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Loetscher T, Potter KJ, Wong D, das Nair R.
Cognitive rehabilitation for attention deficits following stroke.
Cochrane Database of Systematic Reviews 2019, Issue 11. Art. No.: CD002842.
DOI: 10.1002/14651858.CD002842.pub3.

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[Intervention Review]

Cognitive rehabilitation for attention deficits following stroke

Tobias Loetscher[1], Kristy-Jane Potter[2], Dana Wong[3], Roshan das Nair[2]

[1]School of Psychology, University of South Australia, Adelaide, Australia. [2]Division of Psychiatry & Applied Psychology, University of Nottingham, Nottingham, UK. [3]School of Psychology and Public Health, La Trobe University, Melbourne, Australia

Contact address: Tobias Loetscher, School of Psychology, University of South Australia, GPO Box 2471, Adelaide, SA, 5001, Australia. tobias.loetscher@unisa.edu.au, tobias.loetscher@alumni.ethz.ch.

Editorial group: Cochrane Stroke Group.
Publication status and date: New search for studies and content updated (no change to conclusions), published in Issue 11, 2019.

Citation: Loetscher T, Potter KJ, Wong D, das Nair R. Cognitive rehabilitation for attention deficits following stroke. *Cochrane Database of Systematic Reviews* 2019, Issue 11. Art. No.: CD002842. DOI: 10.1002/14651858.CD002842.pub3.

ABSTRACT

Background

Many survivors of stroke report attentional impairments, such as diminished concentration and distractibility. However, the effectiveness of cognitive rehabilitation for improving these impairments is uncertain.This is an update of the Cochrane Review first published in 2000 and previously updated in 2013.

Objectives

To determine whether people receiving cognitive rehabilitation for attention problems 1. show better outcomes in their attentional functions than those given no treatment or treatment as usual, and 2. have a better functional recovery, in terms of independence in activities of daily living, mood, and quality of life, than those given no treatment or treatment as usual.

Search methods

We searched the Cochrane Stroke Group Trials Register, CENTRAL, MEDLINE, Embase, CINAHL, PsycINFO, PsycBITE, REHABDATA and ongoing trials registers up to February 2019. We screened reference lists and tracked citations using Scopus.

Selection criteria

We included controlled clinical trials (CCTs) and randomised controlled trials (RCTs) of cognitive rehabilitation for impairments of attention for people with stroke. We did not consider listening to music, meditation, yoga, or mindfulness to be a form of cognitive rehabilitation. We only considered trials that selected people with demonstrable or self-reported attentional deficits. The primary outcomes were measures of global attentional functions, and secondary outcomes were measures of attentional domains (i.e. alertness, selective attention, sustained attention, divided attention), functional abilities, mood, and quality of life.

Data collection and analysis

Two review authors independently selected trials, extracted data, and assessed the risk of bias. We used the GRADE approach to assess the certainty of evidence for each outcome.

Main results

We included no new trials in this update. The results are unchanged from the previous review and are based on the data of six RCTs with 223 participants. All six RCTs compared cognitive rehabilitation with a usual care control.

Meta-analyses demonstrated no convincing effect of cognitive rehabilitation on subjective measures of attention either immediately after treatment (standardised mean difference (SMD) 0.53, 95% confidence interval (CI) –0.03 to 1.08; P = 0.06; 2 studies, 53 participants; very low-quality evidence) or at follow-up (SMD 0.16, 95% CI –0.23 to 0.56; P = 0.41; 2 studies, 99 participants; very low-quality evidence).

People receiving cognitive rehabilitation (when compared with control) showed that measures of divided attention recorded immediately after treatment may improve (SMD 0.67, 95% CI 0.35 to 0.98; P < 0.0001; 4 studies, 165 participants; low-quality evidence), but it is uncertain that these effects persisted (SMD 0.36, 95% CI –0.04 to 0.76; P = 0.08; 2 studies, 99 participants; very low-quality evidence). There was no evidence for immediate or persistent effects of cognitive rehabilitation on alertness, selective attention, and sustained attention.

There was no convincing evidence for immediate or long-term effects of cognitive rehabilitation for attentional problems on functional abilities, mood, and quality of life after stroke.

Authors' conclusions

The effectiveness of cognitive rehabilitation for attention deficits following stroke remains unconfirmed. The results suggest there may be an immediate effect after treatment on attentional abilities, but future studies need to assess what helps this effect persist and generalise to attentional skills in daily life. Trials also need to have higher methodological quality and better reporting.

PLAIN LANGUAGE SUMMARY

Cognitive rehabilitation for attention problems following stroke

Review question

Our aim was to review the evidence about the effect of cognitive rehabilitation on attention, the ability to perform daily activities, mood, and quality of life in people who have attention problems following a stroke.

Background

Many people have problems with attention after stroke. They are unable to concentrate for prolonged periods of time and are distractible, being unable to focus on a specific task in the presence of competing information. 'Cognitive rehabilitation' involves providing therapeutic activities to reduce the severity of cognitive problems, like attention, following damage to the brain. The benefit of cognitive rehabilitation for attention problems following stroke is unclear.

Study characteristics

We identified six studies that compared cognitive rehabilitation with a control group who received their usual care (but not cognitive rehabilitation) for people with attention problems following stroke. We did not consider listening to music, meditation, yoga, or mindfulness to be a form of cognitive rehabilitation. The six studies involved 223 participants who demonstrated attentional problems or reported having such problems following stroke. The evidence is current to February 2019.

Key results

We found no evidence that cognitive rehabilitation improved general (global) measures of attention. The group that received cognitive rehabilitation performed better than the control group on tasks that required people to divide attention. However, this benefit was only seen immediately after the rehabilitation period with no suggestion that the benefits persist for longer. There was no evidence to suggest that cognitive rehabilitation was beneficial for other types of attention problems, or daily life activities, mood, or quality of life. More research is needed.

Certainty of the evidence

The very low to moderate methodological quality of the studies identified, and the lack of studies means that we cannot draw firm conclusions about the effect of cognitive rehabilitation for attention following stroke.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. Attention training compared to control for attention deficits following stroke immediately after treatment

Attention training compared to control for attention deficits following stroke immediately after treatment

Patient or population: people with attention deficits following stroke
Settings: any rehabilitation setting
Intervention: attention training
Comparison: no treatment/treatment as usual

Outcomes	No of participants (studies)	Certainty of the evidence (GRADE)[a]	Estimated effect of intervention (SMD)[b]	95% confidence interval of estimated effect	Comments
Subjective measures – assessed with Cognitive Failures Questionnaire & Mental Slowness Questionnaire	53 (2 RCTs)	⊕⊖⊖⊖ **Very low**[c,d,e]	0.53 SMDs better	0.03 SMDs worse to 1.08 SMDs better	—
Objective global measures	No studies	—	—	—	No data
Alertness – assessed with TAP phasic alertness, Wiener Reaktionsgerat Visual RT, Simple RT & Tempo-Lern Test	136 (4 RCTs)	⊕⊕⊖⊖ **Low**[c,d,f]	0.14 SMDs better	0.20 SMDs worse to 0.48 SMDs better	—
Selective attention – assessed with TAP selective attention, Trail Making A, Zahlen-Verbindungstest, Wiener Reaktionsgerat Choice RT, Ruff 2&7	223 (6 RCTs)	⊕⊕⊕⊖ **Moderate**[c,d]	0.08 SMDs worse	0.35 SMDs worse to 0.18 SMDs better	—
Sustained attention – assessed with IVA-CPT Fullscale Attention Quotient, d2, Konzentrations-Verlaufs-Test, Wiener Vigilanzgerat	169 (4 RCTs)	⊕⊕⊖⊖ **Low**[c,d,f]	0.39 SMDs better	0.16 SMDs worse to 0.94 SMDs better	—
Divided attention – assessed with TAP divided attention, PASAT	165 (4 RCTs)	⊕⊕⊖⊖ **Low**[c,f]	0.67 SMDs better	0.35 SMDs to 0.98 SMDs better	—
Functional abilities – assessed with Barthel, Functional Independence Measure (FIM)	75 (2 RCTs)	⊕⊖⊖⊖ **Very low**[c,d,e]	0.29 SMDs better	0.16 SMDs worse to 0.75 SMDs better	—
Mood (depression) – assessed with Center for Epidemiologic Studies Depression Scale, Zung Depression Status Inventory, Emotional State Questionnaire (Depression subscale)	109 (3 RCTs)	⊕⊕⊖⊖ **Low**[c,f]	0.01 SMDs better	0.36 SMDs worse to 0.39 SMDs better	—

Quality of life – assessed with SF-36 (Mental Component Summary subscale), EQ-VAS	103 (2 RCTs)	⊕⊕⊖⊖ **Low**[c,f]	0.02 SMDs better	0.37 SMDs worse to 0.40 SMDs better	—

CI: confidence interval; **IVA-CPT:** Integrated Visual and Auditory Continuous Performance Test; **n:** number of participants; **PASAT:** Paced Auditory Serial Addition Test; **RCT:** randomised controlled trial; **ROB:** risk of bias; **RT:** reaction time; **SF-36:** 36-item Short Form; **SMD:** standardised mean difference; **TAP:** Tests of Attentional Performance.

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

[a]Downgraded for imprecision: two levels for 1–99 participants; one level for 100–199 participants; no downgrade > 199 participants.
[b]Generally 0.2 represents a small effect, 0.5 a moderate effect, and 0.8 a large effect.
[c]ROB: all studies with unclear risk of performance bias.
[d]ROB: More than 30% of participants with unclear or high risk for detection bias.
[e]Imprecision: very serious concern due to small study population (n < 100).
[f]Imprecision: serious concern due to small study population.

Summary of findings 2. Attention training compared to control for attention deficits following stroke at follow-up

Attention training compared to control for attention deficits following stroke 3–6 months after treatment

Patient or population: people with attention deficits following stroke
Settings: any rehabilitation setting
Intervention: attention training
Comparison: no treatment/treatment as usual

Outcomes	No of participants (studies)	Certainty of the evidence (GRADE)[a]	Estimated effect of intervention (SMD)[b]	95% confidence interval of estimated effect	Comments
Subjective measures – assessed with Cognitive Failures Questionnaire & Mental Slowness Questionnaire	99 (2 RCTs)	⊕⊖⊖⊖ **Very low**[c,d]	0.16 SMDs better	0.23 SMDs worse to 0.56 SMDs better	—
Objective global measures	No studies	—	—	—	No data
Alertness – assessed with Simple RT	31 (1 RCTs)	⊕⊖⊖⊖ **Very low**[c,d]	0.26 SMDs worse	0.97 SMDs worse to 0.45 SMDs better	—

Selective attention – assessed with Trail Making A	99 (2 RCTs)	⊕⊖⊖⊖ **Very low**[c,d]	0.07 SMDs better	0.32 SMDs worse to 0.47 SMDs better	—
Sustained attention – assessed with IVA-CPT Fullscale Attention Quotient	66 (1 RCT)	⊕⊖⊖⊖ **Very low**[c,d]	0.05 SMDs better	0.44 SMDs worse to 0.53 SMDs better	—
Divided attention – assessed with PASAT	99 (2 RCTs)	⊕⊖⊖⊖ **Very low**[c,d]	0.36 SMDs better	0.04 SMDs to 0.76 SMDs better	—
Functional abilities – assessed with Modified Rankin	66 (1 RCTs)	⊕⊖⊖⊖ **Very low**[c,d]	0.02 SMDs better	0.46 SMDs worse to 0.51 SMDs better	—
Mood – assessed with Center for Epidemiologic Studies Depression Scale, General Health Questionnaire	99 (2 RCTs)	⊕⊖⊖⊖ **Very low**[c,d]	0.29 SMDs better	0.11 SMDs worse to 0.69 SMDs better	—
Quality of life – assessed with SF-36 (Mental Component Summary subscale), EQ-VAS	99 (2 RCTs)	⊕⊖⊖⊖ **Very low**[c,d]	0.26 SMDs better	0.13 SMDs worse to 0.66 SMDs better	—

CI: confidence interval; **IVA-CPT:** Integrated Visual and Auditory Continuous Performance Test; **PASAT:** Paced Auditory Serial Addition Test; **RCT:** randomised controlled trial; **ROB:** risk of bias; **RT:** reaction time; **SF-36:** 36-item Short Form; **SMD:** standardised mean difference.

GRADE Working Group grades of evidence
High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

[a]Downgrades for imprecision: two levels for 1–99 participants; one level for 100–199 participants; no downgrade > 199 participants.
[b]Generally 0.2 represents a small effect, 0.5 a moderate effect, and 0.8 a large effect.
[c]ROB: all studies with unclear risk of performance bias.
[d]Imprecision: very serious concern due to small study population (n < 100).

BACKGROUND

Description of the condition

Deficits in attention are one of the most commonly observed cognitive impairments after stroke. The exact frequency of attentional deficits after stroke is a matter of debate. Within the acute phase, estimates range between 46% and 92% (Stapleton 2001). At discharge from hospital, estimates suggest a prevalence between 24% and 51% (Hyndman 2008). Speed of information processing can also be impaired, and estimates have varied between 50% and 70% (Hochstenbach 1998; Rasquin 2004). Attentional deficits may recover over time in some people (Hochstenbach 2003), but in 20% to 50% of stroke survivors there are persistent deficits for years (Barker-Collo 2010; Hyndman 2003).

Attentional impairments manifest themselves in a wide variety of deficits, such as diminished concentration, distractibility, reduced error control, difficulties doing more than one thing at a time, mental slowness, and mental fatigability. Being a mediator of other processes, attentional deficits may also impair higher cognitive functions, such as language and memory (Lezak 2004). While there is a consensus that attention is not a unitary process, there is no agreement on the typologies and taxonomies describing the range of attentional processes. For the current review, we considered the following attentional components: alertness/arousal, selective attention, sustained attention (vigilance), and divided attention (see Table 1). The rehabilitation of deficits in spatial attention is covered in a separate Cochrane Review (Bowen 2013), and therefore not covered in this review.

Table 1: Domains of attention

Domain of attention	Definition	Functional example
Alertness/arousal	Ability and readiness to respond	Response to warning signals
Selective attention	Ability to focus on specific stimuli while ignoring irrelevant stimuli	Reading while people talk in the background
Sustained attention (vigilance)	Ability to maintain attention over a prolonged period of time	Driving a car for long distances
Spatial attention	Ability to detect and deploy attention to all sides of space	Attending to people sitting on left and right side of the table
Divided attention	Ability to multitask and to divide attention between 2 or more tasks	Talking on the telephone while cooking

A distinction between different attentional domains is potentially important when evaluating rehabilitation. There is some evidence that attentional components need to be trained separately as there is little generalisation of treatment from one attentional domain to another (Sturm 1991; Sturm 1997). Moreover, cognitive training for certain domains, such as divided and selective attention, may be more effective than training for other domains, such as alertness and sustained attention (Cappa 2005).

The treatment of cognitive deficits is necessary because these deficits have a negative effect on functional abilities (Barker-Collo 2006), and quality of life (Kwa 1996; Mitchell 2010; Nys 2006). Sustained attention (concentration) is an important prerequisite for motor recovery since sufficient sustained attention is required for learning (Robertson 1997). Deficits in attention can affect the ability to engage with other rehabilitation required for poststroke recovery (e.g. physiotherapy) and are associated with increased risk of falls (Hyndman 2003). Other specific attentional disorders, such as auditory and visual selective attention, and divided attention, also affect functional recovery (Hyndman 2008; Stapleton 2001).

Description of the intervention

Cognitive rehabilitation interventions typically focus on re-establishing previously learned behaviours, developing new behaviours to compensate for cognitive deficits, and adapting to these cognitive deficits (Cicerone 2000). These interventions are guided and informed by psychological theories and models of behaviour and behaviour change, and cognitive or neuropsychological models of brain-behaviour interactions.

For people with attentional deficits, cognitive rehabilitation interventions include tasks designed to restore attention abilities, such as computerised activities and pencil-and-paper tasks requiring attention. The alternative approach is teaching people strategies to compensate for their attention impairments. Attempts to retrain attentional skills have mainly relied on a restitution approach, although trials of attentional rehabilitation for people with other forms of brain injury, for instance traumatic brain injury, have emphasised the development of compensatory strategies rather than the restoration of basic aspects of attention (Cicerone 2005).

Defining cognitive rehabilitation simply on the basis of its impact on 'attention' (or 'cognition' more broadly), however, is not straightforward. For instance, some pharmacological interventions, mindfulness interventions, and listening to music have positive effects on cognition (e.g. Särkämö 2008; Zeidan 2010). However, such interventions, although positively affecting cognition, are not usually regarded as 'cognitive rehabilitation' interventions based on the purported mechanisms of action (see below). Ultimately, cognitive rehabilitation, regardless of its focus

or strategy, aims to improve the person's function in their daily life (Ben-Yishay 1990; Cicerone 2000; Sohlberg 1989).

How the intervention might work

Cognitive rehabilitation is based on two main principles. One is 'restitution', which aims to restore cognitive function through repeated practice. The other is 'compensation', which aims to reduce the effects of cognitive impairment on functional abilities using strategies that minimise demands on attention skills.

