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Interventions for perceptual disorders following stroke (Review)

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[Intervention Review]

Interventions for perceptual disorders following stroke

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ABSTRACT

Background

Perception is the ability to understand information from our senses. It allows us to experience and meaningfully interact with our environment. A stroke may impair perception in up to 70% of stroke survivors, leading to distress, increased dependence on others, and poorer quality of life. Interventions to address perceptual disorders may include assessment and screening, rehabilitation, non-invasive brain stimulation, pharmacological and surgical approaches.

Objectives

To assess the effectiveness of interventions aimed at perceptual disorders after stroke compared to no intervention or control (placebo, standard care, attention control), on measures of performance in activities of daily living.

Search methods

We searched the trials registers of the Cochrane Stroke Group, CENTRAL, MEDLINE, Embase, and three other databases to August 2021. We also searched trials and research registers, reference lists of studies, handsearched journals, and contacted authors.

Selection criteria

We included randomised controlled trials (RCTs) of adult stroke survivors with perceptual disorders. We defined perception as the specific mental functions of recognising and interpreting sensory stimuli and included hearing, taste, touch, smell, somatosensation, and vision. Our definition of perception excluded visual field deficits, neglect/inattention, and pain.

Data collection and analysis

One review author assessed titles, with two review authors independently screening abstracts and full-text articles for eligibility. One review author extracted, appraised, and entered data, which were checked by a second author. We assessed risk of bias (ROB) using the ROB-1 tool, and quality of evidence using GRADE.

A stakeholder group, comprising stroke survivors, carers, and healthcare professionals, was involved in this review update.

Main results

We identified 18 eligible RCTs involving 541 participants. The trials addressed touch (three trials, 70 participants), somatosensory (seven trials, 196 participants) and visual perception disorders (seven trials, 225 participants), with one (50 participants) exploring mixed touch-somatosensory disorders. None addressed stroke-related hearing, taste, or smell perception disorders. All but one examined the effectiveness of rehabilitation interventions; the exception evaluated non-invasive brain stimulation. For our main comparison of active intervention versus no treatment or control, one trial reported our primary outcome of performance in activities of daily living (ADL):

Somatosensory disorders: one trial (24 participants) compared an intervention with a control intervention and reported an ADL measure.

Touch perception disorder: no trials measuring ADL compared an intervention with no treatment or with a control intervention.

Visual perception disorders: no trials measuring ADL compared an intervention with no treatment or control.

In addition, six trials reported ADL outcomes in a comparison of active intervention versus active intervention, relating to somatosensation (three trials), touch (one trial) and vision (two trials).

Authors' conclusions

Following a detailed, systematic search, we identified limited RCT evidence of the effectiveness of interventions for perceptual disorders following stroke. There is insufficient evidence to support or refute the suggestion that perceptual interventions are effective. More high-quality trials of interventions for perceptual disorders in stroke are needed. They should recruit sufficient participant numbers, include a 'usual care' comparison, and measure longer-term functional outcomes, at time points beyond the initial intervention period. People with impaired perception following a stroke should continue to receive neurorehabilitation according to clinical guidelines.

PLAIN LANGUAGE SUMMARY

Interventions for perceptual disorders following stroke

Key messages

Stroke can affect a person’s ability to process and understand information from their senses, including hearing, smell, somatosensation (sense of body temperature, position, and movement), taste, touch, and vision. Processing and understanding information from these senses is known as perception.

Little research has been carried out to find out whether any treatments for stroke-related problems with perception are helpful.

People with stroke-related problems with hearing, smell, somatosensation, taste, touch, and vision should continue to participate in rehabilitation as recommended by clinical guidelines. Healthcare professionals should continue to offer rehabilitation for stroke-related perceptual problems in keeping with current clinical guidelines and recommendations.

What is a perceptual disorder?

Before a stroke, adults gather information about the world through their senses: hearing, smell, somatosensation, taste, touch, and vision. Somatosensation refers to sensation arising from the skin, muscles, or joints, and includes perception of pressure, vibration, temperature, and position. Information gathered might include the colour, shape, and size of objects that they see. Together with memories and cultural experiences, a person can understand how someone is feeling from seeing their facial expression. Other examples are how different odours can be identified through the sense of smell and how different textures can be felt through the sense of touch. A stroke can affect these abilities.

How are perceptual disorders treated?

Healthcare professionals, including occupational therapists, physiotherapists, and psychologists, may offer different therapies. Treatments might include medicine, stimulation of the brain, or perceptual rehabilitation through activities, puzzles, strategies, or intensive repetition of tasks.

What did we want to find out?

We wanted to find out whether receiving any perceptual disorder treatment was better than no treatment at all. We measured improvement by looking at how well people could carry out their daily activities. We measured whether treatments also helped other things, such as quality of life, mental health, and perception. We looked for information on when things did not go well. We also explored whether one treatment was more beneficial than another.

What did we do?

We searched for all relevant research. We assessed the quality of 18 studies and summarised their results.

What did we find out?

The studies we found were about different perceptual disorders: three studies looked at disorders of touch perception, seven looked at somatosensation, seven studies looked at vision, and one looked at several perceptual problems at the same time. The treatments used in these studies included paper-and-pencil copying tasks to improve visual memory and using robots to help improve a person's sense of where their body is positioned. We found no information to show that any treatment worked.

Why are we still uncertain?

We found few studies. Each study included a small number of people with a perceptual problem after a stroke. With small numbers of people involved, the results were not clear. Each study looked at different interventions. Less than half the studies (seven) measured the ability to carry out everyday activities.

How up to date is this information?

Our information is up to date as of August 2021.

Based on the information we gathered, we are still unclear about the benefits or harms of treatments for perceptual problems after stroke. People with perceptual problems after stroke should continue to be offered rehabilitation as recommended in clinical guidelines.

SUMMARY OF FINDINGS

Summary of findings 1. Rehabilitation interventions compared to no treatment or control for hearing, smell, or taste perception disorders

Rehabilitation interventions compared to no treatment or control for hearing, smell, or taste perception disorders

Patient or population: stroke survivors with hearing, smell, and taste perception disorders

Settings: any

Intervention: interventions for hearing, smell, and taste perception disorders

Comparison: no treatment or control

Outcome (at end of intervention period)	Comparison	Relative effect (95% CI)	Number of participants (studies)	GRADE	Comments
Activities of daily living (primary outcome)	-	-	No studies	-	-
Extended activities of daily living	-	-	No studies	-	-
Quality of life and participation	-	-	No studies	-	-
Psychological and mental health	-	-	No studies	-	-
Perception	-	-	No studies	-	-
Adverse events	-	-	No studies	-	-

CI: confidence interval

GRADE Working Group grades of evidence
High quality: further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: we are very uncertain about the estimate.

Summary of findings 2. Rehabilitation interventions compared to no treatment or control for somatosensory perception disorders

Rehabilitation interventions compared to no treatment or control for somatosensory perception disorders

Patient or population: stroke survivors with somatosensory perception disorders

Settings: any

Intervention: interventions for Pusher Syndrome or not Pusher Syndrome

Comparison: no treatment or control

Outcome (at end of intervention period)	Comparison	Relative effect (95% CI)	Number of participants (studies)	GRADE	Comments
Activities of daily living - intervention for not Pusher Syndrome (Analysis 1.1) (primary outcome)	Active intervention vs no treatment	-	No studies	-	-
	Active intervention vs control	MD 10.08 (-2.47 to 22.63)	24 (1 study)	Very low quality[a,b,c]	No difference between intervention and control
Extended activities of daily living	Active intervention vs no treatment or vs control	-	No studies	-	-
Quality of life and participation - mobility and navigation intervention for not Pusher Syndrome (Analysis 1.2)	Active intervention vs no treatment	-	No studies	-	-
	Active intervention vs control	MD 0.50 (-0.38 to 1.38)	24 (1 study)	Very low quality[a,b]	No difference between intervention and control
Psychological and mental health	Active intervention vs no treatment or vs control	-	No studies	-	-
Perception	Active intervention vs no treatment	-	No studies	-	-
	Active intervention vs control	Insufficient detail to allow analysis	24 (1 study)	-	-
Adverse events	Active intervention vs no treatment	-	No studies	-	-
	Active intervention vs control	Insufficient detail to allow analysis	24 (1 study)	-	Authors stated that "all the participants completed the stimulation sessions successfully without complaining about any

discomfort during the procedure"

Pusher Syndrome is a clinical disorder following left or right brain damage in which people actively push away from the nonhemiparetic side.
Not Pusher Syndrome relates to any other somatosensory perception disorder.
CI: confidence interval; **MD:** mean difference

GRADE Working Group grades of evidence
High quality: further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: we are very uncertain about the estimate.

Grading of recommendation, assessment, development and evaluation (GRADE) reasons for downgrading the quality of the evidence
[a]At least one risk of bias category was assessed as high or uncertain
[b]Very small number of participants/studies (downgraded by two levels)
[c]Very wide confidence interval(s)

Summary of findings 3. Rehabilitation interventions compared to no treatment or control for tactile perception disorders

Rehabilitation interventions compared to no treatment or control for tactile perception disorders

Patient or population: stroke survivors with tactile perception disorders

Settings: any

Intervention: rehabilitation

Comparison: no treatment or control

Outcome (at end of intervention period)	Comparison	Relative effect (95% CI)	Number of participants (studies)	GRADE	Comments
Activities of daily living (primary outcome)	Active intervention vs no treatment or vs control	-	No studies	-	-
Extended activities of daily living	Active intervention vs no treatment or vs control	-	No studies	-	-
Quality of life and participation - mobility and navigation	Active intervention vs no treatment	MD 6.50 (-4.81 to 17.81)	30 (2 studies)	Insufficient evidence[a-f]	A number of methodological concerns led to the judgement that

(Analysis 3.1)					there was insufficient evidence to support a conclusion based on these data
	Active intervention vs control	-	No studies	-	-
Psychological and mental health	Active intervention vs no treatment or vs control	-	No studies	-	-
Perception (Analysis 3.2)	Active intervention vs no treatment	MD 4.64 (3.06 to 6.21)	30 (2 studies)	Very low quality[a,b,f]	Favours intervention
	Active intervention vs control	-	No studies	-	-

CI: confidence interval; **MD:** mean difference

GRADE Working Group grades of evidence
High quality: further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: we are very uncertain about the estimate.

