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TABLE OF CONTENTS

[Intervention Review]

Cognitive rehabilitation for memory deficits following stroke

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ABSTRACT

Background

Memory problems are a common cognitive complaint following stroke. Memory rehabilitation programmes either attempt to retrain lost or poor memory functions, or teach patients strategies to cope with them.

Objectives

To determine the effectiveness of cognitive rehabilitation for memory problems following stroke.

Search methods

We searched the Cochrane Stroke Group Trials Register (last searched September 2006). In addition, we searched the following electronic databases; the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* Issue 2, 2005), MEDLINE (1966 to June 2005), EMBASE (1980 to June 2005), CINAHL (1982 to June 2005), PsycINFO (1980 to July 2006), AMED (1985 to June 2005), British Nursing Index (1985 to June 2005), CAB Abstracts (1973 to May 2005) and the National Research Register (June 2006). We handsearched relevant journals and searched reference lists.

Selection criteria

We selected controlled trials of memory retraining in stroke. We excluded studies with mixed aetiology groups unless 75% or more of the participants had a stroke or separate data were available for the stroke patients.

Data collection and analysis

Two review authors selected trials for inclusion, assessed quality, and extracted data.

Main results

Two trials, involving 18 participants, were included. One study compared the effectiveness of a mnemonic strategy treatment group with a 'drill and practice' control, while the other compared the effectiveness of an imagery mnemonics programme with a 'pragmatic' memory rehabilitation control programme. Formal meta-analyses could not be performed due to a paucity of studies and lack of commonly-employed outcome measures. The results do not show any significant effect of memory rehabilitation on performance of objective memory tests, and no significant effects of treatment on subjective and observer-rated measures of memory.

Authors' conclusions

There was no evidence to support or refute the effectiveness of memory rehabilitation on functional outcomes, and objective, subjective, and observer-rated memory measures. There is a need for more robust, well-designed and better-reported trials of memory rehabilitation using common standardised outcome measures.

PLAIN LANGUAGE SUMMARY

Cognitive rehabilitation for memory deficits following stroke

It is uncertain whether cognitive rehabilitation can improve memory problems after stroke. Memory problems are a common complaint for people who have had a stroke. Neuropsychological rehabilitation, and cognitive rehabilitation in particular, may play a role in the recovery of memory functions, or in the individual's potential to adapt to the deficits. Memory rehabilitation can address both these aspects and is a standard part of rehabilitation in many settings. This review of two trials involving 18 participants found that there was little evidence to support the effectiveness of cognitive rehabilitation for memory problems after stroke and more research in this area is needed.

BACKGROUND

Memory deficits are a common complaint following brain damage caused by head injuries (Capruso 1992), strokes (Tatemichi 1994), epilepsy (Giovagnoli 1999), multiple sclerosis (Thornton 1997) and other neurological conditions. Cognitive deficits are commonly observed in approximately one-third of patients who have had a stroke, of which memory problems are the most commonly reported (Doornhein 1998). These memory deficits may affect the patients' ability to recall past events (retrospective memory) and to carry out future intentions (prospective memory) (Van den Broek 2000). These cognitive impairments have been shown to have a negative effect on the patient's functional and social independence (Shimoda 1998), and response to participation in treatment programmes and rehabilitation (Tatemichi 1994).

Cognitive rehabilitation is a "systematic, functionally oriented service of therapeutic activities that is based on assessment and understanding of the patient's brain-behavioural deficits" (Cicerone 2005). Memory rehabilitation is a component of this generic cognitive rehabilitation. Such rehabilitation facilitates the development of behavioural and cognitive strategies which have as their goal a positive impact on the structural and functional recovery of the damaged brain, and improve the quality of life of the individual in general (Robertson 2001).

Traditionally, memory rehabilitation has focussed on teaching patients the use of internal aids (such as mnemonics, rehearsal and mental imagery) and external memory aids (such as the use of diaries, notice boards and lists) to help them remember and recall information. In addition to these, errorless learning (Evans 2000) has become a standard procedure for training in most memory rehabilitation programmes. Technological advances have facilitated the use of pagers (Wilson 2001), mobile phones (Wade 2001), palmtops (Kim 2000), voice organisers (Van den Broek 2000), virtual environments (Rose 1999), and other assistive devices to reduce patients' memory and planning problems.

Despite the availability of these different strategies in memory rehabilitation, many clinicians are reluctant to employ these techniques (Tate 1997). Cicerone et al (Cicerone 2000) identified four prospective randomised controlled trials of memory rehabilitation with participants with traumatic brain injury addressing the effectiveness of compensatory strategies over 'pseudo-treatment' or no-treatment. Three of these studies showed that the use of compensatory strategies significantly improved performance on memory tasks, as measured on neuropsychological tests, or reduced subjective reports of everyday memory failures. One review (Cicerone 2000) found benefits from the rehabilitation programme only when participants were stratified based on severity of memory impairment (with those with mild memory problems having benefited the most). Based on these findings, Cicerone et al (Cicerone 2000) suggested that the evidence for compensatory memory retraining with participants with mild memory problems was "compelling enough to recommend it as a Practice Standard", and that there was no evidence to suggest that cognitive remediation aids in restoring memory function in participants with severe memory problems. However, in their updated review (Cicerone 2005), teaching patients to use external memory aids (including assistive devices) with direct application to functional activities was recommended as a "practice guideline in subjects with moderate or

severe memory impairment".

OBJECTIVES

The aims of this systematic review were to determine whether:

(1) patients who have received cognitive rehabilitation for memory problems following a stroke show better functional outcomes than those given no treatment or a placebo control; and

(2) patients who have received cognitive rehabilitation have better outcome in their memory functions, on objective, subjective, or observer-rated memory measures, than no treatment or a placebo control.

The immediate and long-term outcomes of memory rehabilitation were considered.

METHODS

Criteria for considering studies for this review

Types of studies

We sought to include randomised controlled trials and the pre-crossover component of randomised crossover trials with stroke patients, in which a memory treatment was compared with a control.