Why it is important to do this review

Impairments of attention are a major problem for people with stroke and affect rehabilitation outcome, but the effectiveness of cognitive rehabilitation for attention is uncertain. Finding the best ways to improve cognition is a top 10 research priority for stroke survivors (Pollock 2012). In one survey of stroke survivor needs, 84% of 799 respondents reported that their needs were not fully met in relation to their concentration problems (McKevitt 2010). While attention training has been provided for some people with stroke, it needs further evaluation. There have been few studies that have used control groups, and most evaluations have been based on single-case experimental designs. Although these indicate treatment can be effective, they do not evaluate the general applicability of the findings. This updated review considered the evidence from controlled clinical trials (CCTs) and randomised controlled trials (RCTs) of the effectiveness of cognitive rehabilitation for attention.

OBJECTIVES

To determine whether people receiving cognitive rehabilitation for attention problems 1. show better outcomes in their attentional functions than those given no treatment or treatment as usual, and 2. have a better functional recovery, in terms of independence in activities of daily living, mood and quality of life, than those given no treatment or treatment as usual.

METHODS

Criteria for considering studies for this review

Types of studies

In the first version of this review, we sought all controlled trials which compared cognitive rehabilitation with a control treatment. In the second version of the review, we excluded all non-randomised trials to reduce selection bias. In this third update, we included quasi-randomised or CCTs, as per the updated guidance in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). We also reviewed those non-randomised trials which we excluded from the previous versions of the review to check these against the updated criteria. We decided to do this in advance of searching the literature. We sought RCTs and CCTs in which an attentional treatment was compared with a control. We also sought cross-over RCTs, but only included the outcomes between groups at the pre-cross-over period.

Types of participants

This review was confined to trials that selected people with demonstrable (on formal attention testing) or self-reported attentional deficits following stroke. We excluded trials in which participant selection for attentional training was based on general cognitive impairments (e.g. as assessed with the Mini-Mental State Examination) or other cognitive functions (e.g. aphasia). The participants were restricted to those with stroke. We excluded trials that included participants with mixed aetiologies unless separate data were available relating to people with stroke or if the trials had more than 75% of people with stroke in their sample.

Types of interventions

We included trials in which there was a comparison between a treatment group that received one of various attentional treatment strategies and a control group that received either an alternative form of treatment or no attentional intervention. We considered attention treatments to be any form of intervention with the aim of improving attention abilities. Alternative forms of treatment included computerised activities with low attentional demands and social activities. We excluded interventions that specifically aimed to improve spatial attentional deficits, as this has been the focus of a separate Cochrane Review (Bowen 2013). We did not consider listening to music, meditation, tai-chi, yoga, or mindfulness to be a form of cognitive rehabilitation, although we acknowledge that these interventions may have a positive effect on attention. In a similar vein, we did not include trials with only a single treatment session or pharmacological studies.

Types of outcome measures

The primary outcome was measures of global attentional functions, and the secondary outcomes were measures of the individual domains of attention, functional abilities in activities of daily living (ADL), mood, and quality of life. We assessed the outcomes immediately after treatment and at follow-up. We defined 'long-term' follow-up as more than three months after the intervention. We did not include studies in which the outcome was related exclusively to any single activity of daily living (e.g. driving a car).

Primary outcomes

Subjective reports of global attention as measured by validated rating scales, such as:

- Rating Scale of Attentional Behaviour (Ponsford 1991);
- Moss Attention Rating Scale (Whyte 2003);
- Attention Rating and Monitoring Scale (Cicerone 2002);
- Cognitive Failures Questionnaire (Broadbent 1982).

If an individual study reported more than one of these scales, we used the scale listed first.

Objective reports of global attention as measured by validated batteries assessing a wide range of attentional domains

We were not aware of any assessment batteries with a global score of attention at the start of this review. Batteries such as Test of Everyday Attention do not provide a total score (Robertson 1994). We included any validated assessments reporting global scores of attention.

Secondary outcomes

Objective reports of domains of attention as measured by:

- tests of alertness/arousal;
- tests of selective attention;
- tests of sustained attention;

- tests of divided attention.

We assigned each attentional test to a primary and a secondary attentional domain (see Appendix 1). For each trial, we only included one test measure in the analysis for a specific domain. We chose measures allocated to a primary domain over those allocated to secondary domains. We used the following hierarchy if a trial provided several measures for the same domain: combined error/speed measures > error measures > speed measures (median reaction times (RTs) > mean RTs). In the case when several tests were used to assess the same attentional domain within the same trial, we chose validated tests in preference to non-validated tests. If two or more standardised tests were used to assess the same attentional domain, we chose the one with the higher reliability and validity rating based on information from the *Compendium of Neuropsychological Tests* (Strauss 2006). If we could not decide with the above criteria, we selected one of the tests at random.

Reports of functional abilities in daily living, mood, and quality of life

- Functional abilities as measured by scales such as the Nottingham Extended Activities of Daily Living (NEADL; Nouri 1987), Functional Independence Measure (Granger 1994), Barthel Index (Mahoney 1965), and Stroke Impact Scale (Duncan 2003).
- Mood as measured by scales such as the General Health Questionnaire (GHQ; Goldberg 1972), and Hospital Anxiety and Depression Scale (HADS; Zigmond 1983).
- Quality of life, as measured by the World Health Organization Quality of Life (WHOQOL; WHOQOL Group 1998), and 36-item Short Form (SF-36; Ware 1992).

If more than one of these scales were reported, we used the scale listed first.

Search methods for identification of studies

See the 'Specialised register' information available at the Cochrane Stroke Group's website (www.dcn.ed.ac.uk/csrg/entity/searchmethods.pdf). We searched for relevant trials in all languages and arranged for the translation of trial reports published in languages other than English where necessary.

Electronic searches

We searched the Cochrane Stroke Group Register (last searched February 2019). In addition, we searched the following databases and registries:

- the Cochrane Central Register of Controlled Trials (CENTRAL; 2018, Issue 2 in the Cochrane Library; Appendix 2);
- MEDLINE Ovid (from 1948; Appendix 3);
- Embase Ovid (from 1947; Appendix 4);
- PsycINFO Ovid (from 1806; Appendix 5);
- Cumulative Index to Nursing and Allied Health Literature (CINAHL) EBSCO (from 1981; Appendix 6);
- Psychological Database for Brain Impairment Treatment Efficacy (PsycBITE, www.psycbite.com/; Appendix 7);
- REHABDATA (www.naric.com/research/rehab/; Appendix 8);
- US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (www.clinicaltrials.gov/; Appendix 9);
- World Health Organization International Clinical Trials Registry Platform (WHO ICTRP; apps.who.int/trialsearch; Appendix 10).

We developed the MEDLINE search strategy with the help of the Cochrane Stroke Group Information Specialist and modified it for the other databases. The search strategy included Cochrane's highly sensitive search strategies for identification of RCTs, as described in the *Cochrane Handbook for Systematic Reviews of Interventions* (Lefebvre 2011), and the Cochrane Stroke Group's search strategies for the identification of stroke studies in respective databases and other resources. The Cochrane Stroke Group Trials Information Specialist checked the search strategies from the previous review (no changes made). To identify new articles since the last review, the searches for this update were run from January 2012 to February 2019.

Searching other resources

To identify further published, unpublished, and ongoing trials, we scanned citations of the primary study articles, and we scanned reference lists from review articles and books identified in the searches.

For a previous version of this review, we conducted a handsearch of the following journals.

- *American Journal of Occupational Therapy* (1947 to 1998); *Aphasiology* (1987 to 1998); *Australian Journal of Occupational Therapy* (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 and Rehabilitation* (1992 to 1998) formerly *International Disability Studies* (1987 to 1991) formerly *International Rehabilitation Medicine* (1979 to 1986); *International Journal of Language and Communication Disorders* (1998) formerly *European Journal of Disorders of Communication* (1985 to 1997) formerly *British Journal of Disorders of Communication* (1977 to 1984); *Journal 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* (1993 to 1998); *International Journal of Rehabilitation Research* (1977 to 1998); *Journal of Rehabilitation Sciences* (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); *Journal of Cognitive Rehabilitation* (1988 to 1998) formerly *Cognitive Rehabilitation* (1983 to 1987).

Since handsearching these journals in 1999, many have been updated as part of Cochrane's handsearching effort. After checking the Master List of journals that was maintained by Cochrane, we were confident that relevant trials would be found from the search of CENTRAL. Therefore, we did not repeat handsearching of these journals.

Data collection and analysis

Selection of studies

We completed study selection for this update using the Covidence systematic review software (Covidence).

One review author (KJP) screened all the titles and abstracts of records obtained from the searches of the electronic databases and another review author (TL, RdN, or DW) independently reviewed all studies and excluded those that were clearly not relevant. We obtained the full text of the remaining studies (where possible) and two review authors independently assessed which studies met the inclusion criteria in relation to study type, participants, interventions, comparisons, and outcomes (KJM reviewed all studies, with the remaining review authors splitting the studies as second review authors). Two review authors (KJP, TL) resolved any disagreements by discussion.

Data extraction and management

For each of the studies meeting the inclusion criteria, we extracted the following characteristics:

- method of participant assignment and blinding;
- setting and participant details (including age, gender, time since stroke, eligibility criteria);
- intervention (including comparison intervention, treatment durations);
- outcome measures (including assessment methods and time points of assessments);
- results.

One review author (TL) extracted the study characteristics, and a second review author (KJP) checked the details.

Assessment of risk of bias in included studies

We applied Cochrane's recommended approach for assessing risk of bias in studies included in Cochrane Reviews (Higgins 2011). Two review authors (TL, KJP) assessed the methodological quality of each study in the following six domains: sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting, and 'other issues'. We judged each of these domains as either having a 'low', 'unclear', or 'high' risk of bias. We resolved disagreements by discussion. We used the results of the 'Risk of bias' assessment to inform the GRADE assessment.

Measures of treatment effect

We summarised ordinal scales using methods for continuous data. We expressed the intervention effect as a mean difference (MD) where studies measured outcomes using the same scales, or standardised mean difference (SMD) where studies used different scales, with the corresponding 95% confidence interval (CI). For some scales, a higher score indicated better ability/performance, and for others higher scores indicated worse ability/performance. Therefore, we multiplied the mean values from one set of studies by –1 to ensure that all the scales pointed in the same direction.

Unit of analysis issues

There were no unit of analysis issues. Four of the six identified studies used parallel group designs. For the two cross-over RCTs, we only considered the outcomes between groups at the precross-over period (Röhring 2004; Sturm 1991).

Dealing with missing data

We sought data that were not available or were unclear from the reports through correspondence with the first author of the publication. If we could not obtain the required information for an included study, we did not include that study in the analysis.

Assessment of heterogeneity

We assessed statistical heterogeneity using Chi^2 statistics and I^2 statistic estimates to quantify inconsistency across trials (Higgins 2011). We considered an I^2 value above 50% to indicate substantial heterogeneity and 75% to indicate considerable heterogeneity.

Assessment of reporting biases

As no trials registers and study protocols were available for the identified studies, we investigated selective reporting by comparing the methods section of the studies with the results reported. We did not inspect funnel plots for publication biases due to the small sample size of fewer than 10 studies (Higgins 2011).

Data synthesis

We conducted a meta-analysis using the Review Manager software RevMan 5.3 (Review Manager 2014). A fixed-effect model with 95% CI was used if there was acceptable heterogeneity between trials (I^2 < 50%). We used a random-effects model for the meta-analysis if we judged the characteristics of studies to be similar and heterogeneity was not considerable (i.e. I^2 < 75%). If we judged studies to be dissimilar (e.g. considerable variation in study characteristics, or considerable heterogeneity (I^2 > 75%)), we would have reported outcomes narratively. In the case of considerable heterogeneity, we would have explored subgroup analyses.

GRADE and 'Summary of findings' table

We used the GRADE approach to assess the certainty of evidence (Guyatt 2008). We downgraded evidence by one level ('high quality' to 'moderate quality') for serious study limitations related to 1. risk of bias, 2. consistency of evidence, 3. directness of evidence, and 4. imprecision of effect estimates. In case of very serious limitations, we downgraded the certainty of evidence by two levels. We created 'Summary of findings' tables to provide synthesised information regarding the overall certainty of evidence for the primary and secondary outcomes. We used GRADEpro GDT software to construct the tables (GRADEpro GDT 2015).

Subgroup analysis and investigation of heterogeneity

If sufficient data were available, we planned to perform subgroup analyses to determine whether outcomes varied according to time since onset of stroke, frequency of intervention (number of sessions per week), intensity of intervention (total hours of intervention), and type of intervention.

Sensitivity analysis

We planned a sensitivity analysis on the methodological quality of studies by excluding studies with high risk of bias.

RESULTS

Description of studies

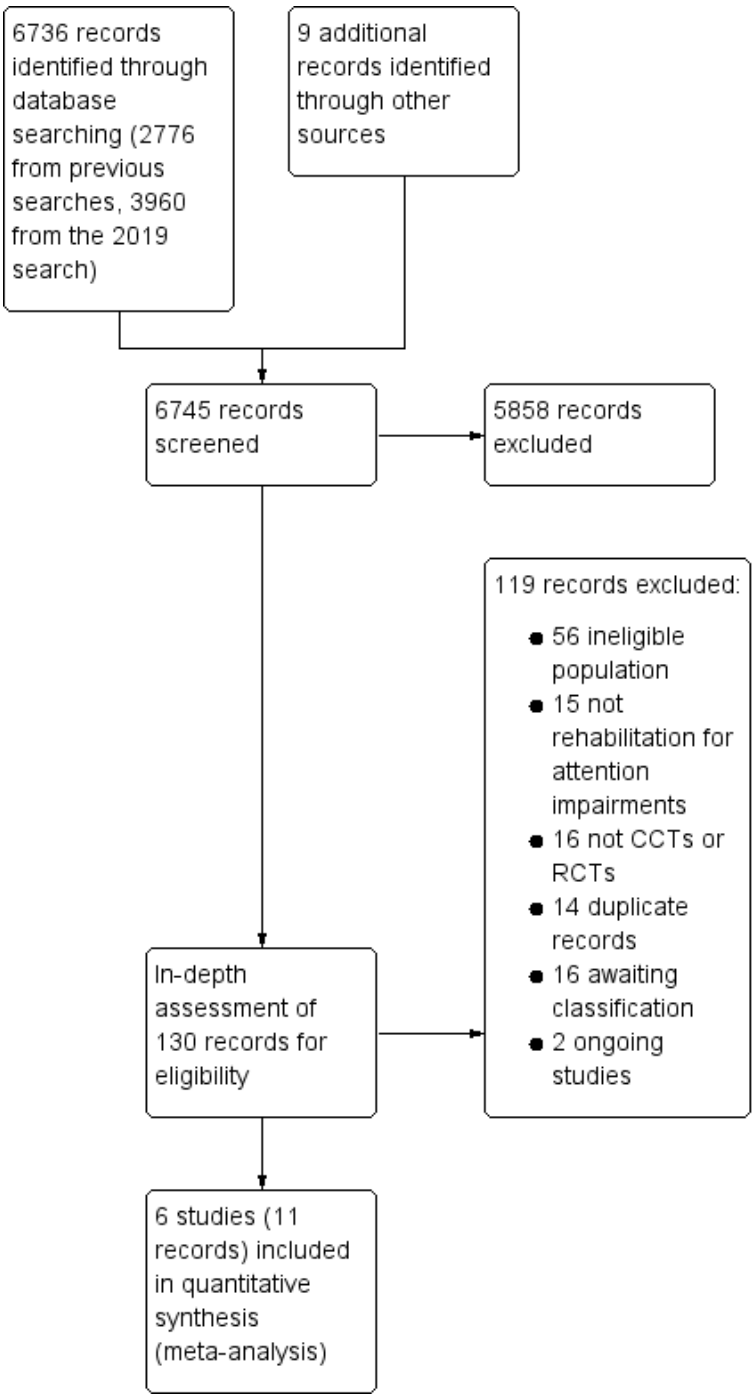
See Characteristics of included studies table.

Results of the search

The searches for studies in the previous reviews identified 2785 records. The search for this update was completed in February

2019 and retrieved 3960 new records. Initial screening of the 6745 records identified 130 possibly relevant studies. An in-depth assessment of these papers identified six studies (11 records) that met the inclusion criteria. The study selection process is outlined in Figure 1.

Figure 1. Study flow diagram. CCT: controlled clinical trial; RCT: randomised controlled trial.



Of the 119 studies that we excluded, 14 were duplicate records of studies and 87 did not meet the inclusion criteria. The reasons for exclusion of studies are summarised in the Characteristics of excluded studies table. We excluded 56 studies because they were not stroke (i.e. less than 75% of study participants had a stroke) or participants were not selected because of attentional problems. We excluded 16 studies because they were not CCTs or RCTs, and 15 studies because they did not involve cognitive rehabilitation for attention impairments. We excluded a further 16 studies because insufficient information was available to make a decision at this stage (see Characteristics of studies awaiting classification table), and we two studies are ongoing (see Characteristics of ongoing studies table).