Grading of recommendation, assessment, development and evaluation (GRADE) reasons for downgrading the quality of the evidence
[a]At least one risk of bias category is high or uncertain
[b]Very small number of participants/studies (downgraded by two levels)
[c]Poor overlap of confidence intervals
[d]Heterogeneity, as indicated by I^2 greater than or equal to 50%
[e]Uncertainty regarding the unit of data presented for this outcome (states time in methods section and speed in results table; assumed to be time for direction of analysis)
[f]Baseline differences between groups for this outcome

Summary of findings 4. Rehabilitation interventions compared to no treatment or control for vision perception disorders

Rehabilitation interventions compared to no treatment or control for vision perception disorders

Patient or population: stroke survivors with vision perception disorders

Settings: any

Intervention: rehabilitation

Comparison: no treatment or control

Outcome (at end of intervention period)	Comparison	Relative effect (95% CI)	Number of participants (studies)	GRADE	Comments
Activities of daily living (primary outcome)	Active intervention vs no treatment or vs control	-	No studies	-	-
Extended activities of daily living (Analysis 5.1)	Active intervention vs no treatment	-	No studies	-	-
	Active intervention vs control	MD 0.94 (-1.60 to 3.48)	33 (1 study)	Very low quality[a,b]	No difference between groups
Quality of life and participation	-	-	No studies	-	-
Psychological and mental health	-	-	No studies	-	-
Perception (Analysis 5.2)	Active intervention vs no treatment	MD -1.75 (-5.39 to 1.89)	27 (1 study)	Very low quality[a,b,c]	No difference between groups
	Active intervention vs control	-	No studies	-	-
Adverse events	Active intervention vs no treatment or vs control	-	No studies reported adverse events	-	-

CI: confidence interval; **MD:** mean difference

GRADE Working Group grades of evidence
High quality: further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: we are very uncertain about the estimate.

Grading of recommendation, assessment, development and evaluation (GRADE) reasons for downgrading the quality of the evidence
[a]At least one risk of bias category is high or uncertain
[b]Very small number of participants/studies (downgraded by two levels)
[c]Baseline differences between groups

BACKGROUND

Description of the condition

Stroke is the second most frequent cause of mortality (Katan 2018), and the second leading cause of disability-adjusted life-years worldwide (Lanas 2021). In 2019, over 12 million people experienced a stroke (GBD 2019 Stroke Collaborators), with over 100,000 occurring in the United Kingdom (UK) each year (Royal College of Physicians 2021; Public Health Scotland 2021). Stroke can impact a person's ability to process sensory information (Mercier 2001). It is estimated that one in five stroke survivors experience a perceptual disorder (Rowe 2009).

Perception is the ability of the brain to interpret and integrate information received by the senses. It can involve multiple steps in the processing of sensory information, including understanding the information received, organising it, and assigning meaning (Lezak 2012). This includes hearing (auditory), smell (olfactory), somatosensation, touch (tactile), taste (gustatory), and visual systems. We present our definition of perception and details of the senses and disorders included in this review in the Types of participants section.

Perceptual disorders reduce an individual's ability to understand their relationship to the environment and, in turn, to respond appropriately. Hearing perception disorders can affect listening and communication ability, impacting on participation in rehabilitation (Koohi 2017a). Inability to smell can result in safety concerns (e.g. detecting smoke, gas, or stale food (Wehling 2015)), whilst altered perception of touch can place affected limbs at risk of injury (such as burns) and negatively impact independence in everyday activities (Doyle 2010). Disordered perceptions of touch and somatosensation may: impair the control of posture and movement; lead to poorer performance of motor tasks; contribute to slower and/or poorer recovery of motor function; and negatively impact independence in everyday activities (Abe 2012; Carey 2011b; Doyle 2010; Tyson 2008). Taste dysfunction can lead to impaired appetite due to unpleasantness of eating, potentially contributing to malnutrition, weight loss, and increased risk of depressive symptoms (Dutta 2013). Studies have shown that visual perceptual disorders are associated with reduced ability in activities of daily living (Prince 2017), greater disability, reduced quality of life (Ali 2013), and are a predictor of poor self-care (Bernsprang 1987).

Despite the adverse impact of perceptual disorders on long-term quality of life, they are frequently undetected by healthcare professionals (Dutta 2013). Current guidelines include limited information on perception, with little guidance on how to select or implement interventions (NICE 2013; Royal College of Physicians 2016).

Description of the intervention

A range of interventions to address perceptual disorders currently exists. Interventions often involve a rehabilitation focus, aiming to restore, compensate, or substitute for a loss of function. They vary, depending on the sense affected and the specific nature of the dysfunction. Rehabilitation interventions can include those led by healthcare professionals (including physiotherapists and occupational therapists), such as functional training in everyday tasks for visual perceptual disorders (Edmans 2000), or exercises for vertical training and postural control for somatosensory disorders (An 2020). Technology-based interventions can include robotic devices for gait training (Yun 2018), computer training with neurofeedback to test changes in visual perception (Cho 2015), or specialist hearing devices (Koohi 2017b). A range of specialist equipment is available and includes touch discrimination blocks for touch perceptual disorders (Carey 1993), and a suspension device for posture correction (Jahn 2017). In addition, non-invasive brain stimulation (Koo 2018), such as transcranial direct current stimulation, has been described in the treatment of somatosensory or touch disorders. Pharmacological interventions for auditory or visual hallucinations have also been reported (Chen 2011; Fifer 1993).

How the intervention might work

Rehabilitation interventions

Rehabilitation interventions are "designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment" (World Health Organization 2011). They can be categorised as restorative, compensatory, or substitutive in approach (Kerkhoff 2000). Restorative interventions involve direct training of the impaired function with the aim of recovering this function. Strategies can include repetition of exercises or games to achieve postural control (Choi 2018), training with different materials to improve texture discrimination (Carey 1993), or practice of (visual) perceptual tasks (e.g. card sequencing or figure copying (Edmans 1991)). In each case, the aim is that skills gained in therapy contexts will transfer to everyday activities.

Compensatory approaches to rehabilitation focus on using a spared function to overcome limitations. Strategies might include route training to compensate for impaired visual perception (Brunsdon 2007), and learning emotional strategies to assist in the development of coping skills for perceptual impairments (McDowell 2019). Substitution approaches may involve the use of external devices or equipment, such as a specialist hearing aid as a substitute for an auditory perceptual disorder (Fifer 1993).

Non-invasive brain stimulation

Transcranial direct current stimulation (tDCS) involves non-invasive brain stimulation that modulates cortical excitability through use of weak electrical currents. Stimulation is delivered via electrodes placed on the stroke survivor's scalp (Koo 2018), with the aim of modulating the primary somatosensory cortex, whereas galvanic vestibular stimulation (GVS) uses current applied to the left and right mastoids to stimulate the vestibular system at the perceptual level (Nakamura 2014).

Pharmacological interventions

A range of pharmacological interventions, including aripiprazole and haloperidol (Chen 2011; Nguyen 2011), have been described as interventions for auditory or visual hallucinations.

Why it is important to do this review

Perceptual disorders following stroke can affect all senses (hearing, smell, somatosensation, taste, touch and vision). Currently, information on interventions available for perceptual disorders is limited. A range of healthcare professionals care for stroke survivors, yet some may not be fully aware of the range of perceptual impairments that can present following stroke (Dutta

2013). As a result, some impairments may go undiagnosed (Jones 2006), and therefore, untreated. Stroke survivors may be unaware of their own perceptual disorder(s) and lack understanding of the impact they have on everyday activities, which may in turn reduce their self-confidence (Hazelton 2019a). Visual perceptual disorders are arguably the most well known, yet care provision for these disorders varies, with significant inequity in access even within the UK (Rowe 2015). Barriers to service provision include healthcare providers' limited knowledge, unclear treatment protocols, and a lack of evidence to inform effective rehabilitation (Pollock 2011a).

The first version of this review was published in 2011 (Bowen 2011). This updated and revised version reflects the recognition that an updated synthesis of new evidence in this field is needed.

Stakeholder involvement

In order to ensure that this review update was relevant and meaningful to key stakeholders, a group of five people with lived experience of stroke and four with expert clinical knowledge were involved throughout all stages of the review. This stakeholder group was formed as part of a wider project relating to evidence for perceptual problems after stroke (Hazelton 2019b). We adopted a 'top and tail' approach to the stakeholder group's input into the review (Pollock 2019a); that is, the stakeholder group contributed to decision making at the planning and methods stage of the review update, and during the interpretation of results during the final stages of the review update. We facilitated involvement through the use of structured methods, such as discussion and independent voting via a series of meetings and online communications. The stakeholder group informed and agreed on the definitions of perception and the senses used in this version of the review. The group also established priorities for outcome measures, which informed the primary and secondary outcomes of interest for this review update. The group members considered the results of the review and contributed ideas which have been incorporated into the organisation, interpretation of data analyses, discussion, and conclusions of this review.

OBJECTIVES

To assess the effectiveness of interventions aimed at perceptual disorders after stroke compared to no intervention or control (placebo, standard care, attention control), on measures of performance in activities of daily living.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised controlled trials (RCTs) of interventions that targeted perceptual disorders as a consequence of stroke. In the case of cross-over trials, we analysed data from baseline to the point of cross-over.

Types of participants

Participants were adults (18 years and older) with impaired perception as a result of a stroke. We used the definition of perception set out in the World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF) (b156): “specific mental functions of recognizing and interpreting sensory stimuli” (World Health Organization 2001). We used this definition because it is internationally recognised, can be applied across all senses, and distinguishes perception from closely related functions, such as sensation and cognition. Following detailed discussion with our stakeholder group, we refined and clarified the scope of the definition to include disorders affecting six areas: hearing (auditory), smell (olfactory), somatosensation (relating to information from the skin, mucous membranes, limbs, and joints; includes proprioception, pressure, and temperature), touch (tactile), taste (gustatory), and vision (visual). Although touch could be considered a component of somatosensation, we chose to present these separately. We considered touch and somatosensation to be separate and distinguishable functions and believed that this would be more accessible to stroke survivors and families, for whom touch is well-recognised as one of the five “traditional” senses.

We excluded trials of interventions for disorders of sensation (informed by the WHO ICF categories of ‘Sensory functions and pain’ (b210-b229)). Thus, for example, we excluded interventions for visual field loss, or for disorders of touch that involved only detection of tactile stimuli, but no recognition or interpretation of that sensory information. We excluded disorders of other specific mental functions, such as memory (b144), thought (b160), and higher-level cognitive functions (b164). We refer to these collectively as cognition or cognitive function throughout the rest of this review.

Clinically, neglect is widely accepted to be an attentional disorder (Corbetta 2011), and we therefore excluded interventions for unilateral neglect (which are considered in another Cochrane Review (Longley 2021). We excluded apraxia as it relates to the knowledge and production of movement rather than perception (Heilman 2003); it is also the focus of another Cochrane Review (West 2008). We excluded trials relating to the perception of other stroke-related problems or the consequences of such problems, such as perception of pain, numbness, or weakness. We excluded trials that used other definitions of perception, such as those relating to the way in which an object or concept is regarded, understood, or interpreted.

Given the complex nature of perception and perceptual disorders and the associated language, we anticipated challenges in the application of our perception definition and eligibility criteria (above), and in distinguishing between perceptual disorders and those of other functions. We therefore planned to use relevant stroke and disorder details (lesion location, classification systems used, or reported theories of neural function) to support the application of our definition. We included trials that combined perceptual disorders with disorders that affected other functions; we also planned to include trials where the precise nature of the perceptual disorder could not be determined.