Types of participants

Trials included in this review were confined to those with patients who had memory deficits following stroke, as confirmed by neurological examination, computerised tomography (CT) scan, or both. Thus, trials that included participants whose memory deficits were the result of traumatic brain injury, brain tumour, multiple sclerosis, epilepsy, or any other brain damaged condition were excluded unless a subgroup (of at least 75%) of stroke patients could be identified for which there were separate data, or such data could be obtained from the study authors. Memory deficits were not defined in advance but it was assumed that those patients given treatment for impaired memory had memory deficits, identified by specific measures of memory function employed by the different trials.

Types of interventions

We included trials in which there was a comparison between a treatment group that received one of various memory treatment strategies and a control group that received either an alternative form of treatment or no memory intervention. Memory treatments were considered to be any attempt to modify memory function by means of drill-and-practice, or by the use of memory aids (internal, external, or both), or by teaching patients strategies to cope with their memory problems. We did not include drug studies.

Types of outcome measures

The primary outcomes were functional measures (including quality of life). Secondary outcomes were measures of memory including: objective measures of memory impairment using standardised memory tests or batteries; subjective assessment of memory problems using questionnaires or self-report scales; and observer-rated measures of memory.

Search methods for identification of studies

See: 'Specialized register' section in Cochrane Stroke Group
We searched the Cochrane Stroke Group Trials Register, which was last searched by the Review Group Co-ordinator in September 2006. Furthermore, we searched the following electronic databases (Appendix 1). All potential studies were identified by one review author (RN), and independently checked by the other review author (NBL).

- Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* Issue 2, 2005)
- MEDLINE (1966 to June 2005)
- EMBASE (1980 to June 2005)
- Cumulative Index to Nursing and Allied Health Literature (CINAHL) (1982 to June 2005)
- PsycINFO (1980 to July 2006)
- Allied and Complementary Medicine Database (AMED) (1985 to June 2005)
- British Nursing Index (1985 to June 2005)
- CAB Abstracts (1973 to May 2005)
- National Research Register (June 2006)

We undertook citation tracking of all primary study articles and scanned reference lists from book chapters and review articles. In an effort to identify trials not included in the electronic databases we handsearched the following journals in 1999 for the previous version of this review.

- *American Journal of Occupational Therapy* (1947 to 1998)
- *Aphasiology* (1987 to 1998)
- *Australian Occupational Therapy Journal* (1965 to 1998)
- *British Journal of Occupational Therapy* (1950 to 1998)
- *British Journal of Therapy and Rehabilitation* (1994 to 1998)
- *Canadian Journal of Occupational Therapy* (1970 to 1998)
- *Clinical Rehabilitation* (1987 to 1998)
- *Disability Rehabilitation* (1992 to 1998), formerly International *Disability Studies* (1987 to 1991), formerly *International Rehabilitation Medicine* (1979 to 1986)

- *International Journal of Language & Communication Disorders* (1998), formerly *European Journal of Disorders of Communication* (1985 to 1997), formerly *British Journal of Disorders of Communication* (1977 to 1984)
- I*nternational Journal of Rehabilitation Research* (1977 to 1998)
- J*ournal of Clinical Psychology in Medical Settings* (1994 to 1998), formerly *Journal of Clinical Psychology* (1944 to 1994)
- *Journal of Developmental and Physical Disabilities* (1992 to 1998), formerly *Journal of the Multihandicapped Person* (1989 to 1991)
- *Journal of Rehabilitation* (1963 to 1998)
- *Journal of Rehabilitation Science* (1989 to 1996)
- *Neuropsychological Rehabilitation* (1987 to 1998)
- *Neurorehabilitation* (1991 to 1998)
- *Occupational Therapy International* (1994 to 1998)
- *Physiotherapy Theory and Practice* (1990 to 1998), formerly *Physiotherapy Practice* (1985 to 1989)
- *Physical Therapy* (1988 to 1998)
- *Rehabilitation Psychology* (1982 to 1998)
- *The Journal of Cognitive Rehabilitation* (1988 to 1998), formerly *Cognitive Rehabilitation* (1983 to 1987)

The 1999 handsearch included a broad range of journals as it covered searches for trials in four areas of rehabilitation. For the 2006 update, therefore, we checked the Master List of journals that is searched by The Cochrane Collaboration (http://www.cochrane.us/masterlist.asp), and many of the journals specific to cognitive rehabilitation have been updated as part of the Collaboration's handsearching effort. Relevant trials would be found from the search of the Cochrane Central Register of Controlled Trials (CENTRAL) carried out quarterly by the Cochrane Stroke Group and we did not wish to duplicate effort. Handsearching of these journals was not repeated as they are now covered by electronic databases.

Data collection and analysis

One review author (RN), in consultation with a senior librarian, developed the electronic search strategy. Abstracts of the studies obtained by this search strategy were evaluated by this review author, and trials were identified for inclusion in the review using the four inclusion criteria (types of trials, participants, interventions, and outcome measures). The second review author (NBL) cross-checked the search strategy, and independently appraised the protocol characteristics and the quality of selected trials.

Study quality

The two review authors independently assessed the methodological quality of each of the selected trials and rated them according to Cochrane Collaboration Guidelines. We resolved differences in opinion by discussion. The main considerations were whether participant allocation had been random, whether it had been adequately concealed, and whether outcomes were conducted blind to group allocation.

Data extraction

One review author (RN) extracted study characteristics and outcomes and these were checked by the second review author (NBL). We developed a data extraction tool similar to that proposed by the CONSORT statement (Moher 2001). The following was recorded for each trial.