Included studies

We included six studies treating attentional deficits after stroke in this review (see Characteristics of included studies table). The six studies included 223 participants. Of the six RCTs, four used a parallel group design (Barker-Collo 2009; Schottke 1997; Westerberg 2007; Winkens 2009), and two used a cross-over design (Röhring 2004; Sturm 1991). Five studies reported the method of generating the random schedule. Two of these used random number tables (Röhring 2004; Sturm 1991), one used an online Internet randomisation service (Barker-Collo 2009), one used coin tossing (Schottke 1997), one used drawing numbers from a bucket (Westerberg 2007), and in one this was unclear (Winkens 2009). Three studies generated the sequence independently (Barker-Collo 2009; Westerberg 2007; Winkens 2009), and it was unclear in the other three (Röhring 2004; Schottke 1997; Sturm 1991). In all studies, the participants and therapists were aware of the treatment being given. Three studies assessed outcomes using a blinded assessor (Barker-Collo 2009; Röhring 2004; Winkens 2009), in two the therapist conducted the outcome assessments (Schottke 1997; Westerberg 2007), and in one this was unclear (Sturm 1991).

One study was conducted in New Zealand (Barker-Collo 2009), and five in Europe: three in Germany (Röhring 2004; Schottke 1997; Sturm 1991), one in Sweden (Westerberg 2007), and one in the Netherlands (Winkens 2009). The number of participants recruited to the studies varied between 78 (Barker-Collo 2009), and 18 (Westerberg 2007). Four studies included only participants with stroke (Barker-Collo 2009; Schottke 1997; Westerberg 2007; Winkens 2009). Two studies recruited most participants within the first two months after stroke (Barker-Collo 2009; Schottke 1997), three mainly within one year of stroke (Sturm 1991; Westerberg 2007; Winkens 2009), and one study recruited participants up to four years after stroke (Röhring 2004). Three studies recruited participants with both right and left hemisphere lesions (Barker-Collo 2009; Schottke 1997; Westerberg 2007), one included people with left hemisphere lesions in the randomised trial (Sturm 1991), and two studies did not report this information (Röhring 2004; Winkens 2009). The mean age of the samples was under 65 years in all except one study (Barker-Collo 2009). The proportion of men ranged between 51% (Schottke 1997), and 70% (Sturm 1991).

Two studies identified attention deficits on tests of attention using specified cut-offs (Barker-Collo 2009; Schottke 1997), two studies on tests for attention without specification of cut-offs (Röhring 2004; Sturm 1991), and two studies on self- or therapist-reported attention deficits (Westerberg 2007; Winkens 2009). Groups were well matched at baseline apart from three studies. In two studies, the time after stroke was shorter for controls than intervention group participants (Schottke 1997; Winkens 2009), and in one study, the control group had more people with aphasia and scored lower in tasks assessing reasoning abilities (Sturm 1991).

Interventions aimed to either restore attentional functions (Barker-Collo 2009; Röhring 2004; Schottke 1997; Sturm 1991; Westerberg 2007), or provide compensatory strategies (Winkens 2009). One study applied both intervention approaches (Schottke 1997). Interventions lasted from three weeks (Schottke 1997; Sturm 1991), to 11 weeks (Röhring 2004), and the number of sessions of treatment varied between 13 (Schottke 1997), and 55 (Röhring 2004), for the restorative approaches. The compensatory approach was delivered for 10 hours (Winkens 2009). The control groups in all studies received usual care with no treatment of attention deficits.

The six studies used over 30 psychometric tests with more than 40 test variables as attentional outcome measures. Four of the six studies assessed at least one functional outcome (Barker-Collo 2009; Röhring 2004; Schottke 1997; Winkens 2009). All studies reported outcomes immediately after treatment; two studies also reported outcomes of follow-up assessments (long-term effects) (Barker-Collo 2009; Winkens 2009).

For measures of attention, the findings of four individual studies supported the efficacy of treatment (Barker-Collo 2009; Schottke 1997; Westerberg 2007; Sturm 1991), but two studies found limited evidence of benefit (Röhring 2004; Winkens 2009).

Risk of bias in included studies

The risk of bias for each study is summarised in Figure 2. An overview of the risk across all studies is provided in Figure 3.

Figure 2. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

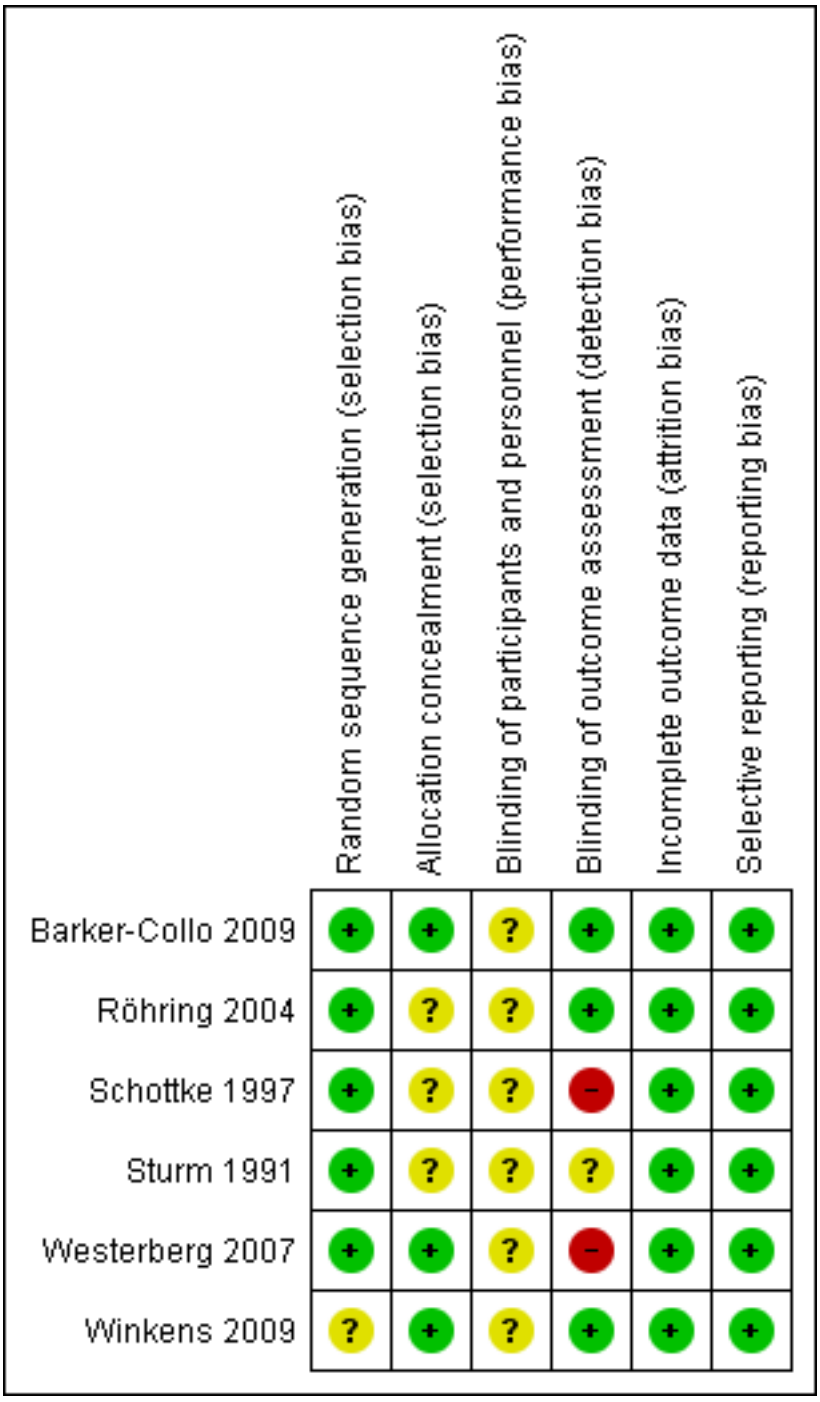
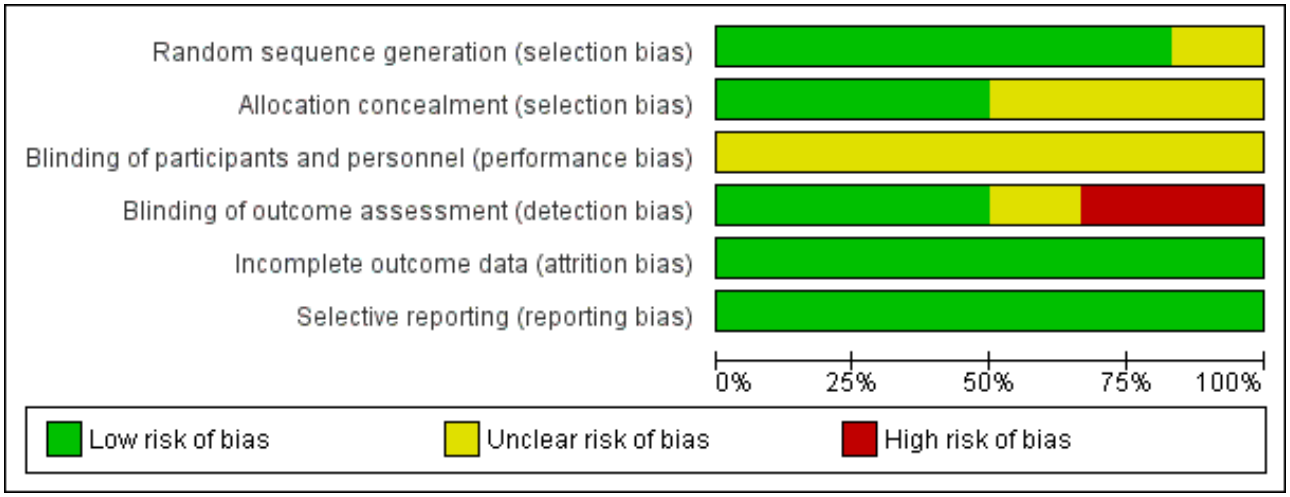


Figure 3. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.



Allocation

While all six studies were described as randomised, there were insufficient details available in one study to judge the risk of bias for the randomisation process (Winkens 2009). In three out of the six studies, there was insufficient information to allow judgement of the risk of an allocation concealment bias (Röhring 2004; Schottke 1997; Sturm 1991).

Blinding

All studies compared the effect of an intervention with care as usual. Blinding of the participants and therapists was not possible once the intervention started, and therefore no studies were double-blind. Two studies showed a high risk of detection bias as the outcome assessment was not conducted blinded to the group allocation (Schottke 1997; Westerberg 2007). One study is at unclear risk as there was insufficient information to judge the risk of a detection bias (Sturm 1991).

Incomplete outcome data

All studies were at low risk of attrition bias. Dropouts from studies appeared generally balanced across groups (6.8% for the treatment groups and 5.3% for the control groups).

Selective reporting

There was no indication of any selective reporting, but none of the trials appeared to be prospectively registered on trial registries.

Effects of interventions

See: **Summary of findings for the main comparison** Attention training compared to control for attention deficits following stroke immediately after treatment; **Summary of findings 2** Attention training compared to control for attention deficits following stroke at follow-up

We assessed the effect of interventions immediately after treatment and at follow-up. The included studies applied diverse outcome measures. The measures we chose for the analysis of treatment effects on attentional and functional outcomes are listed in Table 1 and Table 2.

Primary outcomes

Effects immediately after treatment

Two studies involving 53 participants assessed subjective reports of global attentional functions with either the Cognitive Failures Questionnaire (Westerberg 2007), or the Mental Slowness Questionnaire (Winkens 2009). There was a no convincing effect in favour of the intervention compared with care as usual (SMD 0.53, 95% CI −0.03 to 1.08; P = 0.06; very low-quality evidence; Analysis 1.1).

Long-term effects

The two studies involving 99 participants investigating long-term effects on subjective reports of global attentional functions found no evidence for effects of treatment (SMD 0.16, 95% CI −0.23 to 0.56; P = 0.41; very low-quality evidence; Analysis 2.1) (Barker-Collo 2009; Winkens 2009).

We identified no studies that reported objective measures of global attention at the end of treatment or in the longer term.

Secondary outcomes

Effects immediately after treatment

People receiving cognitive rehabilitation (when compared with control) showed improvements on measures of divided attention recorded immediately after treatment. Four studies comprising 165 participants assessed divided attention using the Paced Auditory Serial Addition Test (PASAT) (Barker-Collo 2009; Westerberg 2007; Winkens 2009), or the divided attention subtest from the Tests of Attentional Performance battery (TAP) (Röhring 2004). The analysis found that the intervention was beneficial compared with care as usual (SMD 0.67, 95% CI 0.35 to 0.98; P < 0.0001; low-quality evidence; Analysis 3.4).

We found no convincing effects on other domains of attention. Four studies comprising 136 participants investigated an effect on alertness (SMD 0.14, 95% CI −0.20 to 0.48; P = 0.41; low-quality evidence; Analysis 3.1; Röhring 2004; Schottke 1997; Sturm 1991; Winkens 2009). Six studies comprising 223 participants examined the effects on selective attention (SMD −0.08, 95% CI −0.35 to 0.18;

P = 0.53; moderate-quality evidence; Analysis 3.2). Four studies comprising 169 participants examined the effects on sustained attention (Barker-Collo 2009; Röhring 2004; Schottke 1997; Sturm 1991). As the heterogeneity between trials for this measure was high (I^2 > 50%), we used a random-effects model for analysing sustained attention (SMD 0.39, 95% CI −0.16 to 0.94; P = 0.16; low-quality evidence; Analysis 3.3).

Rehabilitation of attention did not show any convincing effects on functional abilities in daily living (SMD 0.29, 95% CI −0.16 to 0.75; P = 0.21; 2 studies, 75 participants; very low-quality evidence; Analysis 4.1; Röhring 2004; Schottke 1997), mood (SMD 0.01, 95% CI −0.36 to 0.39; P = 0.94; 3 studies using depression scales, 109 participants; low-quality evidence; Analysis 4.2; Röhring 2004; Schottke 1997; Winkens 2009), or quality of life (SMD 0.02, 95% CI −0.37 to 0.40; P = 0.94; 2 studies, 103 participants; low-quality evidence; Analysis 4.3; Barker-Collo 2009; Winkens 2009).

Long-term effects

Two studies comprising 99 participants assessed long-term effects of treatment on divided attention and there was no convincing effect of treatment compared with care as usual (SMD 0.36, 95% CI −0.04 to 0.76; P = 0.08; very low-quality evidence; Analysis 5.4; Barker-Collo 2009; Winkens 2009). There was no convincing evidence for treatment effects on the other domains of attention. One study comprising 31 participants examined effects on alertness (SMD −0.26, 95% CI −0.97 to 0.45; P = 0.47; very low-quality evidence; Analysis 5.1; Winkens 2009). Two studies comprising 99 participants investigated effects on selective attention at follow-up (SMD 0.07, 95% CI −0.32 to 0.47; P = 0.72; very low-quality evidence; Analysis 5.2; Barker-Collo 2009; Winkens 2009), and one study comprising 66 participants assessed the effect on sustained attention (SMD 0.05, 95% CI −0.44 to 0.53; P = 0.84; very low-quality evidence; Analysis 5.3; Barker-Collo 2009).

The only study testing for long-term effects on functional abilities in daily living comprising 66 participants found no evidence for an effect of treatment (SMD 0.02, 95% CI −0.46 to 0.51; P = 0.92; very low-quality evidence; Analysis 6.1; Barker-Collo 2009). Two studies with 99 participants found no convincing effects on mood (SMD 0.29, 95% CI −0.11 to 0.69; P = 0.15; very low-quality evidence; Analysis 6.2) or quality of life (SMD 0.26, 95% CI −0.13 to 0.66; P = 0.19; very low-quality evidence; Analysis 6.3) (Barker-Collo 2009; Winkens 2009).

Subgroup and sensitivity analyses

We were unable to run subgroup or sensitivity analyses because there were insufficient data available.

DISCUSSION

We found no new trials for this update. The results are unchanged from the previous review and are based on the data of six trials with 223 participants.

Summary of main results

There was no evidence to support a beneficial effect of cognitive rehabilitation on global attentional functions (very low-quality evidence). People receiving cognitive rehabilitation showed improvements on measures of divided attention immediately after rehabilitation (moderate effect size, low-quality evidence), but there was no convincing evidence that these improvements were retained (very low-quality evidence). There was no evidence to support the effect of cognitive rehabilitation on specific attentional domains (alertness, selective attention, sustained attention), functional abilities, mood (depression), and quality of life.

Overall completeness and applicability of evidence

Some authors provided unpublished data (Barker-Collo 2009; Röhring 2004; Winkens 2009), and others clarified aspects that were unclear from the published reports (Schottke 1997; Sturm 1991; Westerberg 2007). We excluded some studies on the basis of information from authors (Kim 2008), and others confirmed the results were not yet published (see Characteristics of studies awaiting classification table).

Trials generally had small sample sizes ranging from 18 to 78, which limits the ability to generalise from these studies. Future studies should be adequately powered to detect the effects of treatment on functional outcomes. The results from these studies should enable a power calculation for future studies.

The studies included a wide variety of interventions; almost all were computerised. The comparison for most studies was treatment as usual. Future studies could be improved by the use of attention placebo control groups that provide the computerised activities but not the attention retraining activities (e.g. as in Gray 1992). However, this may not be feasible in attentional rehabilitation studies where it is difficult to mask the nature of the intervention to the participants (e.g. in a group-based intervention with a facilitator, where the objective or focus of the intervention may be clear to the participants).