In discussion with our stakeholder group, we decided how to address more complex, stroke-related disorders, as follows.

- We excluded balance because: it frequently incorporates a broad range of non-perceptual input; it is a stage ‘after’ perception (analogous to reading and vision); it has an evidence base that often takes a physical function approach; and its inclusion could make the results less meaningful.
- We included Pusher Syndrome, "a clinical disorder following left or right brain damage in which patients actively push away from the nonhemiparetic side" (Karnath 2003). Whilst the aetiology

and mechanism of the disorder are not fully understood, we considered it a disorder of the perception of body posture.

Pusher Syndrome and balance disorders present differently, but on occasion may not be well differentiated in clinical practice: we made our decision to include Pusher Syndrome but exclude balance disorders based on detailed discussion with our stroke-specialist clinicians within our research and stakeholder group. Our main consideration was to focus as much as possible on *perception*, rather than the many, closely-related disorders seen after stroke (as detailed above). In order to do this, clear boundaries were required; however, we are aware that other approaches to this problem could have been used.

Types of interventions

We included any intervention that addressed a perceptual disorder. We grouped trials according to the sense affected (i.e. hearing (auditory), smell (olfactory), somatosensation (including proprioception, pressure, and temperature), touch (tactile), taste (gustatory), or vision (visual)). We planned to include and code interventions that addressed perceptual disorders across more than one sense as a 'mixed' group.

We categorised interventions by the perceptual disorder targeted, followed by the therapeutic approach adopted: rehabilitation, pharmacological, non-invasive brain stimulation, surgical, or assessment and screening intervention. We further subcategorised rehabilitation interventions by the mode of action: restitution, compensation, substitution, or a combination of these (Table 1).

Two review authors (CH/KMc/KT) independently classified included intervention approaches, with input from a third author (DG/SH) where differences could not be resolved through discussion. We included interventions delivered in any stroke care setting (hospital, community, and outpatient settings) and any geographical location.

We included trials in which a comparison was made between an active treatment group that received an intervention for a perceptual disorder, versus a group that received no treatment or control intervention (placebo, standard care, attention control – see Table 2) or an alternative perceptual intervention.

In addition, we aimed to examine whether one active intervention was more effective than any other active intervention for people with perceptual deficits after stroke in relation to the outcomes listed above. We also considered if some interventions were more effective for stroke survivors with specific demographic variables (including age, stroke severity, time since stroke), as measured by the primary outcome (ADL).

Types of outcome measures

Stakeholder Involvement

Our stakeholder group informed the selection of included outcome measures. This process involved identifying relevant outcome categories, then using a consensus process to rank them by importance in the context of this review.

Primary outcomes

Our primary outcome was performance in activities of daily living (ADL) immediately post-intervention ('immediate' time point). We also planned to analyse ADL when measured at a follow-up time point of three months after the intervention. We recognise that other follow-up time points – for example, a longer (6- to 12-month) follow-up – are also important, but chose to focus on a short-term (3-month) follow-up because: (1) based on experience in other reviews, we considered that trials were most likely to provide data for this time point (Hazelton 2022; Longley 2021; Pollock 2019b); and (2) synthesising data for this time point would enable us to explore whether any treatment effects observed immediately after treatment were maintained in the short term. We included any validated, standardised measure of ADL, such as the Barthel Index (Mahoney 1965), Functional Independence Measure (Keith 1987), Modified Rankin Scale (Rankin 1957), Katz Index of Activities of Daily Living (Katz 1983), Assessment of Motor and Process Skills (AMPS) (Fisher 1994), and Rehabilitation Activities Profile (Lankhorst 1996). Where trials provided data on more than one ADL outcome measurement instrument, we extracted and analysed the measure occurring earliest in the above list.

Secondary outcomes

Additional outcomes of relevance to this review included:

- extended activities of daily living (EADL), measured by scales such as the Frenchay Activities Index, Nottingham Extended Activities of Daily Living scale, Lawton Instrumental Activities of Daily Living, and Rivermead Activities of Daily Living score;
- quality of life and participation. This included three groups of outcomes:
  - quality of life (QoL), measured by scales including the EQ5D, Health-related quality of life scale, Quality of Well Being Scale, SF36, Stroke Impact Scale;
  - social activities and participation, measured by scales including the Social Problem-Solving Video Measure, Australian Community Participation Questionnaire, and the ICEpop CAPability measure for Older people;
  - mobility and navigation, measured by scales such as the Rivermead Mobility Index, 6-Minute Walk Test, functional ambulation, and Timed Up and Go Test;
- mental health and psychological well-being of:
  - stroke survivors, measured by scales such as the Hospital Anxiety and Depression Scale, Beck Depressive Inventory, General Health Questionnaire, and Geriatric Depression Scale discharge destination;
  - family, friends, and carers, measured by scales such as the Carer Strain Index, Brief Family Distress Scale, and Perceived Caregiver Burden;
- perceptual function, measured by scales such as the Rivermead Perceptual Assessment Battery, Motor-Free Visual Perception Test, Birmingham Object Recognition Battery, and Chessington Occupational Therapy Neurological Assessment Battery;
- adverse events; for example, falls, death, fatigue, and accident rates.

Other outcomes noted, but not analysed were:

- sensation; for example, visual acuity, visual fields;
- motor ability (including balance); for example, grip strength, Berg Balance Scale, Postural Assessment Scale for Stroke, Motor Assessment Scale, Fugl-Meyer Assessment of Motor Recovery after Stroke, and Motricity Index;

- cognition (including attention); for example, the Mini–Mental State Examination, Wechsler Adult Intelligence Scale (WAIS), line cancellation, and star cancellation.

Search methods for identification of studies

We did not apply any language limitations. We arranged for translations of publications if required.

Electronic searches

We searched the following electronic bibliographic databases and clinical trial registers (last searched on 9 August 2021):

- Cochrane Stroke Group's Register, the Cochrane Central Register of Controlled Trials (CENTRAL), and the Cochrane Database of Systematic Reviews (CDSR) in the Cochrane Library (2021, Issue 8) (Appendix 1);
- MEDLINE (Ovid; from 1946) (Appendix 2);
- Embase (Ovid; from 1974) (Appendix 3);
- ERIC (EBSCO; from 1966) (Appendix 4);
- CINAHL (EBSCO) (Cumulative Index to Nursing and Allied Health Literature; from 1982) (Appendix 5);
- AMED (Ovid; from 1885) (Appendix 6);
- PsycINFO (Ovid; from 1806) (Appendix 7);
- Epistemonikos Database (www.epistemonikos.org/) (Appendix 8);
- Web of Science – Core Collection (Appendix 9);
- Centre for Reviews and Dissemination (Database of Abstracts of Reviews of Effects (DARE) and the NHS Economic Evaluation Database (NHS EED), and Health Technology Assessment (HTA) (www.crd.york.ac.uk/CRDWeb/) (Appendix 10);
- ProQuest Dissertations and Theses Global (from 1997) (Appendix 11).

We developed all the search strategies with the help of the Cochrane Stroke Group Information Specialist (MEDLINE Ovid; Appendix 2). Since the previously published version of this review (Bowen 2011), the search strategies have been extensively updated to include any newly identified, relevant controlled vocabulary terms and keywords. The MEDLINE Ovid search strategy included the Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE: sensitivity-maximizing version (2008 revision) as described in the Technical Supplement to Chapter 4, 'Searching for and selecting studies', in the *Cochrane Handbook for Systematic Reviews of Interventions* (Lefebvre 2021).

Searching other resources

In an effort to identify further published, ongoing, and unpublished trials, we conducted supplementary searches of the following resources:

- registers of ongoing trials:
  - US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (www.clinicaltrials.gov) (Appendix 12);
  - World Health Organization International Clinical Trials Registry Platform (trialsearch.who.int) (Appendix 12);
- OpenGrey (www.greynet.org/opengreyrepository.html);
- Grey Matters: a practical tool for searching health-related grey literature, (www.cadth.ca/grey-matters-practical-tool-searching-health-related-grey-literature) (last accessed 24 November 2020);
- Google Scholar (scholar.google.com/) (top 250 most relevant entries);
- NIHR Clinical Research Network (www.nihr.ac.uk/);
- Physiotherapy Evidence Database (PEDro) (pedro.org.au);
- OTseeker (www.otseeker.com);
- PROSPERO International prospective register of systematic reviews (www.crd.york.ac.uk/prospero/).

In addition, we searched national and international guidelines, government websites, relevant healthcare professional (HCP) websites, and the websites of relevant charities and patient support organisations. We also contacted research, professional associations or foundations, and experts in the field.

We completed forward citation tracking using Science Citation index and Google Scholar (scholar.google.com/) and searched the reference lists of included trials.

Data collection and analysis

Selection of studies

The Cochrane Stroke Information Specialist (JC) conducted the database searches, while three review authors (PC, CH, KMc) searched other supplementary resources. One review author (KMc/KT) excluded duplicates and any titles which were obviously not related to stroke and perception. We obtained the abstracts for the remaining references and two review authors (CH, KMc, KT) independently considered each of these abstracts, excluding any trials that clearly did not meet the inclusion criteria. The review authors resolved any disagreements through discussion, involving a third review author or clinical specialist from the stakeholder group with expertise in the relevant field for expert opinion where needed. Two review authors (CH/KMc/KT) obtained and independently assessed the full texts of all potentially relevant trials. We resolved any disagreements following discussion with an additional member of the research team or Clinical Expert Group (see Acknowledgements). We recorded the reason(s) for each exclusion at the full-text screening stage.

Data extraction and management

One review author (KMc/KT) extracted data into drafted, piloted, Excel-based extraction forms, and a second review author (CH/KT) checked data entry in full. We resolved disagreements through discussion or by involving a third review author if necessary.

Where possible we collected the following data.

- Study: country, setting, year, design, number of centres, number of trial arms.
- Methods: randomisation method, prospective power calculation, recruitment details, dropout details.
- Participant: inclusion criteria, exclusion criteria, number, age, sex, stroke details (type, time since stroke, hemisphere affected, severity), perceptual disorder, sense(s) affected and method of diagnosis, severity, presence of other stroke-related impairment.
- Intervention: classification (active intervention/no treatment/control), intervention approach (rehabilitation/non-invasive brain stimulation/pharmacological/surgery/assessment and

screening). Rehabilitation interventions were further classified as restitution, compensation, substitution, or a combination of these. Description using TIDieR headings (Hoffmann 2014), of materials, procedures, who delivered, mode, where, session and duration details, tailoring and modification.

- Outcomes: instrument name and aspect recorded, time point of data collection and results. For dichotomous data, we extracted the numbers who specifically did, or did not, experience the outcome in each group; that is, the 2x2 table. For continuous data, we extracted means and standard deviations for each intervention group. Where these were unavailable, we contacted authors and requested the data or calculated them using Cochrane methods (Higgins 2020). For all outcomes, we recorded any significance test, t, f, P values, and directions of findings. If a trial provided data from more than one outcome measure for the primary outcome (ADL), we extracted them in the order set out in Primary outcomes. Where a trial reported an outcome measure not listed above, we sought data on its validity and reliability in comparison to other outcome measures and ordered them from most to least appropriate. Clinical experts in the relevant topic area then considered and approved these lists.