Method of participant assignment

- Unit of assignment
- Method used to generate the intervention assignment schedule
- Method used to conceal the intervention assignment schedule from participants and clinicians until recruitment was complete and irrevocable
- Method(s) used to separate the generator and executor of the assignment
- The auditable process of executing the assignment method
- Compare the distributions of important prognostic characteristics and demographics at baseline

Blinding

- Whether (and how) outcome assessors were aware of the intervention allocation, by intervention group
- Whether the investigator was unaware of trends in the study at the time of participant allocation
- Whether the data analyst was aware of the intervention allocation
- Whether individual participant data were entered into the trial database without awareness of intervention allocation

Participant follow up

- The numbers and flow of participants, by intervention group, throughout the trial
- The average duration of the trial, by intervention group
- The reason for dropout clearly, by intervention group
- The actual timing of the measurements, by intervention group

Statistical analysis

- Whether the primary analysis has used the intention-to-treat principle
- The intended sample size and its justification
- Trial dropouts and completers

- The reliability, validity, and standardisation of (new and infrequently employed) primary outcome measures

Results

- The appropriate analytical techniques applied to primary outcome measure(s)
- The appropriate measures of variability (e.g., confidence intervals for primary outcome measures)
- The actual probability value and the nature of the significance test
- The appropriate emphasis in displaying and interpreting the statistical analysis, in particular controlling for unplanned comparisons

Other characteristics

- Sample size
- Age range/mean
- Years of education range/mean
- Time post injury
- Treatment duration
- Duration of follow up
- Attempt to see if there was generalisation to functional memory
- Use of homework assignments
- Outcome measures

If these data were not available or unclear from the reports, particularly relating to the randomisation procedure, we contacted the first author of the trial for further information. We conducted the review using the Cochrane Review Manager software, RevMan 4.2, using random-effects standard mean difference (SMD) and 95% confidence intervals.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies; Characteristics of ongoing studies.

A total of 188 studies were identified. Preliminary screening was carried out on the basis of information obtained from the titles of the articles. We examined abstracts for all the studies selected, and obtained full papers if the abstracts suggested that they satisfied the inclusion criteria. We eliminated studies based on the following exclusion criteria: (1) not stroke, or a mixed aetiology group without a stroke sample; (2) not a memory study, or did not have a separate memory component if within the context of a larger cognitive rehabilitation (or cognitive retraining or neuropsychological rehabilitation) study; (3) not an intervention study; and (4) not a randomised controlled trial.

Following this elimination process, seven studies satisfied the inclusion criteria based on the abstracts. However, on review of the full paper, only two of these studies fulfilled the inclusion criteria (Doornhein 1998; Kaschel 2002). Of the four excluded studies, one was a review paper (Imes 1984), one was a series of experiments (Evans 2000) and therefore did not fit the criteria for treatment or psychological intervention as these experiments consisted of learning trials given on a single day. Furthermore, it was not certain whether there was random allocation of participants to the different trials. Two studies (Gasparrini 1979; Wilson 2001) did not have adequate randomisation and concealment. In one study (Wilson 2001) the first 20 referrals were allocated to group A and the second 20 to group B, the next 10 to group A, 10 to group B, and so on. Participant allocation was carried out by the researcher who also carried out the rehabilitation programme (Wilson 2001: Emslie, personal communication 2006). Furthermore, the authors mentioned that there were certain 'restrictions to the randomisation procedure' for reasons related to the individual patient's needs (Wilson 2001). The other study (Gasparrini 1979) used alternate allocation, with no concealment of allocation and assessment of outcome by the researcher giving the therapy (Gasparrini 1979: personal communication 2007). *See* 'Characteristics of excluded studies' table for more details. One further study (Westerberg 2003) is awaiting assessment; only a conference abstract was available for this study, and the authors reported that the paper is in preparation.

Study location

One study was a single centre study from the Netherlands with participants who had sustained a stroke (Doornhein 1998), and the other was a mixed aetiology, multi-centre study (Kaschel 2002).

Participant characteristics

The Doornhein study (Doornhein 1998) had 12 participants who were three to five months post stroke, while the Kaschel study (Kaschel 2002) had a larger sample (n = 21), but only six of them had had a stroke. Therefore, data pertaining to the stroke patients in this study were extracted from the overall data and analysed separately.

Study design

Participants were randomly allocated to the training programme (n = 6) or to a pseudo-treatment 'drill and practice' control group (n = 6) in the Doornhein study (Doornhein 1998). Similarly, the stroke participants in the Kaschel study (Kaschel 2002) had been randomly allocated to the treatment group (n = 3) or the control group (n = 3) along with participants with other aetiologies.

Treatment characteristics

All participants in one study (Doornhein 1998) had two individual sessions per week, for a period of four weeks. The study employed six simple memory strategies applied to specific memory problems identified by the participants in the training programme. Participants in this group were trained to remember names of people and routes using the mnemonic strategies of 'organisation' and verbal and visual 'association'. Homework assignments were designed to make the intervention individual specific. Participants in the pseudo-treatment group were asked to repeat and pay more attention to the material to be learned. The Kaschel study (Kaschel 2002) compared an experimental imagery mnemonics programme and a 'pragmatic' memory rehabilitation control programme. All participants received 30 sessions of therapy over 10 weeks. Imagery training was carried out in two phases (each phase consisting of various stages). In Phase I, participants learnt how to generate images rapidly given verbal information, and in Phase II this acquired skill was transferred to identified problems of daily life. The pragmatic group received treatments that were routinely practiced in the various centres, which included internal and external strategies, attention training, planning procedures, and they were give some 'practical guidelines' to cope with memory problems.

Outcomes assessed

Doornhein (Doornhein 1998) assessed memory tasks that were practised during training (target memory tasks), and memory tasks that were not specifically practised (control memory tasks). Subjective reports of the training programme were also assessed. Kaschel (Kaschel 2002) assessed participants at four time periods: pre-baseline, baseline, immediately post-intervention, and at three month follow up on general memory, domain-specific memory tests, and tests tapping other cognitive domains, such as attention.

Conclusions from individual studies

Participants in the Doornhein study (Doornhein 1998) who received the training programme appeared to perform significantly better than those on the pseudo-treatment group on the trained memory tasks but not on the control memory tasks; and no differences were observed on subjective ratings of everyday memory functions between both groups. The results for the mixed aetiology group as a whole in the Kaschel study (Kaschel 2002) suggested that the use of imagery mnemonics significantly improved performance on delayed recall of verbal material such as stories and appointments, and observer-rated reports of memory failures were also reduced, which was found to be stable at follow up. No improvement in scores for the imagery group was noted on the Wechsler Memory Scale, Rivermead Behavioural Memory Test (RBMT) total score, and the self-report measure on the Memory Assessment Clinics (MAC) Rating Scale. However, significant improvements were noted on the Story (immediate and delayed recall) subtest of the RBMT, delayed recall on the Appointments test, and relatives rating on the MAC. However, while stroke-specific analyses were similar to these findings, they did not reach statistical significance. Although the study authors concluded that imagery mnemonics improved everyday memory performance for the group as a whole, this was not apparent from the stroke data.