Most studies assessed outcomes on measures of attention on standardised tests. The six studies reported 40 different test variables of attentional outcomes. It has been suggested that cognitive training for certain attentional domains might be more effective than for others (see Cappa 2005) and that there is limited generalisation of treatment from one attentional domain to another (Sturm 1997). Therefore, it seemed important to evaluate treatment effects on different attentional domains. However, it would be beneficial if there was broader consensus on the attentional processes these variables tap and greater consistency in the choice of outcome measures. A composite test score assessing several attentional domains would assist with identifying the overall benefit of attention training; however, there is no empirical framework or clear consensus on how to calculate an overall attention composite score (in the same way as, for example, an intelligence quotient (IQ) score). Future work towards a clear definition of attentional impairments and the best methods for measuring these will be needed for the field to progress.

Furthermore, as with cognitive rehabilitation research more broadly, few attention rehabilitation trials measured functional outcomes. Yet for stroke survivors, the impact of attentional impairments on activity and participation is the most meaningful target for change. Indeed, for many clinicians and researchers, this should be the logical endpoint or focus of cognitive rehabilitation. However, self-report measures of everyday attentional difficulties also have the issue of demand characteristics on non-blind participants who are reporting the outcome of the attentional training they know they have received. Measuring the everyday functional impact of attention interventions in valid, reliable

and feasible ways (e.g. perhaps incorporating experience-based sampling, close other/clinician reports, goal attainment scaling, or a combination of these) is another important challenge for this field of research.

The inclusion criteria for attentional deficits varied considerably across trials, and accordingly, the degree of attentional deficits at the start of the treatment differed widely. This review could not address whether treatment success is modulated by the severity of attentional impairments in an individual.

There were insufficient data to evaluate whether treatment is more effective in the postacute phase than in the acute phase of recovery (Cappa 2005; Cicerone 2011). Similarly, we were unable to conduct the planned subgroup analyses to determine whether outcomes varied according to frequency of intervention (number of sessions per week), intensity of intervention (total hours of intervention), and type of intervention because of insufficient data.

Quality of the evidence

The overall certainty of evidence was very low to moderate. The evidence base was small with few methodologically robust RCTs. We typically downgraded evidence because of imprecision due to small sample sizes and risk of bias due to inadequate reporting of allocation concealment and unclear risk of performance bias (see Summary of findings for the main comparison and Summary of findings 2).

Potential biases in the review process

Two review authors independently assessed the included studies and made final decisions following discussion. One review author (TL) proposed the allocation of attention tasks to attentional domains and the second review author of the last update (Nadina Lincoln) confirmed these. While the assignments are consistent with commonly used typologies and taxonomies of attentional processes in clinical settings, we acknowledge that these assignments are, to some degree, arbitrary as the same test variable may tap into several different attentional domains (Lezak 2004; Strauss 2006).

In addition, the exclusion of studies on attention retraining to improve single ADLs (e.g. driving ability), could be seen as a limitation, but outcomes based on individual ADLs would be difficult to aggregate. Based on our knowledge of the literature, we did not feel this was appropriate at this time, but perhaps could be considered when more research accrues. Excluding interventions that could have had an impact on cognition (e.g. music therapy or mindfulness) could have biased the outcomes, but our definition of cognitive rehabilitation and interventions to be considered as cognitive rehabilitation was established a priori. A future more generic review that focuses on all types of non-pharmacological interventions for attentional problems could consider including these and other types of interventions that are likely to have a positive impact on attention (e.g. interventions targeting fatigue and sleep disturbances). Similarly, the selection requirement of demonstrable attention deficits and exclusion of studies which based the selection on impairments in general cognitive functioning (e.g. Mini-Mental State Examination scores) could be considered as a somewhat narrow inclusion criterion. However, we felt it was important to only include studies of cognitive rehabilitation for attentional problems that recruited people who had attentional problems, because this may have affected the outcomes of the intervention. Future reviews could consider widening this inclusion criterion but would need to consider a sensitivity analysis to examine whether there are differential treatment effects between studies that do and do not include those with attentional problems at baseline.

Agreements and disagreements with other studies or reviews

We found some benefits of cognitive rehabilitation for divided attention, but not for other attentional domains. This finding is consistent with a meta-analysis of attention rehabilitation after acquired brain injury, which also found effects confined to divided attention (Virk 2015). Other relevant meta-analyses have tended to find a small effect for attention that was not specific to a particular domain (Bogdanova 2016; Rogers 2018; Weicker 2016); however, not all of these reviews analysed each domain separately.

Rogers 2018 further reported that improvements in attention were observed for interventions targeting visuo-spatial and perceptual skills and general cognition as well those targeting attention. This suggests that a wider definition of attention rehabilitation may have produced different results for this review.

The review concludes that overall there is insufficient evidence to support or refute the effectiveness of cognitive rehabilitation for attention after stroke. This conclusion is unchanged from the previous Cochrane Review (Loetscher 2013), and consistent with another meta-analysis assessing treatment outcomes of attention rehabilitation after acquired brain injury (Park 2001). The finding that short-term gains in attention are not consistently maintained at longer-term follow-up was also reported in the meta-analyses by Rogers 2018 and Virk 2015, supporting the need for evaluations of strategies to sustain gains made in cognitive rehabilitation.

The appraisal of the evidence in favour of rehabilitation is somewhat less positive than reviews of cognitive rehabilitation for people with acquired brain injury (Cappa 2005; Cicerone 2011; Cicerone 2019), as well as one review of non-RCTs in stroke (Merriman 2019). One reason for the discrepancy is probably because the current review applied more rigorous inclusion criteria than these reviews. In Cicerone 2019, for example, seven of the 13 studies reviewed were class III studies. Consistent with this, Rogers 2018 found the strength of the overall effect of cognitive rehabilitation was moderated significantly by study quality, with lower quality studies reporting larger effect sizes.

AUTHORS' CONCLUSIONS

Implications for practice

The effectiveness of cognitive rehabilitation for attention deficits following stroke remains unconfirmed. Cognitive rehabilitation may improve some specific aspects of attention immediately after treatment. There was no evidence to indicate whether the benefits persist in the long term. However, improving attention in the short term may enable people to engage better in rehabilitation and improve their ability to cope with tasks in which they are required to do two things at the same time, such as walking and talking. It is important that when rehabilitation for attention is carried out the benefits are monitored closely because at present no specific rehabilitation approach can be recommended.

Implications for research

There was some limited evidence that cognitive rehabilitation may improve some aspects of attention immediately after treatment, but there was insufficient evidence to support or refute the persisting effects of cognitive rehabilitation on attention, or on functional outcomes in the long term. Therefore, it is important that more randomised trials are conducted to inform clinical practice. Cognitive impairment has been named as a key priority in the Second Stroke Recovery and Rehabilitation Roundtable (Bernhardt 2019). However, clear definition and measurement of treatment targets, both at the level of impairment (i.e. robust attention composite scores) as well as activity and participation (i.e. valid and feasible measures of the everyday functional impact of attentional impairment), are urgent priorities for attention rehabilitation research. Additionally, the long-term effects of cognitive rehabilitation need to be evaluated in addition to short-term effects, and interventions should incorporate strategies for sustaining the gains made.

There needs to be more attention to both the design of methodologically sound studies and reporting that conforms with the CONSORT guidelines. Trialists are encouraged to refer to the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011), and the *Template for Intervention Description and Replication* (TIDieR; Hoffmann 2014), for the reporting of interventions. In addition, trials need to have adequate power to detect clinically meaningful differences between groups. It is important that such evaluations are carried out as the best ways to improve cognition after stroke is one of the top 10 research priorities reported by people with stroke (Pollock 2012).

This review is ongoing and the authors would like to receive information on ongoing trials for a future update.

ACKNOWLEDGEMENTS

We thank the principal investigators of included and excluded studies for providing data and additional information. We also thank Hazel Fraser for her assistance with searching and overall guidance. We also thank Nadina Lincoln, Mariam Majid and Nicola Weyman for their contributions to the previous reviews, and Katharine Baker for her assistance with screening of articles.

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CHARACTERISTICS OF STUDIES

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

Barker-Collo 2009

Methods	RCT, parallel group design Concealed online Internet randomisation service with stratified minimisation Implementation of randomisation sequence by the treating clinician who had no access to assessment data. Randomisation information was not accessible by any other study staff during the study. Approach: restoration of attentional functions with the means of APT
Participants	New Zealand, recruited from 2 hospitals Total participant sample 78; 10 lost at 5 weeks, 12 were not assessed at 6 months Treatment group: n = 38; mean (± SD) age 70.2 ± 15.6 years; 60.5% males; mean (± SD) 18.5 ± 12.0 days since onset; hemisphere of lesion: 14 left (44%), 15 right (47%), 3 bilateral or unclear (9%) Control group: n = 40; mean (± SD) age 67.7 ± 15.6 years; 60.0% males; mean (± SD) 18.6 ± 7.6 days since onset; hemisphere of lesion: 25 left (58%), 17 right (40%), 1 bilateral or unclear (2%) Inclusion criteria: attention deficit defined as performance > 1 SD below norm on any attentional tests; stroke using WHO criteria; admitted to 1 of 2 hospitals; within 2 weeks of stroke Exclusion criteria: unable to give consent; MMSE < 20; medically unstable; unable to speak English; other relevant conditions, such as dementia
Interventions	Treatment: up to 30 hours' individual APT for 1 hour on weekdays for 4 weeks, mean (± SD) 13.5 ± 9.4 hours Control: no treatment
Outcomes	Measured immediately after treatment (5 weeks) and at follow-up (6 months) Primary outcome: • IVA-CPT Full-Scale Attention Quotient (z-scores) Secondary outcomes: • IVA-CPT Auditory attention (z-scores) • IVA-CPT Visual attention (z-scores) • Bells test (omissions of left-, central, and right-sided targets) • Trail Making A & B (z-scores) • PASAT (z-scores for 2 and 2.4 seconds) • SF-36 (Mental Component Score and Physical Component Score) • Modified Rankin (raw score)* • Cognitive Failures Questionnaire (raw score)* • GHQ-28 (raw score)* *Only measured at 6 months' follow-up
Notes	Provided numbers of side of hemisphere lesions did not add up to total participant sample. Additional data for analysis provided by authors.

Risk of bias

Bias	Authors' judgement	Support for judgement

Barker-Collo 2009 *(Continued)*

Random sequence generation (selection bias)	Low risk	Internet based and independent
Allocation concealment (selection bias)	Low risk	Concealed
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Participants and therapist not blinded as aware of intervention being given.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Trained assessor blind to randomisation
Incomplete outcome data (attrition bias) All outcomes	Low risk	Intention-to-treat analysis Last observation carried forward
Selective reporting (reporting bias)	Low risk	No indication in article

Röhring 2004

Methods	RCT, cross-over group design with pair matching Pairs were matched for age, sex, aetiology, side of brain lesion, and time since incident. Allocation to groups according to table of random numbers Planned cross-over design, but only results of first phase (group 1 received intervention, group 2 no training) were reported Approach: restoration of attentional functions by computer training
Participants	Germany, single-centre study Total participant sample: 48 (62 people started study, but 7 people lost in intervention group because of: insufficient training (n = 2), personal reasons (n = 2), medical reasons (n = 2), and because of an exclusion criteria defined after start of training (n = 1). The 7 matched participants in the control group were also excluded from analysis). Participant sample included 5 people with TBI Treatment group: n = 24; mean (± SD) age 51.6 ± 13.0 years; 62.5% males Control group: n = 24; mean (± SD) age 54.9 ± 11.4 years; 62.5% males No subgroup data for hemisphere of lesion, aetiology, and time since incident (group mean (± SD) 25.5 ± 13.7 months) Inclusion criteria: attention deficits (tests and cut-off criteria not specified); brain damage > 6 months and < 4 years; available transport opportunity to clinic; being able to keep concentration up for 30 minutes per day Exclusion criteria: aged > 70 years; probability of progressing brain disorder; other major neurological or psychiatric disorders; major neuropsychological deficits; any disability that would prevent independent use of the computer program
Interventions	Treatment: 30–45 minutes of computer-based training at home for 5 days per week for 11 weeks in total. Cogpack (evosoft TeleCare/Dr Hein GmbH) was used as training software. Self-reported mean (±

Röhring 2004 *(Continued)*

	SD) training time was 241 ± 135 minutes per week. All participants had 1 therapy session per week at the clinic in addition to the computer training. Control: no treatment, but regularly contacted by therapists to learn about the participants' well-being
Outcomes	Measured after intervention (11 weeks) Several measures, but no definition of primary outcome measure: • d2 (Hits-Errors, T-scores provided by authors) • Tests of Attentional Performance (subtests for intrinsic alertness, phasic alertness, divided attention, selective attention) • LGT-3 (Learning/Memory task) • Leistungsprüfsystem L-P-S (subtests out of an IQ test) • Personality Questionnaire • Barthel • FIM • Zung Depression Status Inventory • SF-36 (no data after treatment available)
Notes	No matching for attention deficits or any other outcome measures at baseline. Data for analysis provided by authors.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Random number table
Allocation concealment (selection bias)	Unclear risk	No information available
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Participants and therapists not blinded to intervention
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Assessor blinded (information provided by authors)
Incomplete outcome data (attrition bias) All outcomes	Low risk	Missing data in treatment group (n = 7) was controlled for by excluding the corresponding matched participant in control group for the analysis.
Selective reporting (reporting bias)	Low risk	While not all of the study's specified outcome measures were reported in the paper (e.g. at 4 months' follow-up only 1 attentional outcome measure was reported), all data were provided by the authors for the current analysis.

Schottke 1997

Methods	RCT, multicentre study, parallel group design with pair matching

Schottke 1997 *(Continued)*

	Pairs were matched for side and aetiology of lesion, education level, and participating centre. Allocation of 1 person from each matched pair to treatment group by coin toss. 3 people could not be matched and were allocated to the control group. No concealment of intervention or outcome measurement (assessment and training by same person) Approach: restoration of attentional functions and compensatory strategies
Participants	Germany, recruited from 2 hospitals Total participant sample 29; 0 people lost to follow-up Treatment group: n = 16; mean (± SD) age 64.1 ± 8.5 years; 56.3% males; mean (± SD) 51.6 ± 21.5 days since onset; hemisphere of lesion: 5 left, 11 right Control group: n = 13; mean (± SD) age 65.4 ± 10.9 years; 46.2% males; mean (± SD) 37.5 ± 11.4 days since onset; hemisphere of lesion: 2 left, 11 right Inclusion criteria: attention deficit defined as standard scores < 80 in any of the attentional tests; stable cardiovascular system; able to travel to training room; cerebral infarct or haemorrhage; neurological symptoms lasting > 24 hours Exclusion criteria: aphasia
Interventions	Treatment: 13 training sessions in 3 weeks, which included a wide range of different training methods (e.g. computerised reaction training, paper-and-pencil tasks, scanning training, cognitive-behavioural training, and relaxation techniques). Duration of a single session not specified. Control: treatment as usual
Outcomes	Measured after intervention (3 weeks) Several standardised measures of attention with no definition of primary outcome measure: • Tempo-Lern-Test (percentile scores for each of the 3 experimental blocks) • Wahl-Reaktions-Test (percentile scores for 2 reaction time measures) • Zahlen-Verbindungstest (percentile scores) • Konzentrations-Verlaufs-Test (standard scores for speed, errors, and combined speed/errors scores) • Visual-Discrimination-Conditioner (raw score correct responses) • Line Bisection (deviation in % from true mid-point) • Behavioural Test of Inattentiveness in Daily Life (raw scores) • Barthel completed by self and another (raw scores) • Emotional State Questionnaire (raw scores for the subscales 'depression', 'fear', 'fatigue', 'activity', and 'relaxation')
Notes	Time after stroke significantly shorter for controls compared to the treatment group. Visual-Discrimination-Conditioner programme used for treatment and outcome assessment.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Coin tossing
Allocation concealment (selection bias)	Unclear risk	No information reported

Schottke 1997 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No blinding
Blinding of outcome assessment (detection bias) All outcomes	High risk	Training and assessment by same person
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data
Selective reporting (reporting bias)	Low risk	No indication in article, but study protocol not available

Sturm 1991

Methods	RCT, cross-over group design Participants with left-brain damage were allocated to 2 comparable groups with respect to age, sex, and time postonset. Allocation of people to treatment group by random number table. There was a third training group with right-brain damaged people. They were trained 'late' in the cross-over design and their data were excluded from the current analysis. Approach: restore attentional functions by computer training
Participants	Germany Total participants sample: 37; 0 people lost to follow-up Treatment group: n = 13; mean (± SD) age 51.5 ± 9.5 years; 69.2% males; mean (± SD) 15 ± 9.7 weeks since onset; hemisphere of lesion: 13 left, 1 non-stroke participant Control group: n = 14; mean (± SD) age 49.6 ± 9.5 years; 71.4% males; mean (± SD) 16.4 ± 9.2 weeks since onset; hemisphere of lesion: 14 left, 2 non-stroke participants No inclusion or exclusion criteria specified. All participants had attentional deficits according to authors.
Interventions	Treatment: 30 minutes' computer-based training at clinic, 14 sessions spread over 3 consecutive weeks. Cognitrone and Wiener Determinationsgerat were used as training software. Control: no treatment
Outcomes	Measured after intervention at 3 weeks, after cross-over at 6 weeks, and at 12 weeks' follow-up Several measures, but no definition of primary outcome measure: • Wiener Determinationsgerat (hits and false alarms, z-scores) • Cognitrone (hits and false alarms, z-scores) • Wiener Reaktionsgerat (reaction times for visual, auditory and choice subtests, z-scores) • Wiener Vigilanzgerat (hits and false alarms, z-scores) • d2 (hits minus errors, z-scores) • Non-attentional tasks, such as Raven Standard Progressive Matrices and WAIS subtest
Notes	Cognitrone and Wiener Determinationsgerat were used for training, outcome measures based on these tasks were excluded for analysis.