Assessment of risk of bias in included studies

We used the Cochrane risk of bias (ROB-1) tool to judge risk of bias (Higgins 2011). Two review authors (CH, KT) independently performed assessment, grading the risk due to selection bias (randomisation, allocation concealment), performance bias (differences in the interventions), detection bias (masking of outcome assessment), attrition bias (trial withdrawals), reporting bias, and any other sources of bias.

Two review authors independently categorised the risk of bias as high, low, or unclear, with any disagreements between authors discussed with a third review author to reach consensus. Reasons for judgements were transparently reported. We looked for an intention-to-treat analysis when participants had dropped out of trials and sought evidence of additional publications if outcome measures were not fully reported.

If judgements for performance bias and detection bias differed (e.g. low and unclear), we labelled the overall category as unclear. Where we judged a trial as having a high risk of performance or detection bias, then we considered blinding as an overall category as having a high risk of bias.

Measures of treatment effect

We used Review Manager software (version 5.4; Review Manager 2020) to carry out statistical analyses to determine treatment effects. We used a random-effects model for meta-analysis throughout. For dichotomous variables, we calculated a Peto odds ratios with 95% confidence intervals (CI). For continuous data, we calculated the mean difference (for measurements in the same scale) or standardised mean differences (for measurements on different scales) and 95% CIs.

We treated ADL and other ordinal scales for secondary outcomes as continuous outcomes (as an accepted meta-analytic technique for ordinal outcome data is not yet available).

Where reported outcomes used a measurement scale where a lower value indicates a better outcome, we multiplied the reported values by -1, so that in all analyses a higher value was indicative of a better outcome.

We used final-value scores for analysis. If trials reported change-from-baseline values and the baseline value was available, we calculated the final-value scores. If trials reported change values and the baseline value was not available, we used these data in meta-analyses but planned sensitivity analyses to investigate the effect of including the data.

We used data from trials involving stroke survivors. For trials with a mixed population, we planned to extract the stroke-specific data where these were available. Where these were unavailable, we used mixed population data when more than 80% of participants were stroke survivors. We planned to conduct sensitivity analyses to investigate the effect of including these data.

Unit of analysis issues

We did not anticipate any specific unit of analysis issues. Where trials had more than one eligible active intervention group within the same comparison (against a control, placebo, standard care, or no treatment group), we divided the control group data between the multiple pair-wise comparisons to ensure there was no double counting of participants within any one analysis.

Dealing with missing data

Where we identified missing outcome data, we requested these data from the trialists. If data remained unavailable, we calculated the value where possible; for example, by estimating a standard deviation (SD) based on a reported standard error, using *Cochrane Handbook for Systematic Reviews of Interventions* methods (Higgins 2020). We planned to conduct sensitivity analyses to investigate the effect of entering assumed values.

Assessment of heterogeneity

We calculated statistical heterogeneity using the I^2 statistic, and discussed the results in light of *Cochrane Handbook* guidance on heterogeneity (Deeks 2020). We used the I^2 statistic to categorise the level of heterogeneity as follows:

- I^2 of 0% represents no heterogeneity;
- $0\% < I^2 < 30\%$ may represent some heterogeneity;
- $30\% \leq I^2 < 50\%$ may represent moderate heterogeneity;
- $50\% \leq I^2 < 75\%$ may represent substantial heterogeneity;
- $I^2 \geq 75\%$ may represent considerable heterogeneity.

We conducted pre-specified subgroup analyses (Subgroup analysis and investigation of heterogeneity), and considered further sensitivity analyses based on characteristics arising during data extraction.

Assessment of reporting biases

We compared the availability of our planned outcomes (i.e. as listed in study protocols or methods) with those reported in the included trials. We noted where study authors described an outcome as measured but did not report it or where data were unavailable for analysis. We planned to examine a funnel plot for possible publication bias if we identified 10 or more trials reporting a single outcome (Egger 1997).

Data synthesis

Our analysis pooled trials that compared: (1) active intervention to no treatment; and (2) active intervention to a control intervention (placebo, standard care, or attention control). We stratified these analyses according to intervention approach category (rehabilitation/non-invasive brain stimulation/surgery/pharmacology/assessment and screening).

The pre-specified comparisons were:

- active intervention for**hearing perception** impairment versus **no treatment**;
- active intervention for **hearing perception** impairment versus **contro**l (attention control/standard care/placebo);
- active intervention for **smell perception** impairment versus **no treatment**;
- active intervention for **smell perception** impairment versus **control** (attention control/standard care/placebo);
- active intervention for **somatosensory perception** impairment versus **no treatment**;
- active intervention for **somatosensory perception** impairment versus **control** (attention control/standard care/placebo);
- active intervention for **touch perception** impairment versus**no treatment**;
- active intervention for **touch perception** impairment versus **control** (attention control/standard care/placebo);
- active intervention for **taste perception** impairment versus **no treatment**;
- active intervention for **taste perception** impairment versus**control** (attention control/standard care/placebo);
- active intervention for **visual perceptual** impairment versus **no treatment**;
- active intervention for **visual perceptual** impairment versus **control** (attention control/standard care/placebo).

The planned outcome measures and time points for each comparison above were:

- ADL: immediate post-intervention time point;
- ADL: follow-up time point (three months);
- EADL: immediate post-intervention time point;
- QoL: immediate post-intervention time point;
- Mental health and psychological well-being: immediate post-intervention time point;
- Perceptual function: immediate post-intervention time point;
- Adverse events: immediate post-intervention time point.

We directly compared one active intervention with another, where we considered it meaningful to do so. The review author team took these decisions by considering the perceptual disorder addressed, the nature of the intervention, and the outcome measures assessed in the relevant trials.

We tabulated outcome measures available at follow-up time points.

For trials reporting other outcomes of interest (sensation, cognition, motor function), we tabulated outcome measures at the immediate and follow-up time points, but did not conduct a meta-analysis of these data.

Subgroup analysis and investigation of heterogeneity

Following stakeholder input, we planned to conduct the following subgroup analyses, to explore different treatment approaches and participant/stroke variables:

- treatment approach: rehabilitation, non-invasive brain stimulation, surgery, pharmacology, assessment and screening;
- participants: age (adult 18 to 65 years, older adult > 65 years), sex;
- stroke characteristics: stroke severity, time since stroke, type of stroke, laterality of stroke.

When 10 or more trials were included in a single analysis (with sufficient information to determine the subgroups), we planned to use established subgroup analysis methods (Deeks 2020).

Sensitivity analysis

We planned to carry out sensitivity analyses on the primary outcome to explore the risk of bias categories (selection bias, performance bias, detection bias, attrition bias reporting bias and any other sources of bias) and publication type.

Where possible, we explored the effect of including trials which were at 'high' or 'unclear' risk of bias.

Summary of findings and assessment of the quality of the evidence

We presented our findings for (1) the intervention versus no treatment comparison, and (2) the intervention versus control comparison, containing intervention subgroups where relevant. We presented data for six different outcomes: activities of daily living, extended activities of daily living, quality of life, mental health and psychological well-being (of stroke survivors and family, friends, and carers), perceptual function, and adverse events.

Two review authors independently rated our confidence in the cumulative evidence for each synthesis using GRADE methodology and considering design, inconsistency, indirectness, imprecision, and publication bias. Where necessary, we reached agreement through discussion. We downgraded the level of evidence accordingly, with one downgrade for each concern, and a maximum of two downgrades for any one criterion. Beginning with a default grade of high quality for each comparison, one downgrade reduced the level of evidence to moderate quality, two downgrades reduced it to low quality, and three or more downgrades reduced it to very low quality. We used the following definitions of evidence quality (Guyatt 2008):

- high quality: when further research is very unlikely to change our confidence in the estimate of effect;
- moderate quality: when further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate;
- low quality: when further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate;
- very low quality: when we are very uncertain about the estimate.

We considered other factors that may have affected the quality of evidence and transparently recorded the reasons for downgrading evidence quality.

RESULTS

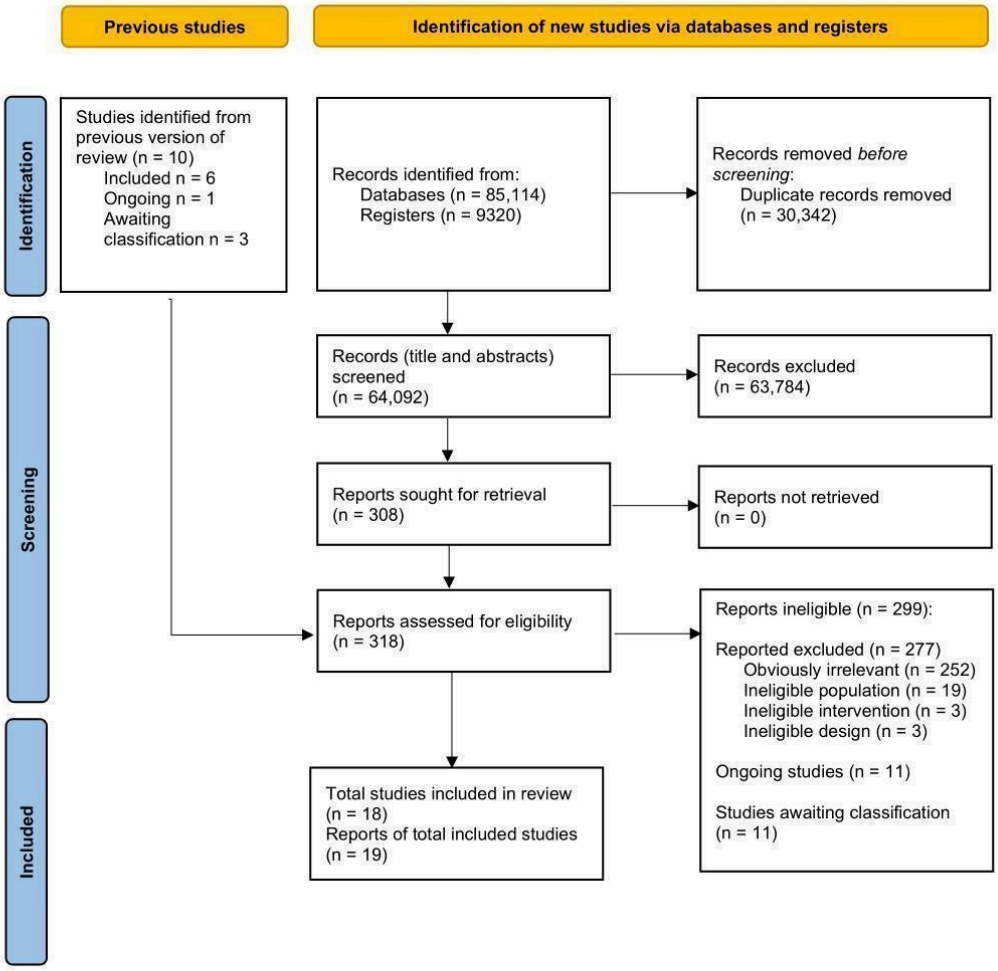
Description of studies

See: Characteristics of included studies; Characteristics of excluded studies; Characteristics of ongoing studies; and Characteristics of studies awaiting classification.