Risk of bias in included studies

The quality of the studies considered for inclusion was assessed using the data extraction tool described above. Particular attention was paid to the randomisation, treatment allocation, concealment and blinding procedures, and the flow of participants through the trial.

Neither study published the method used to generate the intervention assignment schedule, details of allocation concealment, or blinding. In both studies outcome assessments were not blind. In one study (Doornhein 1998) the same person carried out the outcome evaluations and the training sessions. The other study (Kaschel 2002) did not publish allocation concealment and details of blinding. However, the author (in personal communication in 2006) does suggest that allocation concealment was adequate, but not all outcome assessors were blind to treatment allocation, some having conducted the retraining programmes themselves. Furthermore, as this trial (Kaschel 2002) was a multi-centre study involving different countries, some of the tests were translated for this trial, specific details of which were not reported. Neither study employed a flowchart to depict the flow of participants through the trials, as recommended by the CONSORT statement (Begg 1996; Moher 2001). The personal communication with Kaschel (reported above) demonstrated that while the methodology of studies may have been sound, their reporting was inadequate.

Effects of interventions

Outcome data were available from two trials of 18 participants. Formal meta-analysis was not possible, but individual results were summarised for the immediate and long-term effects on the primary and secondary outcomes. The primary outcomes were functional outcome measures (including quality of life); and the secondary outcomes were objective measures, subjective measures, and observer-rated measures of memory.

Functional outcomes

Neither trial included any functional outcome (or quality of life) measures.

Comparisons 01.01 and 01.02: Objective memory measures

Both studies included objective memory tests as outcome measures. These were specific to the two studies and no common outcome measures were used. A total of eight immediate outcome measures were used. There were no significant effects of treatment on list learning, face recognition, and immediate and delayed recall of stories; but there was a difference on the route learning task which had a standard mean difference (SMD) of 2.23 (95% confidence interval (CI) of 0.66 to 3.80). No treatment gains were observed on the total scores of either the RBMT or the WMS. Only one study (Kaschel 2002) reported long-term effects using an objective memory measure (RBMT). No improvement was noted on the immediate and delayed recall of the RBMT story or the total RBMT score. Therefore, there were no immediate and long-term effects of memory rehabilitation using objective memory measures.

Comparisons 01.03 and 01.04: Subjective memory measures

The two studies used different outcomes on subjective measures of memory. One study (Doornhein 1998) employed the Memory Questionnaire while the other (Kaschel 2002) used the MAC-S (self) rating scale. No treatment effects were observed on either of these measures. Only one study (Kaschel 2002) reported the long-term effects using the MAC-S (self) rating scale, and there were no immediate or long-term effects of memory rehabilitation on this measure.

Comparisons 01.05 and 01.06: Observer-rated measures

The observer-rated measure employed by Kaschel (Kaschel 2002) was the MAC-F (family) rating scale. There was no evidence of treatment effectiveness on the immediate or long-term outcomes as measured by this scale.

DISCUSSION

There is limited literature on the effectiveness of cognitive rehabilitation for memory problems following stroke. While there are many studies using the single case experimental design paradigm, which have shown improvements in memory functions following cognitive training programmes, controlled trials have been few. When controlled trials were identified, they were either limited by having small sample sizes (thereby increasing the possibility of making a type II error) or including mixed aetiology patient groups. Mixed aetiology studies are beneficial in determining the potential for the generalisability of training programmes across diagnostic groups, but there are likely to be differential effects of the training based on diagnosis, and even severity (Cicerone 2000). Sub-group analysis on the basis of aetiology is one option to glean more information regarding the effectiveness of an intervention. However, given that most trials in memory rehabilitation are small and underpowered, further fractionating will lead to further reduction in power, which may lead to inconclusive findings. Furthermore, many studies suffered from poor quality of reporting, particularly failing to state the randomisation, concealment and blinding procedures. Given these limitations, only two studies were included in this review. They had small sample sizes, despite one having been a multi-centre trial (Kaschel 2002). Some trials only assess immediate outcomes, and only one trial reported here (Kaschel 2002) had follow-up assessments. Without long-term assessments, the persistence of treatment effects, if any, cannot be determined. Furthermore, as was observed by one study (Kaschel 2002), changes (including improvements) were noticed on some measures only at follow up.

Most trialists did not comply with the CONSORT guidelines (Moher 2001), or its predecessors (Begg 1996) to report their trial. The obvious result of such failings was the lack of clarity in discerning the methodology of the study. Another major concern was the degree of clinical and methodological heterogeneity trials in memory rehabilitation possess. Without trials explicitly elucidating methodological procedures, heterogeneity cannot be adequately addressed. The use of 'control' and 'target' outcome measures are valuable in determining treatment effects, and the degree to which such effects are generalisable. In one study (Doornhein 1998), while there was evidence to suggest minimal effectiveness of a memory strategy training programme, there was no evidence of generalisation of treatment effects to tasks that were not trained. The other study (Kaschel 2002) also had some outcome measures (such as the d2 attention task) on which they did not find differences between groups post-intervention. Generalisation of treatment effectiveness, when evident, has been poorly reported in many trials, and this has been a criticism levelled against many memory rehabilitation interventions.

The results of this review suggested that there was no evidence to support or refute the effectiveness of memory rehabilitation on functional outcomes, or objective memory tests, subjective or observer-rated measures of memory.

AUTHORS' CONCLUSIONS

Implications for practice

Given that a large number of individuals complain of memory problems post-stroke, and considering that there are some centres offering a variety of interventions to address these problems, questioning the effectiveness of these treatment programmes is pertinent. The studies examined in this review reflected the diversity of intervention strategies employed in memory rehabilitation, and variation in outcome measures to evaluate their effectiveness. However, most common interventions used memory aids,

and have attempted to demonstrate their superiority in reducing memory problems over 'drill and practice' strategies. The results from individual studies appeared to support a general trend: use of memory aids is better than 'drill and practice' strategies or no treatment at all. However, this review found little evidence to suggest that memory rehabilitation was more effective than no rehabilitation or control. The results of this review suggested that there is insufficient evidence to support or refute the provision of memory rehabilitation in clinical practice.