Sturm 1991 *(Continued)*

	Control group was more aphasic and scored significantly lower on WAIS, in the Intelligence structure task and the Ravens than the intervention group.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Use of random number table (personal communication of authors)
Allocation concealment (selection bias)	Unclear risk	No information reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No information reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No information reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data, but it was noteworthy that 90% of people with right-brain damage initially agreed to participate in the study refused to participate when contacted later for starting the training.
Selective reporting (reporting bias)	Low risk	No indication in article, but study protocol not available

Westerberg 2007

Methods	RCT, parallel group design 3 people who did not take part in the study performed the randomisation. Small identical paper notes with numbers corresponding to each of the participants were put in a bucket. The notes were folded so that it was impossible to see the numbers. 1 person held the bucket, the 2 other people drew notes in an alternating manner. Before the procedure it was determined that all participants drawn by the first person would be in the training group, and the participants drawn by the other person were in the control group. The principal investigator (not involved in randomisation process) had the key to the correspondence between the numbers and the participant names. The result of the randomisation was kept secret from the therapists. After the first neuropsychological assessment (T1) a sealed, prenamed envelope, which revealed the randomisation to either the treatment or control group condition, was opened by the therapist so that the participants could have the instructions for their intervention. Approach: restore attentional functions by computer training of working memory functions
Participants	Sweden, recruited from 1 hospital Total participant sample 21; 3 lost after baseline testing (only data of remaining people reported) Treatment group: n = 9; mean (± SD) age 55.0 ± 8 years; 89% males; mean (± SD) 19.3 ± 6.2 months since onset; hemisphere of lesion: 4 left (44%), 4 right (44%), 1 unclear (11%) Control group: n = 9; mean (± SD) age 53.6 ± 8 years; 44% males; mean (± SD) 20.8 ± 6.2 months since onset; hemisphere of lesion: 3 left (33%), 4 right (44%), 2 unclear (22%)

Westerberg 2007 *(Continued)*

	Inclusion criteria: self-reported deficits in attention; had stroke between 12 and 36 months ago; stroke documented by PET, MRI, or CT; aged 30–65 years; had daily access to a computer with Internet connection at home. Exclusion criteria: intelligence quotient < 70; motor or perceptual disability that would prevent use of the computer program; changing medication during the study period; fulfilling criteria for major, depressive-disorder diagnosis as per the DSM-IV diagnosis code
Interventions	Treatment: 40 minutes of computer-based training at home for 5 days per week for 5 weeks in total. Visuo-spatial and auditory working memory tasks were performed by using the RoboMemo Software (Cogmed Cognitive Medical Systems, Sweden). Sufficient compliance was defined as 20 days of training (achieved by all participants not withdrawing from the study) Control: no training
Outcomes	Measured after intervention (5 weeks) Several measures, but no definition of primary outcome measure: • Cognitive Failures Questionnaire • PASAT (time in seconds at 2.4 seconds ISI) • Ruff 2&7 (time in seconds to complete cancellation task) • Stroop (time in seconds and number of correct responses) • Digit Span from WAIS-R (raw scores) • Span Board from WAIS-R (raw scores) • Raven's progressive matrices (raw scores) • Claeson-Dahl Task (raw scores)
Notes	The study authors informed on an error in the original paper. The correct Ruff 2&7 values for the treatment group were 130.3 (21.9) seconds at pretraining and 115.4 (21.7) seconds at post-training.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Sealed envelopes prepared by a person unrelated to the study.
Allocation concealment (selection bias)	Low risk	Sealed preaddressed envelope (prepared by people unrelated to the study) opened after the initial assessment.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Participants and therapist not blinded
Blinding of outcome assessment (detection bias) All outcomes	High risk	Assessor not blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	Missing outcome data balanced in numbers across intervention groups, lost participants scored within group mean level in the baseline.
Selective reporting (reporting bias)	Low risk	No indication in article, but study protocol not available

Winkens 2009

Methods	RCT, multicentre study, parallel group design Random assignment list created before start of trial; independent person used the list to assign people to the 2 groups after recruitment Approach: learning of compensatory strategies
Participants	Netherlands, recruited from 8 rehabilitation centres Total participant sample 37: 2 lost at post-treatment assessment, another 1 at 3-month follow-up Treatment group: n = 20; mean (± SD) age 49.5 ± 8 years; 45% males; mean (± SD) 19.3 ± 29.6 months since onset Control group: n = 17; mean (± SD) age 53.9 ± 11.1 years; 71% males; mean (± SD) 6.9 ± 5.4 months since onset No data for hemisphere of lesion, and aetiology Inclusion criteria: stroke > 3 months; referred for cognitive rehabilitation for mental slowness Exclusion criteria: aged < 18 years; stroke < 3 months; severe or disabling premorbid or current (continuing) pathological conditions; severe cognitive, communication, physical, or psychological problems that the person was unable to perform the tasks, based on the clinical judgement of the treating team.
Interventions	Treatment: 10-hour teaching in time pressure management session duration varied between 1 and 2 hours a week depending on the person Control: care as usual
Outcomes	Measured after intervention (time not explicitly specified, but likely to be around 5 weeks) and at 3-month follow-up Primary outcomes: • information intake task (number of correct responses and used strategies • Mental Slowness Observation test (time, number of correct responses and used strategies) • Mental Slowness Questionnaire (raw score) Secondary outcomes: • PASAT (number of correct responses at 3.2 seconds ISI) • Trail Making A & B (time in seconds for both parts) • Simple Reaction Time (time in seconds) • Stroop (time in seconds for each subtest) • Symbol Digit Modalities test (number of correct responses) • Auditory Verbal Learning test (number of correct responses) • Fatigue Severity Scale (raw scores) • EuroQol-5D (raw scores) • Center for Epidemiologic Studies Depression Scale (raw scores)
Notes	People with stroke were relatively young and ADL-independent. Control group were more recent after onset. Additional data for analysis provided by the authors.

Risk of bias

Bias	Authors' judgement	Support for judgement

Winkens 2009 *(Continued)*

Random sequence generation (selection bias)	Unclear risk	"Random assignment list" was used, no details given
Allocation concealment (selection bias)	Low risk	After selection of participants independent person used random list to assign people to groups
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Participants and therapist not blinded
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Assessment by blinded research assistant. Analyses showed that assistant had guessed the allocation correctly in 24 of 37 cases (Cohen k = 0.29, P = 0.05)
Incomplete outcome data (attrition bias) All outcomes	Low risk	Missing outcome data balanced in numbers across intervention groups
Selective reporting (reporting bias)	Low risk	No indication in article, but study protocol not available

ADL: activities of daily living; APT: attention process training; CT: computerised tomography; DSM-IV: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; FIM: Functional Independence Measure; GHQ: General Health Questionnaire; ISI: interstimulus interval; IVA-CPT: Integrated Visual and Auditory Continuous Performance Test; MMSE: Mini-Mental State Examination; MRI: magnetic resonance imaging; n: number of participants; PASAT: Paced Auditory Serial Addition Test; PET: positron emission tomography; RCT: randomised controlled trial; SD: standard deviation; SF: Short Form; TBI: traumatic brain injury; WAIS-R: Wechsler Adult Intelligence Scale – Revised; WHO: World Health Organization.

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

Study	Reason for exclusion
Aben 2013	Not rehabilitation of attentional deficits
Aivazian 1994	Not rehabilitation of attentional deficits
Akinwuntan 2010	Not selected on the basis of having impairment of attention
Albrittain-Ross 2017	Not CCT/RCT
Alexopoulos 2012	Not selected on the basis of having impairment of attention
Arnemann 2015	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
Bergquist 2012	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
Bertens 2015	Not rehabilitation of attentional deficits
Bezdenezhnykh 2015	Not selected on the basis of having impairment of attention
Blanchet 2016	Not selected on the basis of having impairment of attention
Bo 2019	Not selected on the basis of having impairment of attention

Study	Reason for exclusion
Boman 2004	Not CCT/RCT
Carelli 2009	Not CCT/RCT
Carr 2012	Not selected on the basis of having impairment of attention
Chen 2011	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
Chen 2015	Not selected on the basis of having impairment of attention
Cho 2016	Not selected on the basis of having impairment of attention
Chung 2013	Not original study (e.g. reviews)
Crotty 2009	Not selected on the basis of having impairment of attention
De Luca 2014	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
De Luca 2018a	Not selected on the basis of having impairment of attention
De Luca 2018b	Not selected on the basis of having impairment of attention
Dirette 2004	Not CCT/RCT
Edmans 2009	Not selected on the basis of having impairment of attention
Faria 2016	Not selected on the basis of having impairment of attention
Gates 2011	Not selected on the basis of having impairment of attention
Gauggel 1996	Not CCT/RCT
Giaquinto 2003	Not rehabilitation of attentional deficits
Gracey 2017	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
Graf 2011	Not selected on the basis of having impairment of attention
Gray 1992	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
Hashimoto 2006	Not CCT/RCT
Jiang 2016	Not selected on the basis of having impairment of attention
Kang 2008	Not CCT/RCT
Kang 2009	Not rehabilitation of attentional deficits
Kaur 2018	Not selected on the basis of having impairment of attention
Kim 2008	Not selected on the basis of having impairment of attention
Kim 2013	Not selected on the basis of having impairment of attention
Klonoff 2010	Not CCT/RCT

Study	Reason for exclusion
Levine 2011	Not selected on the basis of having impairment of attention
Mazer 2003	Not selected on the basis of having impairment of attention
McDonnell 2007	Not rehabilitation of attentional deficits
Mead 2007	Not rehabilitation of attentional deficits
Middleton 1991	Not CCT/RCT
Miotto 2009	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
NCT00298558	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
NCT01109836	Not rehabilitation of attentional deficits
NCT01365858	Not selected on the basis of having impairment of attention
NCT01372059	Not rehabilitation of attentional deficits
NCT01886183	Not selected on the basis of having impairment of attention
NCT02482688	Rehabilitation of spatial neglect
Otfinowski 2006	Not selected on the basis of having impairment of attention
Park 2015	Not selected on the basis of having impairment of attention
Park 2018	Not selected on the basis of having impairment of attention
Piccardi 2006	Not CCT/RCT
Ploughman 2008	Not selected on the basis of having impairment of attention
Ploughman 2017	Not selected on the basis of having impairment of attention
Prokopenko 2013	Not selected on the basis of having impairment of attention
Pulin 2017	Not CCT/RCT
Pyoria 2007	Not selected on the basis of having impairment of attention
Pyun 2009	Not CCT/RCT
Quaney 2009	Not selected on the basis of having impairment of attention
Ressner 2018	Not selected on the basis of having impairment of attention
Rizkalla 2011	Not selected on the basis of having impairment of attention
Shi 2017	Not selected on the basis of having impairment of attention
Shiflett 2002	Not rehabilitation of attentional deficits
Skidmore 2014	Not CCT/RCT

Study	Reason for exclusion
Skidmore 2015	Not selected on the basis of having impairment of attention
Sohlberg 2000	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
Spahn 2010	Not rehabilitation of attentional deficits
Spikman 2010	Not selected on the basis of having impairment of attention
Stapleton 2001	Not rehabilitation of attention deficits
Sturm 1997	Not CCT/RCT
Sturm 2006	Not rehabilitation of attentional deficits
Särkämö 2008	Not selected on the basis of having impairment of attention
Särkämö 2010	Not selected on the basis of having impairment of attention
Thimm 2006	Not rehabilitation of attentional deficits
Tornas 2014	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
Van de Ven 2017	Not selected on the basis of having impairment of attention
Villalobos 2018	Not stroke (if mixed sample, less than 75%), or no stroke-specific data
Von Koch 2000	Not selected on the basis of having impairment of attention
Wagenaar 1992	Not treatment of attention deficits
Wentink 2016	Not selected on the basis of having impairment of attention
Yamamoto-Mitani 2007	Not CCT/RCT
Zucchella 2014	Not selected on the basis of having impairment of attention

CCT: controlled clinical trial; RCT: randomised controlled trial.

Characteristics of studies awaiting assessment *[ordered by study ID]*

Bartfai 2014

Methods	RCT
Participants	120 consecutive participants with stroke or traumatic brain injury
Interventions	20 hours' attention process training
Outcomes	Not known
Notes	Protocol published, full paper is submitted for publication

Bayat 2014

Methods	RCT
Participants	60 participants
Interventions	4 groups (computer training, music listening, combined computer training and music listening, no intervention)
Outcomes	Not known
Notes	Conference abstract. Study authors did not reply to queries.

Bushnick 2010

Methods	RCT
Participants	125 participants ≥ 1-year postinjury with diagnosis of cognitive impairment
Interventions	Use of the orthotic device "Planning and Execution Assistant and Trainer (PEAT)"
Outcomes	Not known
Notes	Conference abstract. Authors replied that study is not published.

Chen 2018

Methods	RCT
Participants	14 participants with aneurysmal subarachnoid haemorrhage enrolled
Interventions	Tablet-assisted cognitive rehabilitation
Outcomes	Not known
Notes	Conference abstract. Authors replied that study is not published.

Dawson 2017

Methods	RCT
Participants	15 participants with stroke
Interventions	16 hours of Cognitive Orientation to Occupational Performance Approach (delivery via telerehabilitation)
Outcomes	Not known
Notes	Conference abstract. Authors replied that study is not published.

Flynn 2000

Methods	RCT
Participants	30 participants with stroke
Interventions	Attention training
Outcomes	Not known
Notes	Study completed according to National Research Register (Register is no longer searchable and has not been updated since September 2007). Study author did not reply to queries in previous update.

Frommelt 2003

Methods	RCT
Participants	Not known
Interventions	Compensatory skills training versus retraining basic cognitive impairments (either memory skills training or problem solving)
Outcomes	Not known
Notes	ISRCTN45171788. Data collection finished. Authors replied that study is not published.

Gil-Pages 2018

Methods	Cross-over RCT
Participants	Participants with chronic-stage stroke
Interventions	6 weeks' customised telerehabilitation
Outcomes	Several measures of attention
Notes	NCT03326349. Recruitment completed. Authors replied that study is not published.

Holleman 2012

Methods	RCT
Participants	38 participants with acquired brain injury
Interventions	Intensive NeuroRehabilitation (INR) programme
Outcomes	Not known
Notes	Conference abstract. Study authors did not reply to queries.

Huang 2015

Methods	RCT
Participants	60 participants with poststroke cognitive dysfunction
Interventions	Computer-based attention training with acupuncture
Outcomes	Not known
Notes	Protocol published, last update on ClinicalTrials.gov (NCT02324959) in December 2014

Kaur 2016

Methods	RCT
Participants	22 participants with aphasia after stroke
Interventions	8-week home-based neuropsychological programme
Outcomes	Improvement in attention, depression, and QoL in the intervention group compared to the control group
Notes	Conference abstract. Study authors did not reply to queries.

Matz 2007

Methods	RCT
Participants	32 participants
Interventions	'Cognitive training sessions' guided by a neuropsychologist over a 3-month period
Outcomes	No training effect for assessed cognitive functions
Notes	Authors contacted twice in previous update, but no replies to queries.

Oh 2017

Methods	Quasi-experimental study with a non-equivalent control group
Participants	42 participants with stroke
Interventions	4-week cognitive training programme
Outcomes	Experimental group showed improvement in attention, visuo-spatial function, verbal memory, and executive function compared to the control group.
Notes	Study authors did not reply to queries.

Peers 2018

Methods	RCT
Participants	People with stroke
Interventions	20 days of cognitive training using either novel Selective Attention Training (SAT) or commercial Working Memory Training (WMT)
Outcomes	Not known
Notes	Conference abstract, recruiting completed according to ISRCTN59754564. Authors replied that study is not yet published.

Zhang 2016

Methods	RCT
Participants	47 participants with attention deficits
Interventions	6 weeks' computer-assisted training or face-to-face training
Outcomes	After 6-week training, the performance of attention was improved significantly in computer-assisted training group and face-to-face training group.
Notes	Conference abstract. Not able to locate authors' contact details

Zhu 2011

Methods	Not known
Participants	46 participants with cognitive dysfunction and depressive symptoms
Interventions	5 weeks' computer-assisted training
Outcomes	Not known
Notes	Not able to locate authors contact details.

QoL: quality of life; RCT: randomised controlled trial.

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

Donnellan 2014

Trial name or title	Multidisciplinary Clinical Rehabilitation REsources And LIfe Strategy Management (REALISM) trial
Methods	RCT
Participants	Stroke survivors
Interventions	Goal setting and attainment care plan based on the adaptive strategies selection, optimisation, and compensation

Donnellan 2014 *(Continued)*

Outcomes	Meta-cognition Questionnaire, Self-regulatory Interview, and executive function using the Trail Making Test (A & B).
Starting date	Not known
Contact information	Dr Claire Donnellan (cdonnel@tcd.ie)
Notes	Authors confirmed that there are no outcomes as yet.