Results of the search

Our database and additional searches identified 94,434 records. In addition, we considered 10 trials identified in the earlier version of the review (Bowen 2011). We retrieved 318 full-text reports to screen for eligibility. We excluded 252 of these as they were obviously irrelevant to the review. Of the remaining 66 reports, we included 18 studies (19 reports), excluded 25 studies (25 reports), identified 11 ongoing studies, and categorised 11 as 'awaiting classification'. We present the flow of literature and results of our search and screening process in the PRISMA flow diagram (Figure 1).

Figure 1. Study flow diagram



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

Figure 1. (Continued)

Included studies

We included 18 trials (541 participants, of whom 535 (98.9%) were stroke survivors) (An 2019; An 2020; Bergmann 2018; Carey 2011a; Chen 2012; Cho 2015; Choi 2018; De Bruyn 2018; Edmans 2000; Kang 2009; Kim 2015; Koo 2018; Lee 2021; Lincoln 1985; Park 2015; Seim 2021; Yang 2015; Yun 2018). Seventeen of the trials recruited only stroke survivors. Of 33 participants included in Lincoln 1985, six had a head injury.

The Bowen 2011 version of this review included six trials and 339 participants (Dirette 1999; Edmans 2000; Hajek 1993; Lincoln 1985; Mazer 2003; Taylor 1971). Following consideration of their populations in relation to the revised inclusion criteria for this update, we excluded four of these trials (Dirette 1999; Hajek 1993; Mazer 2003; Taylor 1971) (see Excluded studies below).

Most included trials were two-arm RCTs, with Kim 2015 randomising participants across two active interventions groups and a no-treatment group. One trial used a cross-over design (Lee 2021).

Trials were conducted across seven countries in Asia, Australia, Europe, and North America (Table 3). Recruitment details were often absent or limited. Most trials (14/18; 77.8%) recruited from a single site. Three recruited across two to six sites (Carey 2011a; Chen 2012; De Bruyn 2018). Trials took place in a hospital or medical facility; none were community based.

Between 11 and 80 (mean 29.9, SD 15.9) participants were randomised to the trials. We present the details of dropouts, including the number of participants lost during intervention delivery and during any follow-up, in Table 4.

Included comparisons

The 18 included trials featured 20 comparisons relevant to our review.

Intervention versus no treatment

There were three comparisons of an intervention with no treatment (Kim 2015: a three-arm RCT, two relevant comparisons; Cho 2015). The former trial explored pressure sense training for touch perception disorder; the latter explored neurofeedback training for visual perceptual deficit.

Intervention versus control (placebo/sham/control)

There were three comparisons of an intervention with a control: Koo 2018 (somatosensory), Seim 2021 (touch), and Lincoln 1985 (visual). The nature of the control group varied. Two trials compared treatment to a placebo intervention: sham transcranial direct current stimulation (tDCS), where electrodes were placed on the scalp, but no current/stimulation applied (Koo 2018); and a sham glove which did not vibrate like its active counterpart (Seim 2021). The control group in Lincoln 1985 used conventional occupational therapy, with participants completing activities that were "not specifically designed to improve perceptual abilities".

Intervention 1 versus intervention 2

Fourteen studies compared two different interventions for perceptual disorders (An 2019; An 2020; Bergmann 2018; Carey 2011a; Chen 2012; Choi 2018; De Bruyn 2018; Edmans 2000; Kang 2009; Kim 2015; Lee 2021; Park 2015; Yang 2015; Yun 2018). The nature of the interventions varied, depending on the nature of the disorders and treatment approach taken (detailed below).

Population

We present details of the participants in included trials in Table 5.

The time since stroke onset varied: the shortest was approximately 19 days (Koo 2018), and longest 4.3 years (Seim 2021). Where reported, trials included haemorrhagic and ischaemic stroke. Two trials described stroke severity using the National Institutes of Health Stroke Scale (NIHSS) measure (Carey 2011a; Yun 2018). Participant ages (mean) ranged from 48.8 years in Lincoln 1985 to 75.5 years in De Bruyn 2018.

We identified no eligible RCTs that addressed interventions for disorders of hearing, taste, or smell perception. Three trials (five randomised comparisons) addressed touch perception dysfunction (Kim 2015; Lee 2021; Seim 2021), seven somatosensory (An 2019; An 2020; Bergmann 2018; De Bruyn 2018; Koo 2018; Yang 2015; Yun 2018), seven visual (Chen 2012; Cho 2015; Choi 2018; Edmans 2000; Kang 2009; Lincoln 1985; Park 2015), and one had mixed touch and somatosensory disorder (Carey 2011a). Mixed-sensory categories were not included in our analysis plan; we excluded these data from analysis.

Touch perception disorders were diagnosed using tools that included the revised Nottingham Sensory Assessment (Lee 2021) and Semmes Weinstein monofilament (Kim 2015; Seim 2021).

Somatosensory perception disorders included Pusher Syndrome in five trials, diagnosed using specialised rating scales, such as the Burke Lateropulsion Scale (An 2019; Yun 2018), and Scale of Contraversive Pushing (Bergmann 2018; Yang 2015), or less specific disorders of somatosensation via practical assessments, such as pinprick and light touch tests (De Bruyn 2018; Koo 2018).

Visual perception disorders addressed generalised visual perceptual disorders (Cho 2015; Choi 2018; Edmans 2000; Kang 2009; Lincoln 1985; Park 2015), diagnosed using specialised tests, such as the Motor-free Visual Perception Test (MVPT) (Choi 2018; Kang 2009), Rivermead Perceptual Assessment Battery (Edmans 2000; Lincoln 1985), or cognitive tests that include visual perception subsections (such as the Modified Mini-Mental State Examination (MMSE); Cho 2015; Park 2015), as well as visual memory deficit (Chen 2012), diagnosed using a complex figure-drawing test.

Interventions

Across 20 comparisons in this review, we evaluated 32 interventions (excluding no-treatment and control groups). We categorised these by approach: one intervention involved non-invasive brain stimulation (Koo 2018); all others used a rehabilitative approach, either compensation (one intervention: Edmans 2000), restitution

(25 interventions: An 2019; An 2020; Bergmann 2018; Chen 2012; Cho 2015; Choi 2018; De Bruyn 2018; Edmans 2000; Kang 2009; Kim 2015; Lee 2021; Lincoln 1985; Park 2015; Seim 2021; Yang 2015; Yun 2018), restitution combined with another rehabilitative approach (four interventions: Bergmann 2018; Carey 2011a; Lee 2021; Yun 2018), and one where the nature of the rehabilitation approach was unclear (Carey 2011a).

Details of the interventions, covering the materials, procedures, provider, therapy modality, location, intervention session details and overall duration, and tailoring or modification of the intervention are available in the Characteristics of included studies table. We provide short summaries below.

Interventions for somatosensation perception disorders

There were seven trials (196 participants) exploring 13 interventions (An 2019; An 2020; Bergmann 2018; De Bruyn 2018; Koo 2018; Yang 2015; Yun 2018).

Interventions

- Rehabilitation (restitution) (10 interventions)
  - game-based vertical posture training (two interventions) (An 2019; An 2020)
  - standard posture training (two interventions) (An 2019; An 2020)
  - conventional physiotherapy (for Pusher Syndrome) (two interventions) (Bergmann 2018; De Bruyn 2018)
  - physiotherapy plus sensorimotor training (De Bruyn 2018)
  - physiotherapy plus motor training (De Bruyn 2018)
  - computerised interactive visual feedback training (Wii Fit) (Yang 2015)
  - Mirror feedback training (Yang 2015)
- Rehabilitation (restitution and substitution) (two interventions)
  - robot-assisted gait training (Bergmann 2018; Yun 2018)
- Non-invasive brain stimulation (one intervention)
  - tDCS (Koo 2018)

Materials and procedures

One non-invasive brain stimulation intervention used relevant equipment to deliver tDCS stimulation to the appropriate hemisphere and region (Koo 2018). All other interventions used rehabilitative approaches. For Pusher Syndrome therapy, these could be grouped into either game-based postural training with supporting equipment or conventional physiotherapy for Pusher Syndrome. For non-Pusher disorders, one trial explored sensory-motor training focusing on sense discrimination, and table-top 'motor therapy'.

- Game-based postural training used one of three (named) interventions: Wii Fit (computer-based exercises and balance board) (Yang 2015), Lokomat (computer-based exercises, supportive harness, and treadmill) (Bergmann 2018; Yun 2018), and Spine Balance 3D (computer-based exercises and whole-body tilt apparatus) (An 2019; An 2020). Each was used to provide physical therapy, with participants asked to achieve a set body position or movement in response to the computerised exercises, and in relation to any positional change caused by the associated equipment.
- Conventional physiotherapy for Pusher Syndrome often involved postural training and weight shifting, using visual cues in the room to regulate posture, alongside verbal feedback from the therapist. Materials used were often unclear but included a chair for seated exercises and a mirror for feedback (An 2019; An 2020; Bergmann 2018; Yang 2015; Yun 2018).
- Sensory-motor training used the Study of the Effectiveness of Neurorehabilitation on Sensation (SENSe) approach with three sensory discrimination tasks: texture discrimination, limb position sense, and object recognition (De Bruyn 2018). Materials in these tasks included different textures (fabric, wallpaper, plastic, and sandpaper), different objects of varying shape, size and materials. A range of exercises were used, such as smoothing out fabric whilst appreciating the texture, moving the limb to a specific position, and arranging bottles in order of weight. 'Motor Therapy' used tabletop games such as chess (with clear cognitive and attentional demand), with a set programme of upper limb exercises used to improve gross movement and dexterity (De Bruyn 2018).

Delivery

All interventions were delivered one-to-one, in a hospital setting. A physiotherapist delivered five of 13 interventions (which for one trial specified that they had "more than five years' experience" (An 2020; Yang 2015; Yun 2018), while the remaining providers were not reported, or unclear.

Sessions and duration

There was a great deal of similarity in the timing and duration of the rehabilitation interventions. Sessions typically lasted 30 to 60 minutes per day, were conducted three to five times per week, for a duration of two to four weeks in total. In contrast, non-invasive brain stimulation was delivered for 20 minutes per day for 10 days (Koo 2018).