Implications for research

The evidence base for the effectiveness of cognitive rehabilitation for memory problems following stroke, from the literature surveyed, appeared weak. Very few randomised controlled trials have been reported, and many of the controlled clinical trials identified had methodological flaws inherent in the study design. There were increased random effects due to sampling errors and small sample sizes, an over-reliance and misinterpretation of significance tests (without mention of confidence intervals), problems related to poor (or absent) randomisation procedures, poor (or absent) blinding, poor quality of reporting of the study, and differences in the nature of the outcomes measured. The results of this review suggested that there is an urgent need for further well-conceptualised, executed, and reported randomised controlled trials of memory rehabilitation that take into consideration some of the issues raised in this review.

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References to other published versions of this review

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Doornhein 1998

Methods	Randomised controlled trial Single centre Participants assigned at random to control group or experimental group Outcome assessment done by person who carried out training; no long-term follow up
Participants	The Netherlands Memory impairment assessed on Dutch version of Rey auditory learning test N = 12 (experimental group = 6, control group = 6) Mean age: experimental group = 51.3 years, control group = 51.7 years Time since stroke: 3 to 5 months
Interventions	Experimental group: memory strategy training 2 sessions per week for 4 weeks; subjective memory problems assessed; mnemonic strategies taught were 'association' and 'organisation. Homework books used Control group: 'drill and practice' exercises, pay more attention, spend more time repeating material
Outcomes	(1) For target memory tasks: Name-Face Paired Associated Memory Test, Stylus Maze Test (2) For Control memory task: 15 Words Test, Oxford Recurring Faces Test, Memory Questionnaire
Notes	Patients with severe aphasia, apraxia, or agnosia were excluded Experimental and control groups comparable on important demographic and illness characteristics Number and flow of participants, by intervention group, throughout trial not mentioned No follow up after the end of treatment Statistics: 2 way-ANOVA, post-hoc Tukey test, intention-to-treat analysis not stated, power not stated

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	No	C - Inadequate

Kaschel 2002

Methods	Randomised controlled trial Multi-centre Participants assigned at random to pragmatic (control) group or imagery (experimental) group Outcome assessment mostly blind (but not in all centres); 4 assessment points: pre-baseline, baseline, post-intervention, follow up at 3 months
Participants	7 centres N = 21 (experimental = 9, control = 12) Mean age: experimental group = 51 years, control group = 41.7 years, overall = 46.3 years Mixed aetiology group, 6 stroke Memory deficits identified by score of 15 or less on RBMT

Kaschel 2002 (*Continued*)

Interventions	Experimental group: imagery training Control group: pragmatic training; 30 sessions over 10 weeks
Outcomes	(1) Wechsler Memory Scale (total score) (2) RBMT (total score, and immediate and delayed story recall) (3) 'Appointments' Everyday Memory Test (4) Memory Assessment Clinics (self and family) rating scales (5) d2 subtest: to assess attention
Notes	Patients with severe memory problems (RBMT scores of 12 points or less), aphasia, neglect, hemianopia, apraxia, agnosia, psychiatric history, substance misuse, affective disorder, or those who cannot generate visual imagery, were excluded

Risk of bias

Item	**Authors' judgement**	**Description**
Allocation concealment?	No	C - Inadequate

RBMT: Rivermead Behavioural Memory Test

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Evans 2000	Not a rehabilitation treatment study, mixed aetiology, with results of stroke patients not reported separately
Gasparrini 1979	Alternate allocation, not random, poor concealment, allocation, treatment and outcomes all completed by same person
Imes 1984	Review paper
Wilson 2001	Inadequate randomisation procedure (alternate allocation of blocks to treatment or waiting list) and poor concealment (allocation and rehabilitation programme conducted by same researcher)

Characteristics of ongoing studies *[ordered by study ID]*

Nair 2007

Trial name or title	Neuropsychological rehabilitation for memory problems following brain damage
Methods	
Participants	People with a diagnosis of traumatic brain injury or multiple sclerosis or stroke with memory problems
Interventions	Compensation versus restitution versus self help (control) group
Outcomes	RBMT-E, Memory Questionnaires, EADL, GHQ, Mental adjustment to brain damage
Starting date	May 2004
Contact information	Roshan Nair, Institute of Work, Health & Organisations, The University of Nottingham
Notes	Study ongoing; expected date of completion September 2007

EADL: extended activities of daily living
GHQ: general health questionnaire
RBMT-E: Rivermead Behavioural Memory Test - extended version