NCT02925637

Trial name or title	Effectiveness of FACoT for individuals post stroke
Methods	RCT
Participants	46 participants (at least 3 years' poststroke)
Interventions	Meta-cognitive-functional Intervention
Outcomes	Canadian Occupational Performance Measure, Instrumental Activities of Daily Living
Starting date	April 2016
Contact information	Tal Adamit (adamit33@bezeqint.net)
Notes	NCT02925637

RCT: randomised controlled trial.

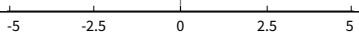
DATA AND ANALYSES

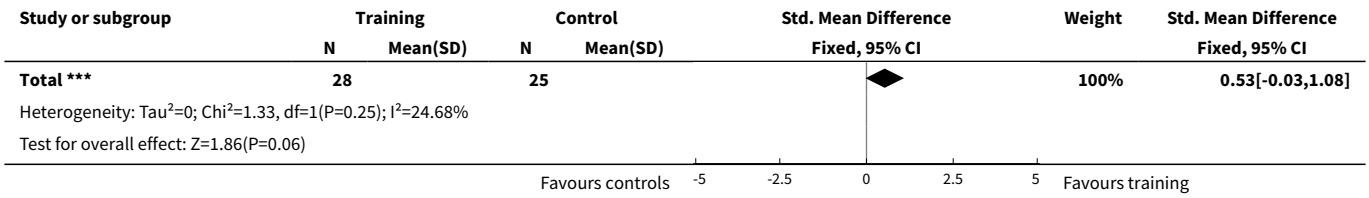
Comparison 1. Attention training versus control – impact on global measures of attention deficits immediately after treatment

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Subjective measures	2	53	Std. Mean Difference (IV, Fixed, 95% CI)	0.53 [-0.03, 1.08]

Analysis 1.1. Comparison 1 Attention training versus control – impact on global measures of attention deficits immediately after treatment, Outcome 1 Subjective measures.

Study or subgroup	Training N	Training Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Fixed, 95% CI	Weight	Std. Mean Difference Fixed, 95% CI
Westerberg 2007	9	-29.2 (12.1)	9	-43 (13.8)		31.08%	1.01[0.02,2.01]
Winkens 2009	19	-36.6 (37.7)	16	-49.1 (42.2)		68.92%	0.31[-0.36,0.98]

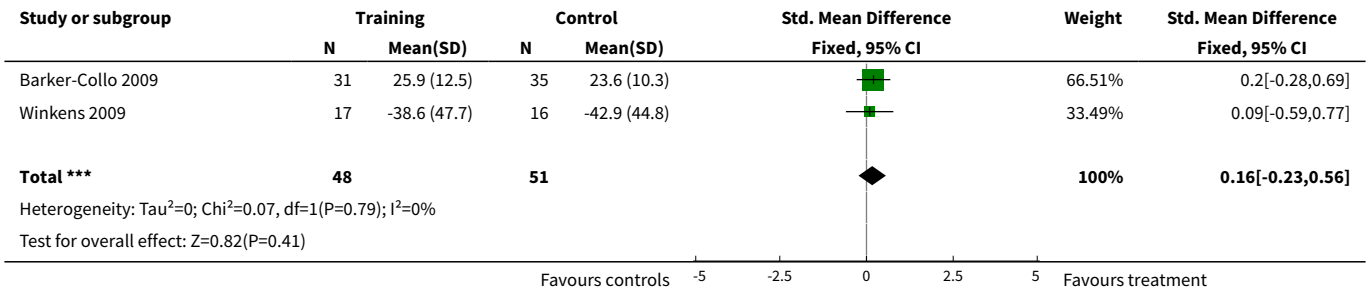




Comparison 2. Attention training versus control – impact on global measures of attention deficits at follow-up

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Subjective measures at follow-up	2	99	Std. Mean Difference (IV, Fixed, 95% CI)	0.16 [-0.23, 0.56]

Analysis 2.1. Comparison 2 Attention training versus control – impact on global measures of attention deficits at follow-up , Outcome 1 Subjective measures at follow-up.

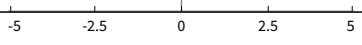


Comparison 3. Attention training versus control – impact on attentional domains immediately after treatment

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Alertness	4	136	Std. Mean Difference (IV, Fixed, 95% CI)	0.14 [-0.20, 0.48]
2 Selective attention	6	223	Std. Mean Difference (IV, Fixed, 95% CI)	-0.08 [-0.35, 0.18]
3 Sustained attention	4	169	Std. Mean Difference (IV, Random, 95% CI)	0.39 [-0.16, 0.94]
4 Divided attention	4	165	Std. Mean Difference (IV, Fixed, 95% CI)	0.67 [0.35, 0.98]

Analysis 3.1. Comparison 3 Attention training versus control – impact on attentional domains immediately after treatment, Outcome 1 Alertness.

Study or subgroup	Training N	Training Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Fixed, 95% CI	Weight	Std. Mean Difference Fixed, 95% CI
Röhring 2004	24	44.2 (11.2)	22	46.5 (12.7)		34.57%	-0.19[-0.77,0.39]
Schottke 1997	16	3.6 (2.1)	13	2.2 (1.8)		20.44%	0.66[-0.1,1.41]
Sturm 1991	13	100.9 (8.7)	14	94.6 (11.9)		19.44%	0.58[-0.19,1.36]
Winkens 2009	18	-0.3 (0.1)	16	-0.3 (0.1)		25.55%	-0.16[-0.83,0.52]
Total ***	**71**		**65**			**100%**	**0.14[-0.2,0.48]**
Heterogeneity: Tau^2=0; Chi^2=5.07, df=3(P=0.17); I^2=40.81%							
Test for overall effect: Z=0.82(P=0.41)							



Analysis 3.2. Comparison 3 Attention training versus control – impact on attentional domains immediately after treatment, Outcome 2 Selective attention.

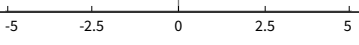
Study or subgroup	Training N	Training Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Fixed, 95% CI	Weight	Std. Mean Difference Fixed, 95% CI
Barker-Collo 2009	32	-3.1 (7.1)	36	-1.9 (3)		30.67%	-0.22[-0.7,0.25]
Röhring 2004	24	42.5 (9.1)	22	46.7 (13.4)		20.55%	-0.36[-0.95,0.22]
Schottke 1997	16	4.3 (2)	13	3.3 (1.7)		12.51%	0.56[-0.19,1.31]
Sturm 1991	13	96.3 (14.2)	14	97.3 (10.9)		12.27%	-0.08[-0.83,0.68]
Westerberg 2007	9	-115.4 (21.7)	9	-112.7 (17.3)		8.18%	-0.13[-1.06,0.79]
Winkens 2009	19	-42.4 (20.3)	16	-43.6 (20.5)		15.82%	0.06[-0.61,0.72]
Total ***	**113**		**110**			**100%**	**-0.08[-0.35,0.18]**
Heterogeneity: Tau^2=0; Chi^2=4.26, df=5(P=0.51); I^2=0%							
Test for overall effect: Z=0.62(P=0.53)							

Analysis 3.3. Comparison 3 Attention training versus control – impact on attentional domains immediately after treatment, Outcome 3 Sustained attention.

Study or subgroup	Training N	Training Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Random, 95% CI	Weight	Std. Mean Difference Random, 95% CI
Barker-Collo 2009	32	-2.2 (3.3)	36	-3 (3.4)		30.1%	0.24[-0.24,0.71]
Röhring 2004	24	43.6 (8.7)	22	45.6 (11.5)		27.17%	-0.19[-0.77,0.39]
Schottke 1997	16	88.4 (15.3)	13	72.4 (6.3)		21.01%	1.28[0.47,2.1]
Sturm 1991	12	100.3 (11.1)	14	94.7 (11.4)		21.72%	0.48[-0.3,1.27]
Total ***	**84**		**85**			**100%**	**0.39[-0.16,0.94]**
Heterogeneity: Tau^2=0.2; Chi^2=8.68, df=3(P=0.03); I^2=65.43%							
Test for overall effect: Z=1.4(P=0.16)							

Analysis 3.4. Comparison 3 Attention training versus control – impact on attentional domains immediately after treatment, Outcome 4 Divided attention.

Study or subgroup	Training N	Training Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Fixed, 95% CI	Weight	Std. Mean Difference Fixed, 95% CI
Barker-Collo 2009	32	-1.1 (0.9)	36	-1.8 (0.7)		40.64%	0.77[0.28,1.27]
Röhring 2004	24	41.5 (9.5)	22	37 (8.8)		28.81%	0.48[-0.11,1.07]
Westerberg 2007	9	53.6 (6.4)	9	47 (8.4)		10.47%	0.84[-0.13,1.82]
Winkens 2009	18	45.3 (9.2)	15	37.7 (14.5)		20.09%	0.62[-0.08,1.33]
Total ***	**83**		**82**			**100%**	**0.67[0.35,0.98]**
Heterogeneity: Tau^2=0; Chi^2=0.7, df=3(P=0.87); I^2=0%							
Test for overall effect: Z=4.15(P<0.0001)							

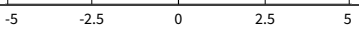


Comparison 4. Attention training versus control – impact on functional abilities in daily living, mood, and quality of life immediately after treatment

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Functional abilities	2	75	Std. Mean Difference (IV, Fixed, 95% CI)	0.29 [-0.16, 0.75]
2 Mood (depression)	3	109	Std. Mean Difference (IV, Fixed, 95% CI)	0.01 [-0.36, 0.39]
3 Quality of life	2	103	Std. Mean Difference (IV, Fixed, 95% CI)	0.02 [-0.37, 0.40]

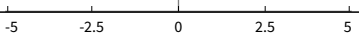
Analysis 4.1. Comparison 4 Attention training versus control – impact on functional abilities in daily living, mood, and quality of life immediately after treatment, Outcome 1 Functional abilities.

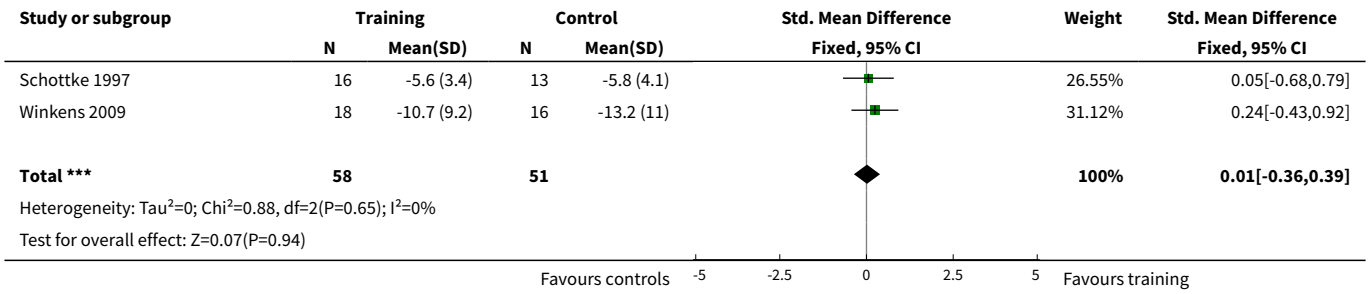
Study or subgroup	Training N	Training Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Fixed, 95% CI	Weight	Std. Mean Difference Fixed, 95% CI
Röhring 2004	24	123.7 (5.2)	22	121.1 (9)		61.32%	0.34[-0.24,0.93]
Schottke 1997	16	71.9 (27.9)	13	65.4 (31.8)		38.68%	0.21[-0.52,0.95]
Total ***	**40**		**35**			**100%**	**0.29[-0.16,0.75]**
Heterogeneity: Tau^2=0; Chi^2=0.08, df=1(P=0.78); I^2=0%							
Test for overall effect: Z=1.26(P=0.21)							



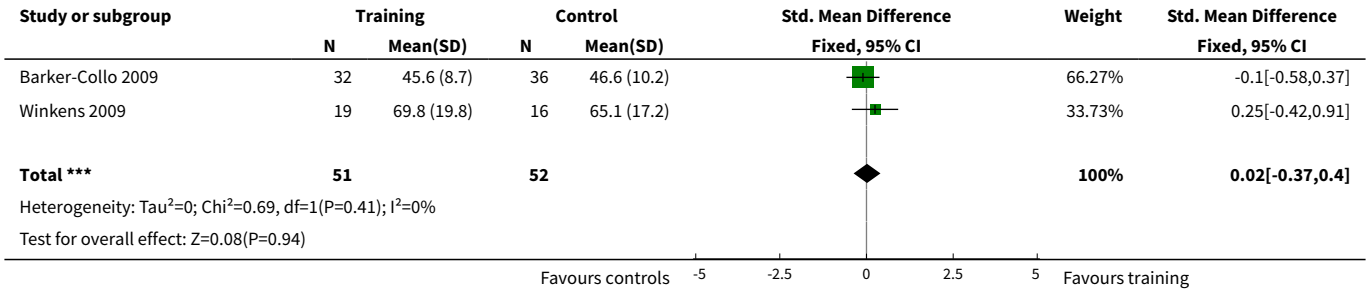
Analysis 4.2. Comparison 4 Attention training versus control – impact on functional abilities in daily living, mood, and quality of life immediately after treatment, Outcome 2 Mood (depression).

Study or subgroup	Training N	Training Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Fixed, 95% CI	Weight	Std. Mean Difference Fixed, 95% CI
Röhring 2004	24	-28.2 (5.5)	22	-27.2 (5.3)		42.33%	-0.18[-0.76,0.4]





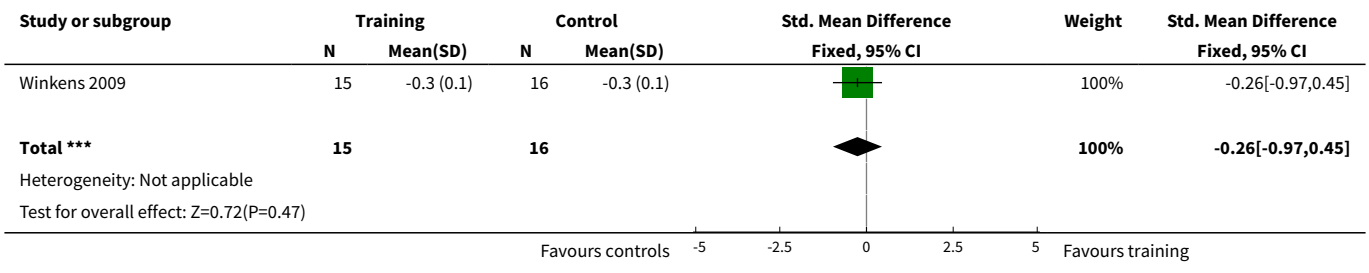
Analysis 4.3. Comparison 4 Attention training versus control – impact on functional abilities in daily living, mood, and quality of life immediately after treatment, Outcome 3 Quality of life.



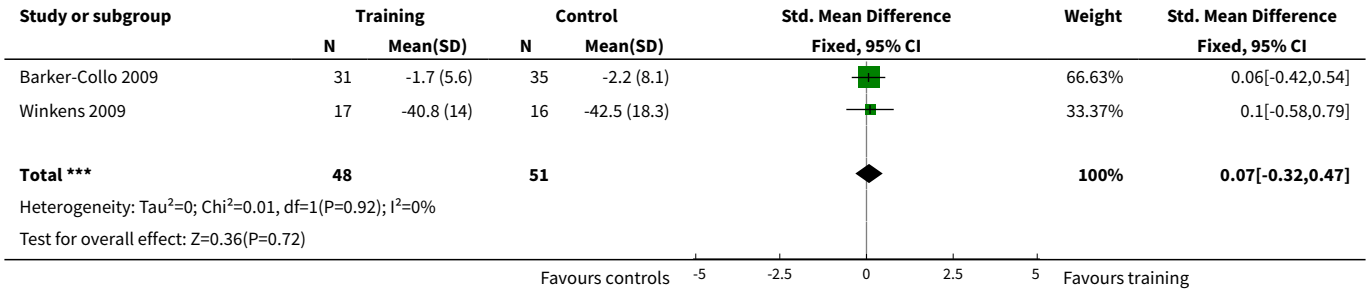
Comparison 5. Attention training versus control – impact on attentional domains at follow-up

Outcome or subgroup title	No. of studies	No. of partici-pants	Statistical method	Effect size
1 Alertness at follow-up	1	31	Std. Mean Difference (IV, Fixed, 95% CI)	-0.26 [-0.97, 0.45]
2 Selective attention at follow-up	2	99	Std. Mean Difference (IV, Fixed, 95% CI)	0.07 [-0.32, 0.47]
3 Sustained attention at follow-up	1	66	Std. Mean Difference (IV, Fixed, 95% CI)	0.05 [-0.44, 0.53]
4 Divided attention at follow-up	2	99	Std. Mean Difference (IV, Fixed, 95% CI)	0.36 [-0.04, 0.76]

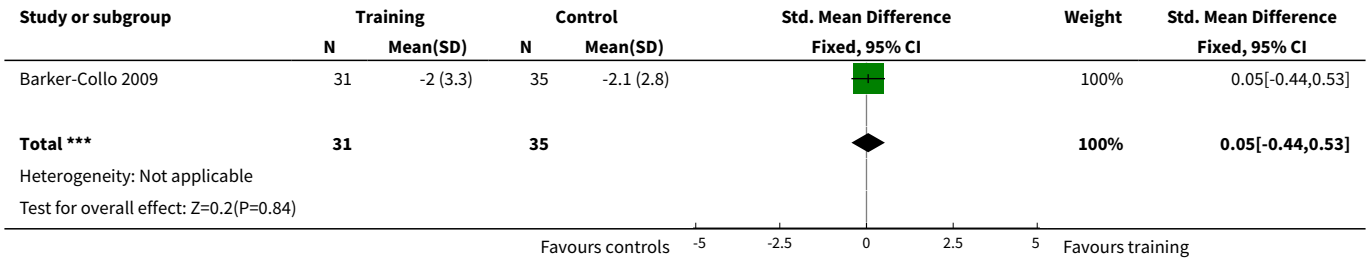
Analysis 5.1. Comparison 5 Attention training versus control – impact on attentional domains at follow-up , Outcome 1 Alertness at follow-up.