Tailoring and modification

No modification was noted in any intervention or trial. The tailoring of interventions varied hugely. For seven interventions, it was not mentioned (An 2019; An 2020; Bergmann 2018; De Bruyn 2018; Koo 2018; Yang 2015); for others, this was clearly fundamental to the intervention delivery, where the exercises were tailored to participant ability before training began (An 2019; An 2020; De Bruyn 2018; Yun 2018). In others, the difficulty level was altered relative to performance; for example, the "the speed and range of trunk movement" was increased or exercises were "changing from sitting to standing" (An 2020).

Interventions for touch perception disorders

Three trials (70 participants) explored five interventions (Kim 2015; Lee 2021; Seim 2021).

Interventions

- Rehabilitation (restitution) (four interventions)
  - pressure sense perception training on stable surface (Kim 2015)
  - pressure sense perception training on unstable surface (Kim 2015)
  - hand exercises (without glove) (Lee 2021)
  - a vibrating glove "VTS Glove" (Seim 2021)
- Rehabilitation (restitution and substitution) (one intervention)
  - robot glove-based hand exercises (Lee 2021)

Materials and procedures

Interventions were of two main types: pressure sense training involving exercises on a stable or unstable surface (Kim 2015), and hand exercises, either with or without a glove to assist (Lee 2021; Seim 2021). In pressure sense training, participants stood on either a stable foam block, or on an unstable balance pad. They were asked to shift weight to their affected side, and pressure in the heel was measured to ensure a desired level was reached (Kim 2015). The hand exercises included a range of passive range of motion tasks, and task-based activities and games. The addition of a robotic glove was used to detect movement and provide a simultaneous display of performance on a computer screen, as well as providing sensory stimulation (Lee 2021). A different, vibrating, glove was used to provide stimulation to skin on the palm and fingers; it did not require any exercises (Seim 2021).

Delivery

Interventions were delivered by physiotherapists (two interventions; Kim 2015), or occupational therapists (OTs) (two interventions: Lee 2021), in one-to-one sessions in a hospital setting (four interventions: Kim 2015; Lee 2021), with the vibrating glove used by participants themselves in their own home (one intervention: Seim 2021).

Sessions and duration

These varied from 30-minute sessions three days per week (Kim 2015), to three-hour sessions seven days per week (Seim 2021). Total duration ranged from four to eight weeks.

Tailoring and modification

None of the trials reported modification of the interventions. Tailoring to participants' ability was not reported for two interventions (Lee 2021; Seim 2021). The interventions with tailoring comprised the pressure sense training, which tailored training to participants' heel pressure, and allowed progression to a harder stage when a suitable pressure level was achieved (Kim 2015), and robot-assisted hand exercises, whose settings were adjusted to participants' ability (Lee 2021).

Interventions for visual perception disorders

Seven trials (225 participants) explored 12 interventions (Chen 2012; Cho 2015; Choi 2018; Edmans 2000; Kang 2009; Lincoln 1985; Park 2015).

Interventions

- Rehabilitation (restitution) (11 interventions)
  - image drawing: global processing training (Chen 2012)
  - image drawing: rote repetition training (Chen 2012)
  - neurofeedback (NFB) training (Cho 2015)
  - Wii Fit virtual reality training (WVRT) (Choi 2018)
  - general balance training (Choi 2018)
  - transfer of training perceptual treatment (Edmans 2000)
  - functional perceptual treatment (Edmans 2000)
  - computerised visual perception rehabilitation with motion tracking (Kang 2009)
  - computer-based cognitive rehabilitation programme (Kang 2009)
  - OT-led perceptual training (Lincoln 1985)
  - computer-based cognitive rehabilitation training (Park 2015)
  - conventional cognitive rehabilitation (Park 2015)
- Rehabilitation (restitution and compensation) (one intervention)
  - functional perceptual treatment (Edmans 2000)

Materials and procedures

All interventions used a rehabilitation approach and could be grouped into five main types: paper-based tasks, occupational therapist-led task-based training, physical interventions, cognitive and perceptual exercises, and neurofeedback training.

Three interventions used paper-based tasks: in two, participants traced then reproduced a complex figure (Rey–Osterrieth Complex Figure) either as a whole figure, or broken down into its component parts (Chen 2012); the third used "conventional cognitive rehabilitation" the exact nature of which was not clearly stated (Park 2015). Three interventions used an occupational therapy approach, training visual perceptual skills using functional and task based training (Edmans 2000; Lincoln 1985). Although not well described, this training included simple perceptual activities, such as stick length sorting, colour matching, and parquetry mosaic tasks. One trial explored physical interventions for visual perceptual disorders alongside balance disturbance (Choi 2018). Wii Fit with balance board training used a range of activities to stimulate interest and motivation, such as simulated tightrope walking and slalom, which encouraged multidirectional weight shifting. Balance training used a balance board, with the participant asked to shift weight, using a mirror for feedback. One approach used computerised exercises – these frequently were called "cognitive" in nature, but had a clear focus on improving visual perceptual skills, including object recognition, object constancy, figure-ground organisation, visual discrimination, and visual organisation (Kang 2009; Park 2015).

Delivery

Delivery was poorly reported for vision interventions. It was explicitly stated that a physiotherapist (one intervention; Choi 2018) and an occupational therapist (three interventions; Kang 2009; Lee 2021) delivered interventions. All were delivered on a one-to-one basis, and in a hospital setting.

Sessions and duration

Two interventions (involving paper-based repetition training) were delivered in a one-off single session of 90 minutes (Chen 2012). For the other interventions, sessions typically lasted 30 minutes, repeated three to five times per week, for four to six weeks.

Tailoring and modification

Again, no intervention modification was reported. Tailoring was either not reported or was unclear for nine interventions; in three others, the intervention exercises and difficulty were based on participants' perceptual ability (Lincoln 1985; Park 2015).

Interventions for hearing, taste, or smell perception disorders

No trials assessed interventions for hearing, taste, or smell perception disorders.

Outcome measures

The outcome measures used in each included trial are detailed in Table 6, which gives the outcome measure category, details of the specific tests used in each category, and timing of assessment.

Our primary outcome of performance in activities of daily living was measured by seven trials. The tools used were the Modified Barthel Index (Edmans 2000; Kang 2009; Lee 2021), Korean modified Barthel Index (An 2019; An 2020; Koo 2018; Yun 2018), and Edmans' ADL index (Edmans 2000).

The order of frequency of reporting other outcomes measures was: perception (11 trials), adverse events (six trials), quality of life and participation - mobility and navigation (four trials) and eADL (one trial). No trials included measures of quality of life and participation - social and participation ability, quality of life and participation - QoL, or mental health and psychological well-being.

In all six trials reporting adverse events, this was not a pre-specified measure, but instead was reported in an ad hoc manner within the results. It was not possible to establish whether the data reflected the number of participants experiencing an adverse event during the trial or the number of adverse event occurrences, irrespective of the number of participants affected. As such, we chose not to include these data in any analyses; instead we presented the available information in a narrative format.

We identified that all five of the trials addressing the somatosensory disorder of Pusher Syndrome used measures of Pusher Syndrome severity. These included the Burke Lateropulsion Scale and the Scale for Contraversive Pushing. We extracted, analysed, and presented these data, as we considered they provided useful treatment effectiveness information.

Excluded studies

We have given details for 25 excluded reports, where inclusion and exclusion decisions were more difficult. Reasons for exclusion were primarily due to the absence of a perceptual disorder diagnosis (see Characteristics of excluded studies).

Four of the excluded trials were included in the Bowen 2011 version of this review (Dirette 1999; Hajek 1993; Mazer 2003; Taylor 1971). The adjusted criteria for our update required trial participants to have a perceptual disorder diagnosis. These four trials did not meet this criterion, and were excluded.

Ongoing studies

We identified 11 ongoing trials (CTRI201804013372; DRKS00021654; Mazer 2009; NCT02524015; NCT03154138; NCT03888326; NCT03991390; NCT04490655; NCT04703218; NCT04818073; NCT04911738) (see Characteristics of ongoing studies). Mazer 2009 was listed as an ongoing study in the first version of this review (Bowen 2011), and details of this completed trial remain unavailable. The remaining ongoing trials address disorders of smell perception (one RCT), somatosensation (seven RCTs), and vision (two RCTs).

Studies awaiting classification

Eleven trials identified are awaiting classification (Chiu 2020; Kim 2016; Kim 2020; Kitisomprayoonkul 2012; Koval'chuk 2011; Leer 1984; NCT04446273; Matz 2007; Morioka 2003; Muffel 2020; Weinberg 1982) (see Characteristics of studies awaiting classification). One of these, Weinberg 1982, was considered in the 2011 version of the review (Bowen 2011); it remains unclear whether the participants had a confirmed perceptual disorder.

Risk of bias in included studies

See Figure 2 and Figure 3 for an overview of our assessments.

Figure 2. Risk of bias graph: review authors' judgements about each methodological quality item presented as percentages across all included studies

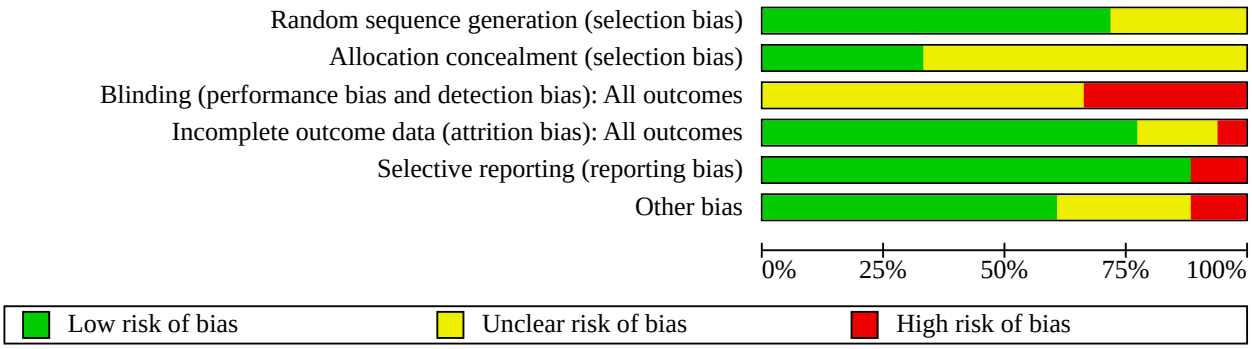
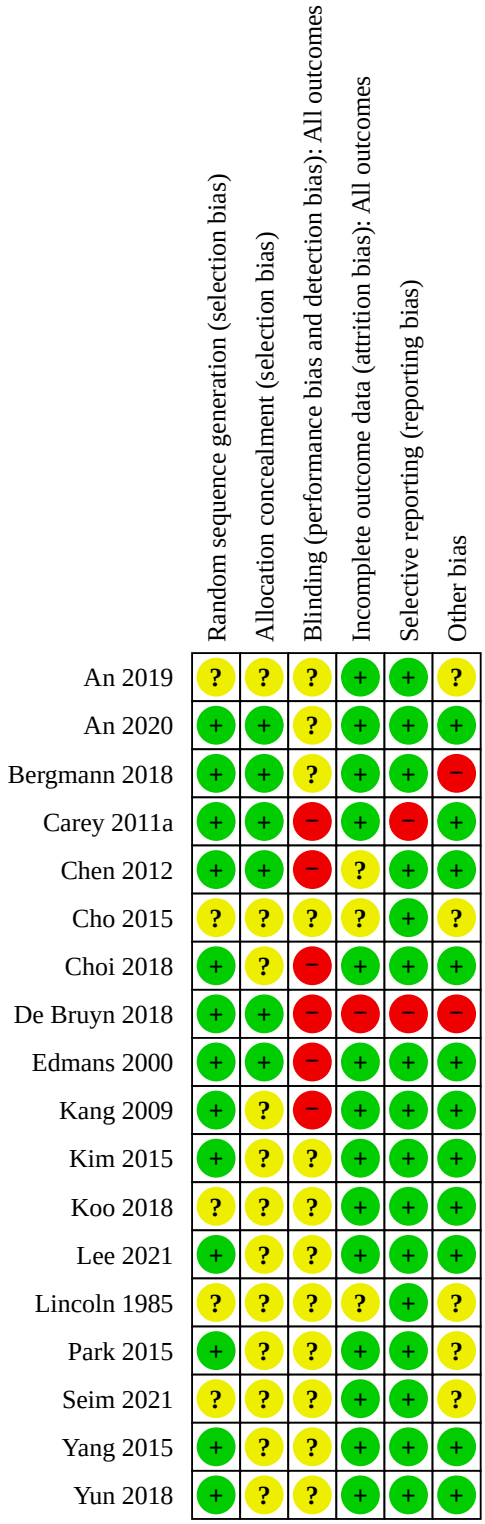


