitive measure designed specifically for MCI, was administered to ten participants, there was, "a trend towards significant improvement".

Discussion

Summary of findings

Ten studies were included in this review. They provide some evidence that memory interventions can help people learn new information, using strategies such as errorless learning. This may have important clinical implications, with the possibility of interventions being designed around learning specific valued pieces of information as has already been done in dementia (Clare *et al.*, 2000). The finding that mnemonic strategies can also aid learning (Hampstead *et al.*, 2008) has not been demonstrated in dementia samples. There was less evidence that computerized memory training or group interventions can generalize to reduce the level of impairment as measured by performance on pre-post tests of memory. This is perhaps unsurprising given the lack of evidence for computerized memory training in other populations, such as mild dementia (Clare *et al.*, 2003), and the fact that there is little generalization from computerized cognitive training to untrained tasks in "cognitively normal" individuals (Owen *et al.* 2010). All results should be interpreted with caution, as only one study was an RCT of "adequate" methodological quality (Jadad *et al.*, 1996), and all the remaining studies were of poorer quality.

There is some evidence that it can be helpful to teach internal and external memory strategies to people with MCI. The one study that contradicted this (Rapp *et al.*, 2002) had a short time frame and taught several different strategies. The more successful interventions were either longer (Troyer *et al.*, 2008), focused on learning a single strategy (Greenaway *et al.* 2009) or the learning of very specific information with strategies directly related to that information (Hampstead *et al.*, 2008).

There is, however, controversy about whether interventions aimed at compensatory strategies or enhanced learning of new information can affect performance in everyday life. This perhaps is because, by definition, cognitive difficulties in MCI have little impact on everyday function in the first place. However, other authors suggest that measurement of more subtle disturbances indicates that complex activities of daily living are affected in MCI (Farias *et al.*, 2006) and memory interventions may impact on these more complex skills (Greenaway *et al.*, 2008).

Limitations

There was heterogeneity in terms of target population, method of delivery, length of treatment and level of impact, suggesting many possible reasons for results to differ across studies as well as the actual content of the interventions. The main limitation, however, was the poor methodological quality of included studies, limiting the degree to which results can be interpreted and generalized. There are definitional problems with the term MCI, for example a lack of agreement on what constitutes "objective memory impairment" (Chertkow *et al.*, 2007).The consequent heterogeneity within the concept of MCI implies that samples may have been dissimilar to each other and that this, rather than differences in intervention, may account for varying results between studies. The concept of MCI is perhaps best viewed as capturing a heterogeneous group which may include some people in a dementia prodrome state and others who are not (Chertkow *et al.*, 2007). Perhaps due to these conceptual controversies, there does not appear to be a clear theoretical framework for explaining the mechanisms of cognitive decline in MCI.

A further limitation is the use, in many cases, of a "treatment as usual/wait list control group". This means that it is often difficult to separate out the aspect of the intervention that is effective. There is often a lack of consensus about the appropriate control group to use in these types of studies. Finally, although many of the included studies did not base their interventions on a theoretical understanding of the breakdown of memory function in MCI, some of the studies reviewed here (e.g. Hampstead *et al.*, 2008) have tried to address this and on the basis of such work we have tried above to make clinical and research suggestions.

Future research

A useful avenue in developing future interventions might be the combination of mnemonic strategies and implicit learning procedures, such as errorless learning and spaced retrieval, to enable patients to learn valued pieces of information (e.g. names of people in a day centre). The poor quality of studies examining computerized interventions suggests that further quality studies in this area may be useful. Given that in Alzheimer's disease there is relatively more impact on acquisition processes than overall memory processes (Sitzer *et al.*, 2006), future research may use measures of both acquisition and overall memory to assess for differential effects. The use of memory enhancement strategies (e.g errorless learning/spaced retrieval) to learn compensatory strategies (e.g. a diary system) could be examined in future research, which could also examine the ability to utilize these compensatory techniques in everyday life using either behavioral observation or standardized carer report measures. Finally, all future research should employ sound methodology, including long-term follow-up (to establish the maintenance of any benefits) and the more selective use of outcome measures, reducing the chance of type-1 error.

Conclusions

Whilst this review points to potentially promising results in the use of memory interventions for people with MCI, there is no quality, consistent evidence to support any one intervention and further research using more rigorous methodology is urgently required. Clinical interventions should involve strategies which are specific to the patient's context and situation, and should be taught intensively for a reasonable period of time. It may be that learning compensatory strategies may be best achieved using implicit memory enhancement techniques such as errorless learning. While the focus of this review was on memory, mood improved in all the studies where it was measured (Belleville *et al.*, 2006; Rozzini *et al.*, 2007; Talassi *et al.*, 2007; Londos *et al.*, 2008). This suggests the possibility of secondary benefits, possibly through giving people some sense of self-efficacy and control in their lives. Hence, even in the absence of an effective evidence-base, there may be clinical justification for doing such work. The relatively short time-frame of interventions required for a significant improvement is promising for workers in busy clinical settings.

Conflict of interest

None

Description of authors' roles

Joshua Stott designed the study, collected the data, analyzed the results and wrote the first draft of the paper. Aimee Spector commented on and revised several further drafts of the paper.

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