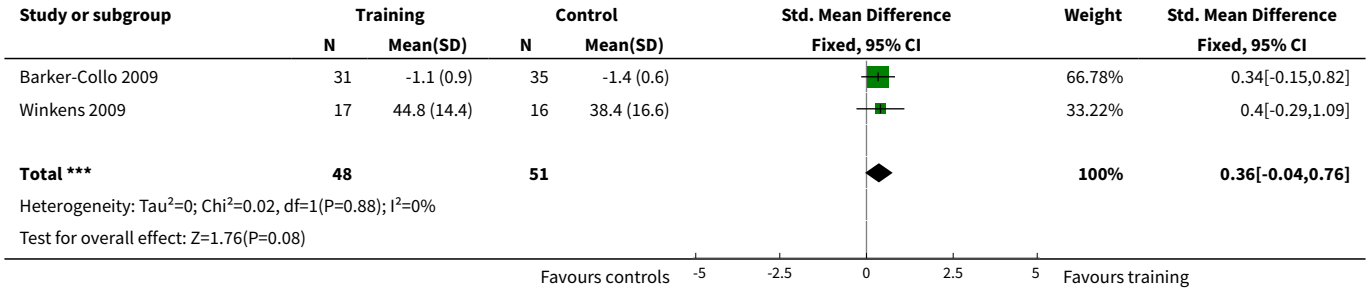
Analysis 5.2. Comparison 5 Attention training versus control – impact on attentional domains at follow-up , Outcome 2 Selective attention at follow-up.



Analysis 5.3. Comparison 5 Attention training versus control – impact on attentional domains at follow-up , Outcome 3 Sustained attention at follow-up.



Analysis 5.4. Comparison 5 Attention training versus control – impact on attentional domains at follow-up , Outcome 4 Divided attention at follow-up.

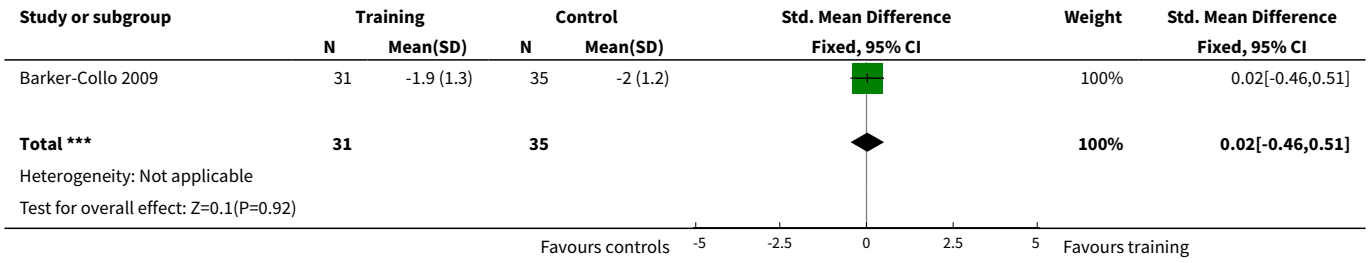


Comparison 6. Attention training versus control – impact on functional abilities in daily living, mood, and quality of life at follow-up

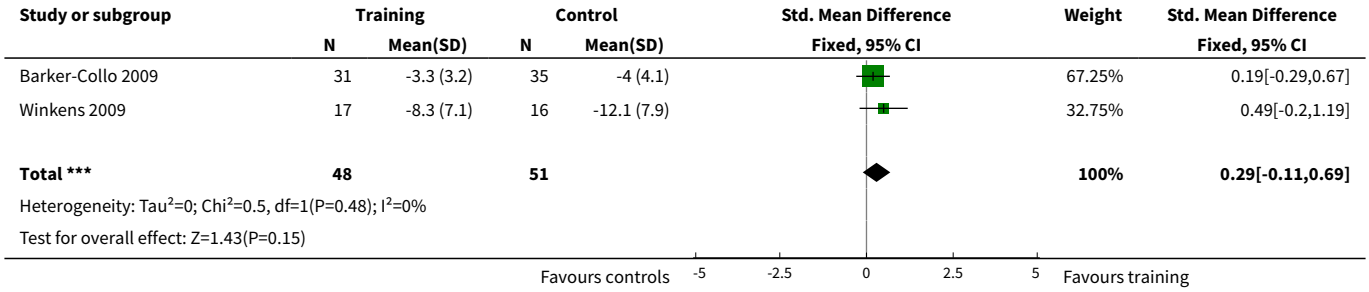
Outcome or subgroup title	No. of studies	No. of partici-pants	Statistical method	Effect size
1 Functional abilities at follow-up	1	66	Std. Mean Difference (IV, Fixed, 95% CI)	0.02 [-0.46, 0.51]

Outcome or subgroup title	No. of studies	No. of partici-pants	Statistical method	Effect size
2 Mood (depression) at follow-up	2	99	Std. Mean Difference (IV, Fixed, 95% CI)	0.29 [-0.11, 0.69]
3 Quality of life at follow-up	2	99	Std. Mean Difference (IV, Fixed, 95% CI)	0.26 [-0.13, 0.66]

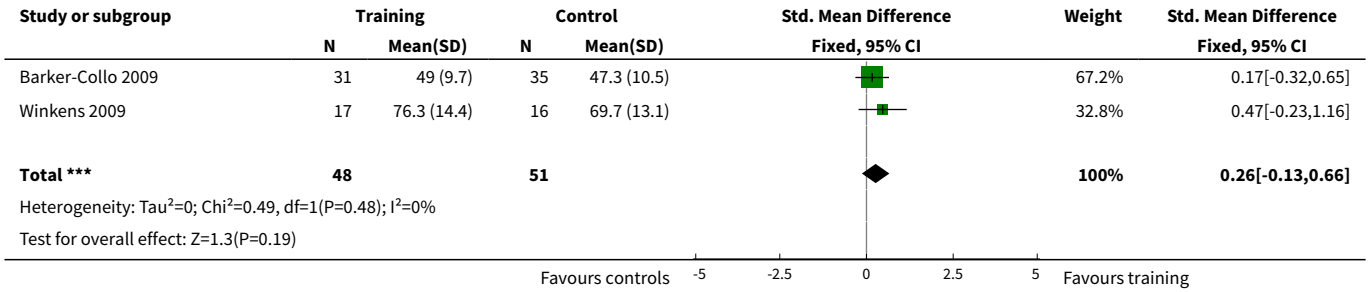
Analysis 6.1. Comparison 6 Attention training versus control – impact on functional abilities in daily living, mood, and quality of life at follow-up, Outcome 1 Functional abilities at follow-up.



Analysis 6.2. Comparison 6 Attention training versus control – impact on functional abilities in daily living, mood, and quality of life at follow-up, Outcome 2 Mood (depression) at follow-up.



Analysis 6.3. Comparison 6 Attention training versus control – impact on functional abilities in daily living, mood, and quality of life at follow-up, Outcome 3 Quality of life at follow-up.



ADDITIONAL TABLES

Table 1. Attentional outcome measures used in the included studies

Study ID	Subjective global measure	Objective global measure	Alertness	Selective attention	Sustained attention	Divided attention
Barker-Collo 2009	Cognitive Failures Questionnaire[a]	—	—	Trail Making A[b]	IVA-CPT Full-Scale Attention Quotient[b]	PASAT (2.4 sec ISI)[b]
Röhring 2004	—	—	TAP phasic alertness	TAP selective attention	d2 (Hits-Errors)	TAP divided attention
Schottke 1997	—	—	Tempo-Lern-Test (1st block)	Zahlen-Verbindungstest	Konzentrations-Verlaufs-Test (combined speed/errors scores)	—
Sturm 1991	—	—	Wiener Reaktionsgerat Visual RT	Wiener Reaktionsgerat Choice RT	Wiener Vigilanzgerat (Hits)	—
Westerberg 2007	Cognitive Failures Questionnaire	—	—	Ruff 2&7	—	PASAT (2.4 sec ISI)
Winkens 2009	Mental Slowness Questionnaire[b]	—	Simple RT[b]	Trail Making A (time)[b]	—	PASAT (3.2 sec ISI)[b]

[a]Only measured at follow-up, but not after treatment.
[b]Measured after treatment and at follow-up.
ISI: interstimulus interval; IVA-CPT: Integrated Visual and Auditory Continuous Performance Test; PASAT: Paced Auditory Serial Addition Test; RT: reaction time; TAP: Tests of Attentional Performance.

Table 2. Functional outcome measures used in the included studies

Study ID	Functional abilities	Mood	Quality of life
Barker-Collo 2009	Modified Rankin[a]	GHQ[a]	SF-36 (MCS subscale)[b]
Röhring 2004	FIM	DSI	—
Schottke 1997	Barthel	EMO-D	—
Winkens 2009	—	CES-D[b]	EQ-VAS[b]

[a]Only measured at follow-up, but not after treatment.
[b]Measured after treatment and at follow-up.
CES-D: Center for Epidemiologic Studies Depression Scale; DSI: Zung Depression Status Inventory; EMO-D: Emotional State Questionnaire (Depression subscale); FIM: Functional Independence Measure; GHQ: General Health Questionnaire; MCS: Mental Component Summary; VAS: visual analogue scale.

APPENDICES

Appendix 1. Allocation of outcome measures to attentional domains

Task	Primary attentional domain	Secondary attentional domain	Study ID
Behavioural Test of Inattentiveness in Daily Life	Unclear	—	Schottke 1997
Bells test	Spatial	Selective	Barker-Collo 2009
Cognitive Failures Questionnaire	Functional	—	Barker-Collo 2009; Westerberg 2007
Cognitrone	Selective	Alertness	Sturm 1991
d2	Selective	Sustained	Sturm 1991
Information Intake Task	Unclear	—	Winkens 2009
IVA-CPT Full-Scale Attention Quotient	Sustained	Selective	Barker-Collo 2009
Konzentrations-Verlaufs-Test	Sustained	Divided	Schottke 1997
Mental Slowness Observation Test	Unclear	—	Winkens 2009
Mental Slowness Questionnaire	Functional	—	Winkens 2009
PASAT (Paced Auditory Serial Addition Test)	Divided	Sustained	Barker-Collo 2009; Westerberg 2007; Winkens 2009
Ruff 2&7	Selective	Sustained	Westerberg 2007
Simple RT	Alertness	Sustained	Winkens 2009
Stroop	Selective	—	Westerberg 2007; Winkens 2009
Symbol Digit Modalities Test	Divided	Sustained	Winkens 2009
TAP subtest divided attention	Divided	Sustained	Röhring 2004
TAP subtest intrinsic alertness	Alertness	Sustained	Röhring 2004
TAP subtest phasic alertness	Alertness	Sustained	Röhring 2004
TAP subtest selective attention	Selective	Sustained	Röhring 2004
Tempo-Lern-Test	Alertness	Sustained	Schottke 1997
Trail Making A	Selective	—	Barker-Collo 2009; Winkens 2009
Trail Making B	Divided	—	Barker-Collo 2009; Winkens 2009
Visual-Discrimination-Conditioner	Sustained	Selective	Schottke 1997

(Continued)

Wahl-Reaktions-Test	Selective	Sustained	Schottke 1997
Wiener Determinationsgerat	Selective	Divided	Sturm 1991
Wiener Reaktionsgerat Auditory RT	Alertness	Sustained	Sturm 1991
Wiener Reaktionsgerat Choice RT	Selective	Alertness	Sturm 1991
Wiener Reaktionsgerat Visual RT	Alertness	Sustained	Sturm 1991
Wiener Vigilanzgerat	Sustained	Selective	Sturm 1991
Zahlen-Verbindungstest	Selective	—	Schottke 1997

IVA-CPT: Integrated Visual and Auditory Continuous Performance Test; RT: reaction time; TAP: Tests of Attentional Performance.

Appendix 2. Cochrane Central Register of Controlled Trials (CENTRAL)

IDSearch

#1MeSH descriptor: [Cerebrovascular Disorders] this term only
#2MeSH descriptor: [Basal Ganglia Cerebrovascular Disease] explode all trees
#3MeSH descriptor: [Brain Ischemia] explode all trees
#4MeSH descriptor: [Carotid Artery Diseases] explode all trees
#5MeSH descriptor: [Intracranial Arterial Diseases] explode all trees
#6MeSH descriptor: [Intracranial Embolism and Thrombosis] explode all trees
#7MeSH descriptor: [Intracranial Embolism and Thrombosis] explode all trees
#8MeSH descriptor: [Stroke] this term only
#9MeSH descriptor: [Brain Infarction] explode all trees
#10MeSH descriptor: [Vasospasm, Intracranial] this term only
#11MeSH descriptor: [Vertebral Artery Dissection] this term only
#12((stroke or poststroke or post-stroke or cerebrovasc* or brain vasc* or cerebral vasc* or cva* or apoplex* or SAH)):ti,ab,kw (Word variations have been searched)
#13(((brain* or cerebr* or cerebell* or intracran* or intracerebral) near/5 (ischaem* or ischemi* or infarct* or thrombo* or emboli* or occlus*))):ti,ab,kw (Word variations have been searched)
#14(((brain* or cerebr* or cerebell* or intracerebral or intracranial or subarachnoid) near/5 (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*))):ti,ab,kw (Word variations have been searched)
#15MeSH descriptor: [Brain Injuries] this term only
#16MeSH descriptor: [Brain Injury, Chronic] this term only
#17{OR #1-#16}
#18MeSH descriptor: [Attention] this term only
#19MeSH descriptor: [Arousal] this term only
#20(((attention* or concentrat* or arousal or alert* or vigilance) near/5 (impair* or deficit* or disorder* or problem* or diminish* or decreas* or reduc*))):ti,ab,kw (Word variations have been searched)
#21((inattention or distract*)):ti,ab,kw (Word variations have been searched)
#22((error near/3 control* near/5 (impair* or deficit* or disorder* or problem* or diminish* or decreas* or reduc*))):ti,ab,kw (Word variations have been searched)
#23((speed near/3 information near/3 process* near/5 (impair* or deficit* or disorder* or problem* or diminish* or decreas* or reduc*))):ti,ab,kw (Word variations have been searched)
#24((mental near/5 (slow* or fatig*))):ti,ab,kw (Word variations have been searched)
#25{OR #18-#24}
#26MeSH descriptor: [Rehabilitation] explode all trees
#27MeSH descriptor: [Cognitive Therapy] this term only
#28MeSH descriptor: [Computer Systems] this term only
#29MeSH descriptor: [Therapy, Computer-Assisted] this term only
#30MeSH descriptor: [Therapy, Computer-Assisted] explode all trees
#31((training or re-training or retraining or therap* or rehabilitat* or neurorehabilitat* or treatment* or therapeutic*)):ti,ab,kw (Word variations have been searched)

#32(rehabilitation):ti,ab,kw (Word variations have been searched)
#33(((attention* or concentrat* or arousal or alert* or vigilance) near/6 (skill* or abilit* or function* or improve* or enhance* or increas* or strateg* or task*))):ti,ab,kw (Word variations have been searched)
#34{OR #26-#33}
#35#17 AND #25 AND #34

Appendix 3. MEDLINE search strategy (Ovid)

1. cerebrovascular disorders/ or exp basal ganglia cerebrovascular disease/ or exp brain ischemia/ or exp carotid artery diseases/ or exp intracranial arterial diseases/ or exp "intracranial embolism and thrombosis"/ or exp intracranial hemorrhages/ or stroke/ or exp brain infarction/ or vasospasm, intracranial/ or vertebral artery dissection/
2. (stroke or poststroke or post-stroke or cerebrovasc$ or brain vasc$ or cerebral vasc$ or cva$ or apoplex$ or SAH).tw.
3. ((brain$ or cerebr$ or cerebell$ or intracran$ or intracerebral) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$)).tw.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracranial or subarachnoid) adj5 (haemorrhage$ or hemorrhage$ or haematoma $ or hematoma$ or bleed$)).tw.
5. brain injuries/ or brain injury, chronic/
6. 1 or 2 or 3 or 4 or 5
7. attention/ or arousal/
8. Attention Deficit Disorder with Hyperactivity/
9. ((attention$ or concentrat$ or arousal or alert$ or vigilance) adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas $ or reduc$)).tw.
10. (inattention or distract$).tw.
11. (error adj3 control$ adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas$ or reduc$)).tw.
12. (speed adj3 information adj3 proces$ adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas$ or reduc$)).tw.
13. (mental adj5 (slow$ or fatig$)).tw.
14. 7 or 8 or 9 or 10 or 11 or 12 or 13
15. exp rehabilitation/ or cognitive therapy/ or exp computers/ or therapy, computer-assisted/ or exp neuropsychological tests/
16. (training or re-training or retraining or therap$ or rehabilitat$ or neurorehabilitat$ or treatment$ or therapeutic$).tw.
17. rehabilitation.fs.
18. ((attention$ or concentrat$ or arousal or alert$ or vigilance) adj6 (skill$ or abilit$ or function$ or improve$ or enhance$ or increas$ or strateg$ or task$)).tw.
19. 15 or 16 or 17 or 18
20. 6 and 14 and 19
21. Randomized Controlled Trials as Topic/
22. random allocation/
23. Controlled Clinical Trials as Topic/
24. control groups/
25. double-blind method/
26. single-blind method/
27. Placebos/
28. placebo effect/
29. cross-over studies/
30. Therapies, Investigational/
31. Research Design/
32. Program Evaluation/
33. evaluation studies as topic/
34. randomized controlled trial.pt.
35. controlled clinical trial.pt.
36. (evaluation studies or comparative study).pt.
37. random$.tw.
38. (controlled adj5 (trial$ or stud$)).tw.
39. (clinical$ adj5 trial$).tw.
40. ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).tw.
41. (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).tw.
42. (therapeutic adj5 (trial$ or stud$)).tw.
43. ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).tw.
44. ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).tw.
45. (coin adj5 (flip or flipped or toss$)).tw.
46. (cross-over or cross over or crossover).tw.
47. placebo$.tw.
48. sham.tw.
49. (assign$ or alternate or allocat$ or counterbalance$ or multiple baseline).tw.