DATA AND ANALYSES

Comparison 1. Memory training versus no memory training

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Objective memory measures (immediate outcome)	2		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
1.1 Paired associate memory tests	1	12	Std. Mean Difference (IV, Random, 95% CI)	0.64 [-0.53, 1.82]
1.2 Route learning tasks	1	12	Std. Mean Difference (IV, Random, 95% CI)	2.23 [0.66, 3.80]
1.3 List learning tasks	1	12	Std. Mean Difference (IV, Random, 95% CI)	1.06 [-0.19, 2.30]
1.4 Face recognition tasks	1	12	Std. Mean Difference (IV, Random, 95% CI)	0.92 [-0.29, 2.14]
1.5 RBMT: total score	1	6	Std. Mean Difference (IV, Random, 95% CI)	-0.18 [-1.79, 1.43]
1.6 RBMT: story (immediate recall)	1	6	Std. Mean Difference (IV, Random, 95% CI)	0.68 [-1.05, 2.42]
1.7 RBMT: story (delayed recall)	1	6	Std. Mean Difference (IV, Random, 95% CI)	1.08 [-0.83, 2.99]
1.8 WMS: total score	1	6	Std. Mean Difference (IV, Random, 95% CI)	-0.66 [-2.39, 1.06]
2 Objective memory measures (long-term outcome)	1		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
2.1 RBMT: total score	1	6	Std. Mean Difference (IV, Random, 95% CI)	-0.40 [-2.04, 1.25]
2.2 RBMT: story (immediate recall)	1	6	Std. Mean Difference (IV, Random, 95% CI)	1.44 [-0.68, 3.56]
2.3 RBMT: story (delayed recall)	1	6	Std. Mean Difference (IV, Random, 95% CI)	1.06 [-0.84, 2.96]
3 Subjective memory measures (immediate outcome)	2		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
3.1 Memory questionnaires	1	12	Std. Mean Difference (IV, Random, 95% CI)	0.18 [-0.95, 1.32]
3.2 Memory Assessment Clinics rating scale (self)	1	6	Std. Mean Difference (IV, Random, 95% CI)	-0.16 [-1.77, 1.44]
4 Subjective memory measures (long-term outcome)	1		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
4.1 Memory Assessment Clinics rating scale (self)	1	6	Std. Mean Difference (IV, Random, 95% CI)	0.74 [-1.01, 2.49]
5 Observer-rated measures (immediate outcome)	1		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
5.1 Memory Assessment Clinics rating scale (family)	1	6	Std. Mean Difference (IV, Random, 95% CI)	0.20 [-1.42, 1.81]
6 Observer-rated measures (long-term outcome)	1		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
6.1 Memory Assessment Clinics rating scale (family)	1	6	Std. Mean Difference (IV, Random, 95% CI)	1.16 [-0.79, 3.11]

Analysis 1.1. Comparison 1 Memory training versus no memory training, Outcome 1 Objective memory measures (immediate outcome).

Review: Cognitive rehabilitation for memory deficits following stroke

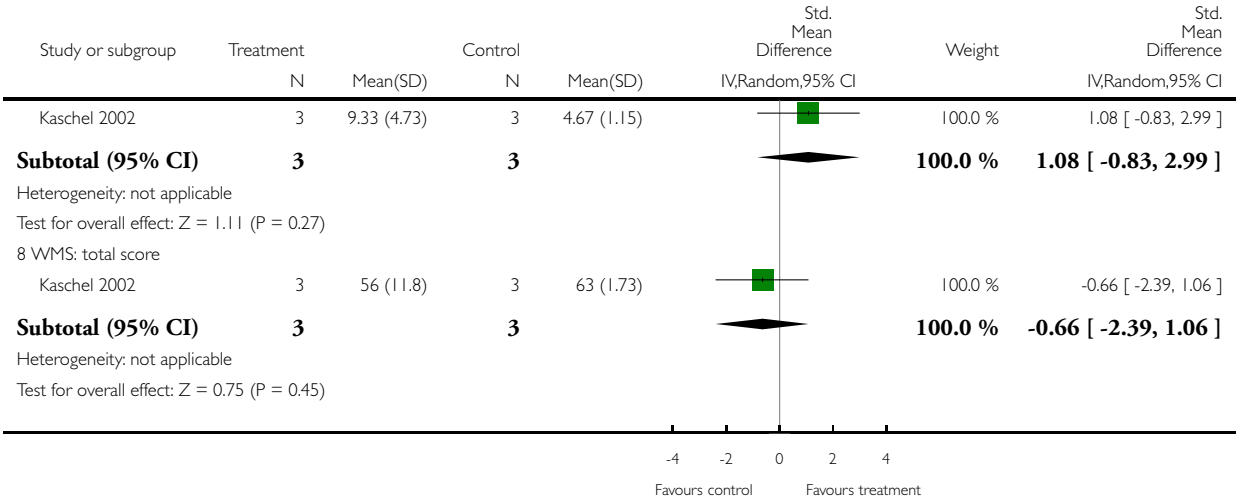
Comparison: 1 Memory training versus no memory training

Outcome: 1 Objective memory measures (immediate outcome)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Paired associate memory tests							
Doornhein 1998	6	9.7 (5.9)	6	5.8 (5.3)		100.0 %	0.64 [-0.53, 1.82]
Subtotal (95% CI)	**6**		**6**			**100.0 %**	**0.64 [-0.53, 1.82]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.07 (P = 0.28)							
2 Route learning tasks							
Doornhein 1998	6	18.9 (0.4)	6	14.4 (2.6)		100.0 %	2.23 [0.66, 3.80]
Subtotal (95% CI)	**6**		**6**			**100.0 %**	**2.23 [0.66, 3.80]**
Heterogeneity: not applicable							
Test for overall effect: Z = 2.79 (P = 0.0053)							
3 List learning tasks							
Doornhein 1998	6	39.2 (11.7)	6	29 (4.7)		100.0 %	1.06 [-0.19, 2.30]
Subtotal (95% CI)	**6**		**6**			**100.0 %**	**1.06 [-0.19, 2.30]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.66 (P = 0.096)							
4 Face recognition tasks							
Doornhein 1998	6	50 (3.5)	6	46.5 (3.5)		100.0 %	0.92 [-0.29, 2.14]
Subtotal (95% CI)	**6**		**6**			**100.0 %**	**0.92 [-0.29, 2.14]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.49 (P = 0.14)							
5 RBMT: total score							
Kaschel 2002	3	18.33 (7.37)	3	19.67 (3.79)		100.0 %	-0.18 [-1.79, 1.43]
Subtotal (95% CI)	**3**		**3**			**100.0 %**	**-0.18 [-1.79, 1.43]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.22 (P = 0.82)							
6 RBMT: story (immediate recall)							
Kaschel 2002	3	10 (5.29)	3	6.67 (1.53)		100.0 %	0.68 [-1.05, 2.42]
Subtotal (95% CI)	**3**		**3**			**100.0 %**	**0.68 [-1.05, 2.42]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.77 (P = 0.44)							
7 RBMT: story (delayed recall)							

(*Continued* . . .)