Figure 3. Risk of bias summary: review authors' judgements about each methodological quality item for each included study



Allocation

All included trials reported randomisation, but the method used was unclear for five trials (An 2019; Cho 2015; Choi 2018; Lincoln 1985; Seim 2021). The concealment of allocation was clearly stated by six trials (An 2020; Bergmann 2018; Carey 2011a; Chen 2012; De Bruyn 2018; Edmans 2000), including the use of sealed, opaque envelopes or a sealed box; however, this was unclear for the remaining trials.

Blinding

In complex rehabilitation trials, adequate blinding of clinicians delivering and participants receiving the intervention is a significant challenge. Blinding of outcome assessors is more achievable and was reported by many trials (13 RCTs) but was unclear for five trials (An 2019; Cho 2015; Kim 2015; Park 2015; Yun 2018). We judged six trials as having a high risk of bias (Carey 2011a; Chen 2012; Choi 2018; De Bruyn 2018; Edmans 2000; Kang 2009).

Incomplete outcome data

We judged three trials as having an unclear risk of bias in this domain (Chen 2012; Cho 2015; Lincoln 1985), with the remaining trials either including all participants in their analyses or accounting for all participants (with reasons given for dropouts) and an intention-to-treat analysis conducted. De Bruyn 2018 had a high risk of bias as three participants were excluded from both primary and follow-up analyses.

Selective reporting

For 16 of the 18 included studies, outcome measures were well reported. One trial provided only partial data for three outcomes, as determined by comparing the published protocol and results article (De Bruyn 2018). The Carey 2011a trial failed to provide data for a secondary outcome, as determined by comparing the methods and results within one published article. We assessed both of these as having a high risk of bias in this domain.

Other potential sources of bias

Two trials had a high risk of bias. In Bergmann 2018, several participants had severe cognitive deficits and eight out of 38 participants were unable to complete a cognitive examination because of the severity of their cognitive or language impairments. Whilst no statistically significant baseline differences were found between the groups and no correlation was found between the cognitive examination and the outcome measure scores, the authors noted that these deficits might have influenced the participants' intervention response. The authors felt this was of particular relevance to the control group intervention because the intervention involved more explicit learning processes, plus the control group had more pronounced cognitive deficits.

In De Bruyn 2018, the mean age of the experimental group was significantly older than the control group, and with more right hemispheric lesions.

Comparability of groups at baseline was adequate for An 2020, Carey 2011a, Chen 2012, Choi 2018, Edmans 2000, Kang 2009, Kim 2015, Koo 2018, Lee 2021, Yang 2015, and Yun 2018. We assessed four trials as having an unclear risk of bias in this respect, either due to a lack of reporting of the baseline characteristics of participants (Cho 2015; Park 2015; Seim 2021), or due to difficulties "securing homogeneity" of participants, the nature of which was not fully explained (An 2019).

For Lincoln 1985, there was a change to eligibility criteria part-way through the recruitment phase of the trial to include participants with left hemisphere strokes, subarachnoid haemorrhage, and head injury, due to slow recruitment. It is unclear what interim analyses were undertaken and what the decision-making process was for continuation, adaptation, and eventual stopping of the trial. We assessed this trial as having an unclear risk of bias.

Effects of interventions

See: **Summary of findings 1** Rehabilitation interventions compared to no treatment or control for hearing, smell, or taste perception disorders; **Summary of findings 2** Rehabilitation interventions compared to no treatment or control for somatosensory perception disorders; **Summary of findings 3** Rehabilitation interventions compared to no treatment or control for tactile perception disorders; **Summary of findings 4** Rehabilitation interventions compared to no treatment or control for vision perception disorders

We present below the results for each sense for: (1) intervention versus no treatment or control comparisons; and (2) active intervention 1 versus active intervention 2 comparisons. Outcomes are only listed under each comparison if data were available in the included trials (i.e. there were no data available for any outcomes not listed below).

Hearing perception

No trials. See Summary of findings 1.

Smell perception

No trials.

Somatosensation perception

See Summary of findings 2. We identified seven trials. Two of these addressed general somatosensory disorders, Koo 2018 and De Bruyn 2018, while five addressed interventions for Pusher Syndrome: An 2019, An 2020, Bergmann 2018, Yang 2015, and Yun 2018. Following discussion amongst the members of the review team, the two groups have been presented separately, as either Pusher Syndrome or not Pusher Syndrome, in order to enable clinically useful synthesis of the data.

Intervention versus no treatment or control

Pusher Syndrome

No trials.

Not Pusher Syndrome

One trial with 24 participants compared transcranial direct current stimulation (tDCS) to sham treatment (Koo 2018).

Activities of daily living

Koo 2018 used the Korean modified Barthel Index. Analysis showed no difference between active intervention and control (mean difference (MD) 10.08, 95% confidence interval (CI) -2.47 to 22.63; P = 0.12; very low-quality evidence; Analysis 1.1).

Quality of life and participation - mobility and navigation

Koo 2018 used the Functional Ambulation Category measure. Analysis showed no difference between active intervention and control (MD 0.50, 95% CI -0.38 to 1.38; P = 0.27; very low-quality evidence; Analysis 1.2).

Perception

Koo 2018 measured somatosensory perception (modified Nottingham Sensory Assessment) in a comparison of intervention with control, but the summary data were unreported (subscales only) and could not be included in this analysis.

Adverse events

Koo 2018 recorded adverse events, stating that "all the participants completed the stimulation sessions successfully without complaining about any discomfort during the procedure".

Active intervention 1 versus active intervention 2

Pusher Syndrome

Five trials addressed this comparison: An 2019, An 2020, Bergmann 2018, Yang 2015, and Yun 2018. Trials compared an intervention training posture and/or movement using computerised, game-based exercises, supported by assistive equipment such as balance boards, treadmills or harnesses, to conventional physiotherapy for Pusher Syndrome. Interventions in both groups were considered similar, and we combined the data in meta-analyses.

Activities of daily living

Three trials (80 participants) used the Korean modified Barthel Index (An 2019; An 2020; Yun 2018). Intervention 1 (computerised balance and movement training) was more beneficial than intervention 2 ("standard" Pusher Syndrome physiotherapy) (MD 10.19, 95% CI 4.94 to 15.44; P < 0.001, I^2 = 0%; very low-quality evidence; Analysis 2.1).

Quality of life and participation - mobility and navigation

One trial (30 participants) was included, which used the Performance-Oriented Mobility Assessment-B (POMA-B) outcome measure (Bergmann 2018). Analysis showed no evidence of a difference between interventions 1 and 2 (MD 1.00, 95% CI -1.51 to 3.51; very low-quality evidence; Analysis 2.2).

Perception

One trial (30 participants) was included, which assessed perception of subjective visual vertical (Bergmann 2018). There was no evidence of a difference between interventions 1 and 2 (standardised mean difference (SMD) 0.52, 95% CI -0.21 to 1.25; very low-quality evidence; Analysis 2.3).

Adverse events

Three studies reported on adverse events; in each case, none were reported (An 2020; Yang 2015; Yun 2018).

Pusher Syndrome outcomes

Four trials (86 participants) were included; they used the Burke Lateropulsion Scale (An 2019; An 2020), or the Scale for Contraversive Pushing (Bergmann 2018; Yang 2015). Analysis showed a tendency for intervention 1 (computerised balance and movement training) to be more beneficial than intervention 2 (standard Pusher Syndrome physiotherapy) (SMD 1.03, 95% CI 0.33 to 1.73, P = 0.004, I^2 = 50%; very low-quality evidence; Analysis 2.4).

Not Pusher Syndrome

One trial with 36 participants addressed this comparison, comparing the SENSe intervention, consisting of sensorimotor therapy and sensory discrimination tasks, with cognitive table-top games and motor exercises (De Bruyn 2018).

Perception

De Bruyn 2018 used the Nottingham Sensory Assessment. Analysis showed there was no evidence of a difference between intervention 1 and intervention 2 (SMD -0.38, 95% CI -1.04 to 0.28; very low-quality evidence; Analysis 2.3).

Touch perception

See Summary of findings 3. We identified three trials: Kim 2015, Lee 2021, and Seim 2021. We were able to analyse data from Kim 2015 and Lee 2021; Seim 2021 did not report any outcomes of interest.

Intervention versus no treatment or control

Kim 2015 compared two active interventions with no treatment.

Quality of life and participation - mobility and navigation

For this outcome, we included one trial with two relevant comparisons (30 participants), both using the Timed Up and Go Test (Kim 2015). Analysis showed there was no difference between active intervention and no treatment (MD 6.50, 95% CI -4.81 to 17.81; P = 0.26, I^2 = 50%; Analysis 3.1). Due to a number of methodological concerns, we judged there was insufficient evidence to support a conclusion based on these data.

Perception

We included one trial with two relevant comparisons (30 participants), both using a dynamometer-based measure of proprioception (Kim 2015). Analysis showed a tendency for the active intervention to be more beneficial than no treatment (MD 4.64, 95% CI 3.06 to 6.21; P < 0.001, I^2 = 0%; very low-quality evidence; Analysis 3.2).

Active intervention 1 versus active intervention 2

Two trials addressed this comparison: Lee 2021 compared robot glove-based hand exercises to hand exercises alone, and Kim 2015 compared pressure sense perception training on a stable surface to an unstable one (balance board). As the interventions were quite different in nature, where more than one trial measured the same category of outcome measure, we did not combine data in a meta-analysis.