50. controls.tw.
51. (treatment$ adj6 order).tw.
52. or/21-51
53. 20 and 52
54. exp animals/ not humans.sh.
55. 53 not 54

Appendix 4. Embase search strategy (Ovid)

1. cerebrovascular disease/ or basal ganglion hemorrhage/ or exp brain hematoma/ or exp brain hemorrhage/ or exp brain infarction/ or exp brain ischemia/ or exp carotid artery disease/ or cerebral artery disease/ or cerebrovascular accident/ or exp intracranial aneurysm/ or exp occlusive cerebrovascular disease/ or stroke/
2. stroke patient/ or stroke unit/
3. (stroke or poststroke or post-stroke or cerebrovasc$ or brain vasc$ or cerebral vasc$ or cva$ or apoplex$ or SAH).tw.
4. ((brain$ or cerebr$ or cerebell$ or intracran$ or intracerebral) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$)).tw.
5. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracranial or subarachnoid) adj5 (haemorrhage$ or hemorrhage$ or haematoma $ or hematoma$ or bleed$)).tw.
6. brain injury/
7. 1 or 2 or 3 or 4 or 5 or 6
8. exp attention/ or attention deficit disorder/ or attention disturbance/ or arousal/ or concentration loss/
9. ((attention$ or concentrat$ or arousal or alert$ or vigilance or attentiveness or awareness) adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas$ or reduc$)).tw.
10. (inattention or distract$).tw.
11. (error adj3 control$ adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas$ or reduc$)).tw.
12. (speed adj3 information adj3 process$ adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas$ or reduc$)).tw.
13. (mental adj5 (slow$ or fatig$)).tw.
14. 8 or 9 or 10 or 11 or 12 or 13
15. cognitive therapy/ or cognitive rehabilitation/ or rehabilitation/
16. exp computer/ or computer assisted therapy/ or computer interface/
17. (training or re-training or retraining or therap$ or rehabilitat$ or neurorehabilitat$ or treatment$ or therapeutic$).tw.
18. rh.fs.
19. ((attention$ or concentrat$ or arousal or alert$ or vigilance or attentiveness or awareness) adj6 (skill$ or abilit$ or function$ or improve $ or enhance$ or increas$ or strateg$ or task$)).tw.
20. 15 or 16 or 17 or 18 or 19
21. 7 and 14 and 20
22. Randomized Controlled Trial/
23. Randomization/
24. Controlled Study/
25. control group/
26. clinical trial/
27. Crossover Procedure/
28. Double Blind Procedure/
29. Single Blind Procedure/ or triple blind procedure/
30. Parallel Design/
31. placebo/
32. experimental design/ or experimental study/ or quasi experimental study/
33. experimental therapy/
34. research subject/
35. Comparative Study/
36. random$.tw.
37. (controlled adj5 (trial$ or stud$)).tw.
38. (clinical$ adj5 trial$).tw.
39. ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).tw.
40. (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).tw.
41. (therapeutic adj5 (trial$ or stud$)).tw.
42. ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).tw.
43. ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).tw.
44. (coin adj5 (flip or flipped or toss$)).tw.
45. (cross-over or cross over or crossover).tw.
46. placebo$.tw.
47. sham.tw.
48. (assign$ or alternate or allocat$ or counterbalance$ or multiple baseline).tw.

49. controls.tw.
50. (treatment$ adj6 order).tw.
51. or/22-50
52. 21 and 51
53. limit 52 to human
54. (traumatic not (traumatic and stroke)).ti.
55. 53 not 54

Appendix 5. PsycINFO search strategy (Ovid)

1. cerebrovascular disorders/ or cerebral hemorrhage/ or exp cerebral ischemia/ or cerebral small vessel disease/ or cerebrovascular accidents/ or subarachnoid hemorrhage/
2. (stroke or poststroke or post-stroke or cerebrovasc$ or brain vasc$ or cerebral vasc$ or cva$ or apoplex$ or SAH).tw.
3. ((brain$ or cerebr$ or cerebell$ or intracran$ or intracerebral) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$)).tw.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracranial or subarachnoid) adj5 (haemorrhage$ or hemorrhage$ or haematoma $ or hematoma$ or bleed$)).tw.
5. hemiparesis/ or hemiplegia/
6. (hemipleg$ or hemipar$ or paresis or paretic).tw.
7. "brain lesions (disorders)"/
8. brain injur$.tw.
9. or/1-8
10. exp attention/ or exp attention deficit disorder/ or exp concentration/ or exp sustained attention/ or exp divided attention/ or attention span/ or exp visual attention/ or exp selective attention/
11. ((attention$ or concentrat$ or arousal or alert$ or vigilance or attentiveness or awareness) adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas$ or reduc$)).tw.
12. (inattention or distract$).tw.
13. (error adj3 control$ adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas$ or reduc$)).tw.
14. (speed adj3 information adj3 process$ adj5 (impair$ or deficit$ or disorder$ or problem$ or diminish$ or decreas$ or reduc$)).tw.
15. (mental adj5 (slow$ or fatig$)).tw.
16. or/10-15
17. cognitive therapy/ or cognitive behavior therapy/ or cognitive rehabilitation/ or rehabilitation/
18. computer assisted therapy/ or exp computers/ or human computer interaction/ or computer training/
19. (training or retraining or therap$ or rehabilitat$ or neurorehabilitat$ or treatment$ or therapeutic$).tw.
20. training/
21. ((attention$ or concentrat$ or arousal or alert$ or vigilance or attentiveness or awareness) adj6 (skill$ or abilit$ or function$ or improve $ or enhance$ or increas$ or strateg$ or task$)).tw.
22. or/17-21
23. clinical trials/ or treatment effectiveness evaluation/ or placebo/
24. (random$ or RCT or RCTs).tw.
25. (controlled adj5 (trial$ or stud$)).tw.
26. (clinical$ adj5 trial$).tw.
27. ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).tw.
28. (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).tw.
29. ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).tw.
30. ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).tw.
31. (cross-over or cross over or crossover).tw.
32. (placebo$ or sham).tw.
33. trial.ti.
34. (assign$ or allocat$).tw.
35. or/23-34
36. 9 and 16 and 22 and 35

Appendix 6. Cumulative Index to Nursing and Allied Health Literature (CINAHL) search strategy (EBSCO)

S1(MH "Cerebrovascular Disorders") OR (MH "Basal Ganglia Cerebrovascular Disease+") OR (MH "Carotid Artery Diseases+") OR (MH "Cerebral Ischemia+") OR (MH "Cerebral Vasospasm") OR (MH "Intracranial Arterial Diseases+") OR (MH "Intracranial Embolism and Thrombosis") OR (MH "Intracranial Hemorrhage+") OR (MH "Stroke") OR (MH "Vertebral Artery Dissections") OR (MH "Brain Injuries")
S2(MH "Stroke Patients") OR (MH "Stroke Units")
S3TI (stroke or poststroke or post-stroke or cerebrovasc* or brain vasc* or cerebral vasc or cva or apoplex or SAH) or AB (stroke or poststroke or post-stroke or cerebrovasc* or brain vasc* or cerebral vasc or cva or apoplex or SAH)
S4TI (brain* or cerebr* or cerebell* or intracran* or intracerebral) or AB (brain* or cerebr* or cerebell* or intracran* or intracerebral)
S5TI (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus*) or AB (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus*)

S6S4 and S5
S7TI (brain* or cerebr* or cerebell* or intracerebral or intracranial or subarachnoid) or AB (brain* or cerebr* or cerebell* or intracerebral or intracranial or subarachnoid)
S8TI (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*) or AB (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*)
S9S7 and S8
S10S1 OR S2 OR S3 OR S6 OR S9
S11(MH "Arousal") OR (MH "Attention")
S12(MH "Attention Deficit Hyperactivity Disorder")
S13TI ((attention* OR concentrat* OR arousal OR alert* OR vigilance OR attentiveness OR awareness) N5 (impair* OR deficit* OR disorder* OR problem* OR diminish* OR decreas* OR reduc*)) OR AB ((attention* OR concentrat* OR arousal OR alert* OR vigilance OR attentiveness OR awareness) N5 (impair* OR deficit* OR disorder* OR problem* OR diminish* OR decreas* OR reduc*))
S14TI (inattention OR distract*) OR AB (inattention OR distract*)
S15TI (error N3 control* N5 (impair* OR deficit* OR disorder* OR problem* OR diminish* OR decreas* OR reduc*)) OR AB (error N3 control* N5 (impair* OR deficit* OR disorder* OR problem* OR diminish* OR decreas* OR reduc*))
S16TI (speed N3 information N3 process* N5 (impair* OR deficit* OR disorder* OR problem* OR diminish* OR decreas* OR reduc*)) OR AB (speed N3 information N3 process* N5 (impair* OR deficit* OR disorder* OR problem* OR diminish* OR decreas* OR reduc*))
S17TI (mental N5 (slow* OR fatig*)) OR AB (mental N5 (slow* OR fatig*))
S18S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17
S19(MH "Cognitive Therapy")
S20(MH "Rehabilitation") OR (MH "Rehabilitation, Cognitive")
S21(MH "Therapy, Computer Assisted")
S22(MH "User-Computer Interface")
S23TI (training OR re-training OR retraining OR therap* OR rehabilitat* OR neurorehabilitat* OR treatment* OR therapeutic*) OR AB (training OR re-training OR retraining OR therap* OR rehabilitat* OR neurorehabilitat* OR treatment* OR therapeutic*)
S24TI ((attention* OR concentrat* OR arousal OR alert* OR vigilance OR attentiveness OR awareness) N6 (skill* OR abilit* OR function* OR improve* OR enhance* OR increas* OR strateg* OR task*)) OR AB ((attention* OR concentrat* OR arousal OR alert* OR vigilance OR attentiveness OR awareness) N6 (skill* OR abilit* OR function* OR improve* OR enhance* OR increas* OR strateg* OR task*))
S25S19 OR S20 OR S21 OR S22 OR S23 OR S24
S26S10 AND S18 AND S25
S27PT randomized controlled trial or clinical trial
S28(MH "Random Assignment") or (MH "Random Sample+")
S29(MH "Crossover Design") or (MH "Clinical Trials") or (MH "Double-Blind Studies") or (MH "Intervention Trials") or (MH "Preventive Trials") or (MH "Randomized Controlled Trials") or (MH "Single-Blind Studies") or (MH "Therapeutic Trials") or (MH "Triple-Blind Studies") or (MH "Comparative Studies")
S30(MH "Control (Research)") or (MH "Control Group")
S31(MH "Factorial Design") or (MH "Quasi-Experimental Studies") or (MH "Nonrandomized Trials")
S32(MH "Placebo Effect") or (MH "Placebos") or (MH "Meta Analysis")
S33(MH "Clinical Research") or (MH "Clinical Nursing Research")
S34(MH "Community Trials") or (MH "Experimental Studies") or (MH "One-Shot Case Study") or (MH "Pretest-Posttest Design+") or (MH "Solomon Four-Group Design") or (MH "Static Group Comparison") or (MH "Study Design")
S35TI random* or AB random*
S36TI (controlled N5 (trial* OR stud*)) OR AB (controlled N5 (trial* OR stud*))
S37TI (clinical* N5 trial*) OR AB (clinical* N5 trial*)
S38TI ((control OR treatment OR experiment* OR intervention) N5 (group* OR subject* OR patient*)) OR AB ((control OR treatment OR experiment* OR intervention) N5 (group* OR subject* OR patient*))
S39TI (therapeutic N5 (trial* OR stud*)) OR AB (therapeutic N5 (trial* OR stud*))
S40TI ((control OR experiment* OR conservative) N5 (treatment OR therapy OR procedure OR manage*)) OR AB ((control OR experiment* OR conservative) N5 (treatment OR therapy OR procedure OR manage*))
S41TI ((singl* OR doubl* OR tripl* OR trebl*) N5 (blind* OR mask*)) OR AB ((singl* OR doubl* OR tripl* OR trebl*) N5 (blind* OR mask*))
S42TI (coin N5 (flip OR flipped OR toss*)) OR AB (coin N5 (flip OR flipped OR toss*))
S43TI (cross-over OR cross over OR crossover OR placebo* OR sham) OR AB (cross-over OR cross over OR crossover OR placebo* OR sham)
S44TI (assign* OR alternate OR allocat* OR counterbalance* OR multiple baseline OR controls OR treatment N6 order) OR AB (assign* OR alternate OR allocat* OR counterbalance* OR multiple baseline OR controls OR treatment N6 order)
S45S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44
S46S26 AND S45

Appendix 7. Psychological Database for Brain Impairment Treatment Efficacy (PsycBITE) search strategy

Target Area: Attention / information processing (speed)
Intervention: Cognitive
Neurological Group: Stroke / CVA (Cerebrovascular Accidents)

Method: Randomized Controlled Trials
Age Group: Adults

Appendix 8. REHABDATA search strategy

Search all fields in REHABDATA for records
with this exact phrase: stroke
with at least one of these words: attention arousal concentrat*
Year of Publication between: 2012 and 2019

Appendix 9. ClinicalTrials.gov search strategy

(attention OR concentration OR arousal) AND INFLECT EXACT "Interventional" [STUDY-TYPES] AND (Brain Injuries OR Vertebral Artery OR Brain Infarction OR Intracranial Hemorrhages OR Carotid Artery Diseases OR Brain Ischemia OR Cerebral Hemorrhage OR Cerebrovascular Disorders OR Stroke) [DISEASE] AND Randomized [TREATMENT]

Appendix 10. WHO ICTRP

stroke AND attention
Phases are: All

WHAT'S NEW

Date	Event	Description
25 June 2019	New search has been performed	Update search completed. No new articles found for inclusion. The review still includes six RCTs with 223 participants
25 June 2019	New citation required but conclusions have not changed	Conclusions unchanged. New authors added.

HISTORY

Protocol first published: Issue 4, 2000
Review first published: Issue 4, 2000

Date	Event	Description
15 October 2012	New search has been performed	We updated the searches and included four new trials. There are now six included trials with a total of 223 participants. We have added a stricter definition of the inclusion criteria and outcome measures. There is also a newly added assessment of long-term effects. The conclusions have not changed since the last version was published
15 October 2012	New citation required but conclusions have not changed	New first author
4 August 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

TL and RdN are the guarantors of this update. They were involved in conceiving and designing the update, screening retrieved papers against the inclusion criteria; analysing and interpreting the data; and writing the update. TL was also involved in writing to study authors for additional information and managing and entering data into Review Manager 5 (Review Manager 2014).

KJP was involved in conceiving and designing the update; undertaking the searches; screening the search results; organising retrieval of papers; screening retrieved papers against the inclusion criteria; writing to study authors for additional information; managing and entering data into Review Manager 5 (Review Manager 2014); analysing and interpreting the data; and writing the update.

DW was involved in conceiving and designing the update; screening retrieved papers against inclusion criteria; analysing and interpreting the data; and writing the update.

DECLARATIONS OF INTEREST

TL: none.

KJM: none.

DW: none.

RdN: none.

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

- National Institute for Health Research (NIHR), UK.
- National Health and Medical Research Council, Australia.

  GNT1136269

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

This is an update of an earlier review and there was no published protocol.

INDEX TERMS

Medical Subject Headings (MeSH)

*Attention; *Cognitive Behavioral Therapy; *Stroke Rehabilitation; Cognition Disorders [etiology] [*rehabilitation]; Randomized Controlled Trials as Topic; Stroke [complications]

MeSH check words

Humans