(. . . *Continued*)

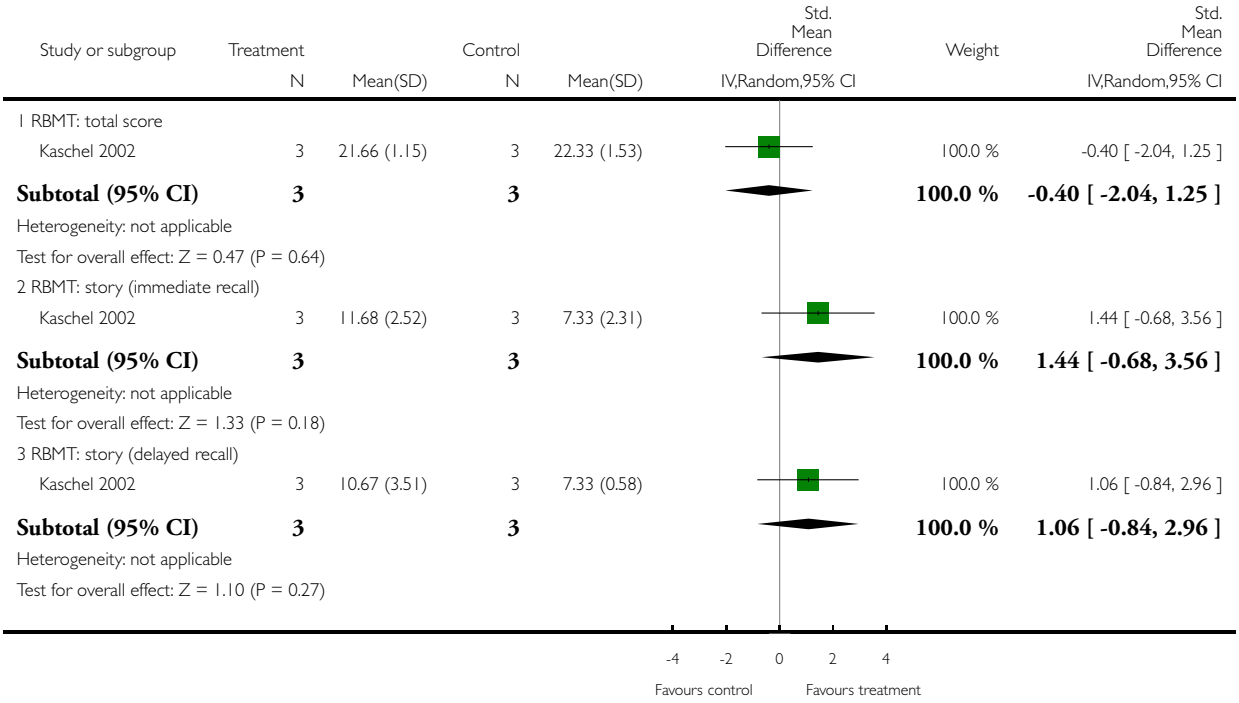


Analysis 1.2. Comparison 1 Memory training versus no memory training, Outcome 2 Objective memory measures (long-term outcome).

Review: Cognitive rehabilitation for memory deficits following stroke

Comparison: 1 Memory training versus no memory training

Outcome: 2 Objective memory measures (long-term outcome)



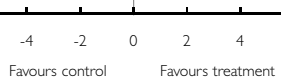
Analysis 1.3. Comparison 1 Memory training versus no memory training, Outcome 3 Subjective memory measures (immediate outcome).

Review: Cognitive rehabilitation for memory deficits following stroke

Comparison: 1 Memory training versus no memory training

Outcome: 3 Subjective memory measures (immediate outcome)

Study or subgroup	Treatment N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Memory questionnaires							
Doornhein 1998	6	93 (53.5)	6	85.3 (11.1)		100.0 %	0.18 [-0.95, 1.32]
Subtotal (95% CI)	**6**		**6**			**100.0 %**	**0.18 [-0.95, 1.32]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.32 (P = 0.75)							
2 Memory Assessment Clinics rating scale (self)							
Kaschel 2002	3	79.67 (20)	3	83 (11.36)		100.0 %	-0.16 [-1.77, 1.44]
Subtotal (95% CI)	**3**		**3**			**100.0 %**	**-0.16 [-1.77, 1.44]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.20 (P = 0.84)							

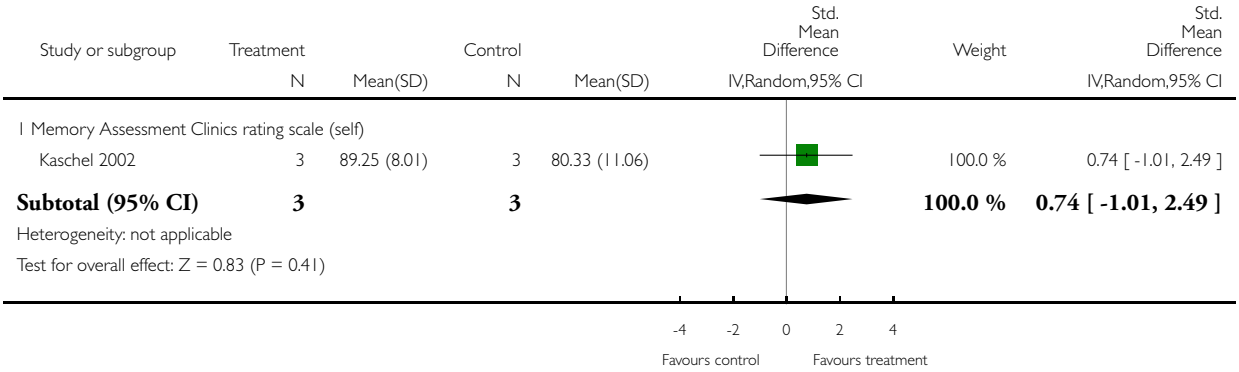


Analysis 1.4. Comparison 1 Memory training versus no memory training, Outcome 4 Subjective memory measures (long-term outcome).

Review: Cognitive rehabilitation for memory deficits following stroke

Comparison: 1 Memory training versus no memory training

Outcome: 4 Subjective memory measures (long-term outcome)

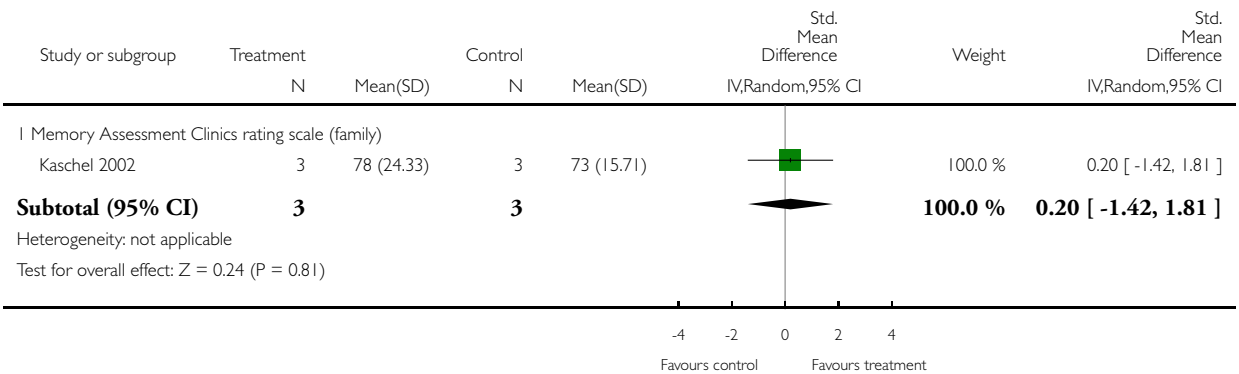


Analysis 1.5. Comparison 1 Memory training versus no memory training, Outcome 5 Observer-rated measures (immediate outcome).

Review: Cognitive rehabilitation for memory deficits following stroke

Comparison: 1 Memory training versus no memory training

Outcome: 5 Observer-rated measures (immediate outcome)

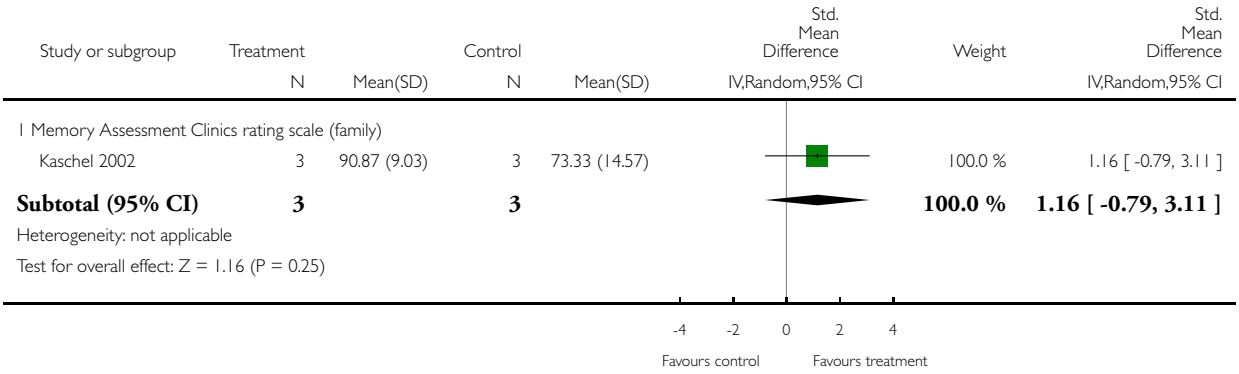


Analysis 1.6. Comparison 1 Memory training versus no memory training, Outcome 6 Observer-rated measures (long-term outcome).

Review: Cognitive rehabilitation for memory deficits following stroke

Comparison: 1 Memory training versus no memory training

Outcome: 6 Observer-rated measures (long-term outcome)



APPENDICES

Appendix 1. MEDLINE search strategy

The following search strategy was used for MEDLINE (Ovid) and modified for the other databases.
1. exp Cerebrovascular Disorders/
2. (stroke$ or cerebrovascular$ or cerebral vascular or CVA$).tw.
3. 1 or 2
4. attention/ or exp cognition/ or exp memory/ or exp cognition disorders/ or exp memory disorders/
5. (cognitive or cognition or attention$ or memory or concentration or distract$ or alert$).tw.
6. 4 or 5
7. (training or re-training or retraining or therap$ or rehabilitation or treatment$ or therapeutic$ or computer-assisted therap$ or computer assisted therap$).tw.
8. exp rehabilitation/
9. exp therapeutics/
10. exp cognitive therapy/
11. exp computers/
12. exp therapy, computer-assisted/
13. exp neuropsychological tests/
14. or/7-13
15. 6 and 14
16. (neurorehabilitation or neuropsychological rehabilitation or cognitive rehabilitation or memory rehabilitation or cognitive retraining).tw.
17. 15 or 16

18. 3 and 17
19. Randomized Controlled Trials/
20. random allocation/ or placebos/
21. Controlled Clinical Trials/
22. clinical trials/
23. randomized controlled trial.pt.
24. controlled clinical trial.pt.
25. clinical trial.pt.
26. (random$ or placebo$).tw.
27. (controlled adj5 (trial$ or stud$)).tw.
28. (clinical$ adj5 trial$).tw.
29. or/19-28
30. 18 and 29
31. limit 30 to humans
32. adult/ or aged/ or "aged, 80 and over"/ or middle aged/
33. 31 and 32

WHAT'S NEW

Last assessed as up-to-date: 31 January 2007.

Date	Event	Description
4 August 2008	Amended	Converted to new review format.

HISTORY

Protocol first published: Issue 2, 2000

Review first published: Issue 2, 2000

Date	Event	Description
19 March 2007	New citation required but conclusions have not changed	Change to authorship.
19 March 2007	New search has been performed	One new trial (Kaschel 2002) has been included in the review since the previous version. The overall conclusions of the review have not changed

CONTRIBUTIONS OF AUTHORS

Nadina Lincoln initiated, co-ordinated, and designed the format of the review; appraised the studies for review; and revised the final report.

Roshan das Nair developed the search strategies and the template to assess the quality of the studies included, collected the data, and wrote the review.

DECLARATIONS OF INTEREST

None known

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

- Stroke Association, UK.

INDEX TERMS

Medical Subject Headings (MeSH)

Attention; Clinical Trials as Topic; Cognition; Memory Disorders [etiology; *rehabilitation]; Perception; Stroke [*complications]

MeSH check words

Humans