Activities of daily living

We included one trial (24 participants), which used the Modified Barthel Index (Lee 2021). This trial demonstrated that there was no difference between the interventions (MD -0.41, 95% CI -12.31 to 11.49; very low-quality evidence; Analysis 4.1).

Quality of life and participation - mobility and navigation

We included one trial (20 participants), using the Timed Up and Go Test (Kim 2015). This trial provided evidence that intervention 2

(training on the unstable balance board) was more beneficial than intervention 1 (training on the stable balance board) (MD -11.60, 95% CI -19.50 to -3.70; very low-quality evidence; Analysis 4.2).

Perception

We included two trials (44 participants): one assessed proprioception using a dynamometer (Kim 2015), and the other used the kinaesthetic subtest of the revised Nottingham Sensory Assessment (rNSA) (Lee 2021). We did not combine data from these two trials for analysis: individually, neither trial provided evidence of a difference between interventions 1 and 2 (Analysis 4.3).

Adverse Events

One trial collected data on adverse events, reporting “no safety concerns or adverse events" (Lee 2021).

Taste perception

No trials.

Visual perception

See Summary of findings 4. We identified seven relevant trials: Chen 2012, Cho 2015, Choi 2018, Edmans 2000, Kang 2009, Lincoln 1985, and Park 2015.

Intervention versus no treatment or control

One trial addressed a comparison of intervention with no treatment, comparing neurofeedback training to no treatment (Cho 2015), and one trial addressed a comparison of intervention with control, comparing perceptual training to a conventional (not perceptual) therapy (Lincoln 1985).

Extended activities of daily living (eADL)

We included Lincoln 1985 (33 participants), which used the Rivermead ADL scale. This trial showed there was no evidence of a difference between active intervention and control (MD 0.94, 95% CI –1.60 to 3.48; P = 0.47; very low-quality evidence; Analysis 5.1).

Perception

Cho 2015 (27 participants) assessed perceptual outcomes using the Motor Free Visual Perception Test (MVPT), and Lincoln 1985 measured perception using the Rivermead Perceptual Assessment battery. As Lincoln 1985 only reported subscale scores for the Rivermead Perceptual Assessment battery, we did not include these data in the analysis. Data from Cho 2015 showed no difference between active intervention and no treatment (MD -1.75, 95% CI -5.39 to 1.89; P = 0.35; very low-quality evidence; Analysis 5.2).

Active intervention 1 versus active intervention 2

Five trials addressed this comparison: Chen 2012, Choi 2018, Edmans 2000, Kang 2009, and Park 2015. The interventions were very dissimilar, including OT-led training in practical tasks, paper-based repetition exercises, and computer-based games; thus, statistical pooling of data was inappropriate.

Activities of daily living

Two trials (96 participants) were included; both used the Modified Barthel Index (Edmans 2000; Kang 2009). We did not combine data due to differences in the interventions. We judged the evidence from each included trial to be of very low quality (Analysis 6.1).

Quality of life and participation - mobility and navigation

One trial (28 participants) used the 10-Metre Walk Test to assess mobility (Choi 2018). It compared Wii Fit virtual reality training to general balance training for visual perceptual disorders. This trial showed no evidence of a difference between the two interventions (MD -0.12, 95% CI -13.62 to 13.38; very low-quality evidence; Analysis 6.2).

Perception

We included five trials (163 participants) (Chen 2012; Choi 2018; Edmans 2000; Kang 2009; Park 2015). They used a range of perception outcome measures: the Modified Taylor Complex Figure (Chen 2012), the MVPT (Choi 2018; Kang 2009; Park 2015), and the Rivermead Perceptual Assessment Battery (Edmans 2000). We did not pool data due to differences in the interventions, but displayed them as standardised mean differences (Analysis 6.3). We judged the evidence from each included trial to be of very low quality.

DISCUSSION

Summary of main results

Our review update explored evidence of the effectiveness of interventions for perceptual disorders after stroke. It included disorders of hearing, smell, somatosensation, taste, touch, and visual perception. The main comparisons of interest were active interventions versus no treatment, and active interventions versus control (placebo, standard care, attention control). Our primary outcome measure was participants' performance in activities of daily living.

We included 18 trials (541 participants; 535 with stroke). They addressed somatosensation (seven trials, 196 participants), touch (three trials, 70 participants), vision (seven trials, 225 participants), and mixed perceptual disorders (one trial, 50 participants). There is insufficient evidence to determine the effectiveness of any one intervention for any sensory modality, nor the effect of one intervention relative to another. Only adequately-sized trials, using relevant outcome measures and with appropriate pretrial development studies, will provide answers to these clinically important questions.

Interventions for hearing perception disorders

We found no RCTs exploring the effectiveness of any intervention for hearing perception disorders in people after stroke.

Interventions for smell perception disorders

We found no RCTs exploring the effectiveness of any intervention for smell perception disorders in people after stroke.

Interventions for somatosensation perception disorders

We found no evidence of a difference between intervention and control for ADL and navigation and mobility outcomes; this evidence is of very low quality. We found no difference between two active interventions for somatosensory perception dysfunction (not Pusher Syndrome) on perception outcomes; this evidence is of very low quality.

For Pusher Syndrome, we found no difference between game-based posture training and standard physiotherapy for measures of mobility and navigation and perception. Game-based posture training may be more beneficial than standard physiotherapy for improving ADL and measures of Pusher Syndrome severity. All evidence was of very low quality.

Interventions for taste perception disorders

We found no RCTs exploring the effectiveness of any intervention for taste perception disorders in people after stroke.

Interventions for touch perception disorders

We found no difference between intervention and no treatment for navigation and mobility outcomes, but there may be a beneficial effect of active intervention on perceptual function; this evidence is of very low quality.

Evidence relating to one intervention versus another was varied, and insufficient to draw generalisable conclusions.

Interventions for visual perception disorders

We found no difference between intervention and no treatment on measures of perception; this evidence was of very low quality. There was no difference between active intervention and control for measures of eADL.

We identified some data for outcomes of ADL, navigation and mobility, and perception from trials comparing one intervention to another. Due to differences in the interventions and comparisons conducted, we did not pool data for statistical analysis, and it was not possible to draw generalisable conclusions.

Key findings of this review

- Perceptual disorders have a significant impact on the daily lives of many stroke survivors, but there is an absence of RCT evidence to inform clinical practice for hearing, taste, and smell disorders after stroke. For vision, touch, and somatosensation, the data provide very low-quality evidence, and are insufficient to support generalisable conclusions about the effectiveness of any one intervention. To date, there is insufficient evidence from adequately powered, appropriately designed, and well reported RCTs to reach clear conclusions.
- Interventions identified primarily used a rehabilitative approach, aiming to restore participants' impaired perceptual function. The nature of the interventions varied, which limited our ability to pool data and reach generalisable conclusions.
- The quality of the evidence relating to all comparisons and outcomes was very low.
- Trialists did not report the involvement of people with perceptual disorders in the design, delivery, or interpretation of the included trials.
- No trials addressing the main comparisons of intervention versus no treatment or control measured our primary outcome (performance in activities of daily living) at a follow-up time point.

Overall completeness and applicability of evidence

Participants

Most participants had stroke, with mean age ranging from 48.8 to 75.5 years, and results are therefore generalisable to this population. The time point of intervention delivery varied from 19 days to 4.3 years after stroke. As the appropriate timing, treatment, and intervention dose may vary by stroke chronicity (Bernhardt 2017), this limits generalisability and confidence in the findings.

Our systematic search did not identify any trials that addressed stroke-related perceptual disorders of hearing, taste, or smell. Whilst each sense provides information about the environment, the processing and understanding of this information varies hugely across the senses. Consequently, findings in one sense are not transferable, and cannot be used to inform treatment of disorders in another.

The perceptual disorders addressed in the trials of interventions for touch and vision varied. Participants recruited to trials of interventions for touch disorders experienced dysfunction of both the upper and lower limbs. The tests used to determine and describe participants' visual perception did not provide detailed information about the specific visual skills impaired (e.g. Rivermead Perceptual Assessment Battery, MVPT) and thus the wider applicability of results is unclear. Within somatosensory disorders, there was a subset of included trials that recruited stroke survivors with Pusher Syndrome, and the findings therefore appear generalisable to this population.

Methods

The included trials recruited between 11 and 80 participants, with limited reporting of the use of a priori power calculations. As smaller trials provide less precise estimates of effect, this is a consideration for the trials included in this review.

Interventions

We considered to what extent the interventions included in this review reflect current practice in the regions where the studies were conducted.

Included trials originated from Asia, Australia, Europe, and North America. Many interventions such as OT-led perceptual training for visual disorders, Pusher Syndrome physiotherapy, and computerised visuo-cognitive training appear to reflect known treatment for perceptual impairments. Other approaches may be less available. The use of tDCS is more limited, often only available through clinical trials or limited (fee-paying) service providers (Schjetnan 2013). According to our clinical specialists, the highly technical, equipment-dependent training for Pusher Syndrome, such as the Lokomat or Spineboard 3D tools, are not part of routine clinical care. The analyses relating to these trials may therefore have limited clinical relevance and applicability.

Comparisons

Of the 20 comparisons included in this review, 14 compared two active interventions. Six included a comparison to either no treatment or a placebo, standard care, or attention control intervention. The included interventions varied; in many cases, we did not consider it appropriate to pool data.

Outcomes

There was limited reporting of performance in activities of daily living, our primary outcome measure. This measure was utilised by seven trials, often using the modified Barthel Index (standard or Korean version). The most frequently reported outcome of interest was perceptual function, with a huge variety of tools both within and across senses. Few trials included the outcomes that would show the transfer of any intervention effect beyond change in perceptual ability to impact on everyday life, such as mental health and psychological well-being, or participation and quality of life. Given that our stakeholder group members identified and prioritised these outcomes, this suggests that researchers should consider their choice of outcomes, so that trials can provide more meaningful data to stroke survivors and healthcare professionals. It was also clear that outcomes were most frequently measured immediately after the intervention; there was no evidence of the effects of an intervention on our primary outcome at any other time point, resulting in an absence of evidence on the longevity of any effect.

Adverse event data were inconsistently reported, and we could not include them in any statistical analyses.

It is unclear why there are few RCTs exploring interventions for perceptual disorders following stroke. Our scoping review of interventions for perceptual disorders after stroke included all study designs and highlighted that there is a paucity of all study designs on the topic, not just RCTs (Hazelton 2022). The causes of a lack of intervention research for perceptual disorders are likely multifactorial, potentially linked to two fundamental issues.

First, there is limited awareness and understanding of perceptual disorders in stroke, and thus there is a need for further research. This covers lack of awareness of the presence, nature, frequency, and impact of perceptual disorders, in both stroke survivors, families, and healthcare professionals delivering care (Bamiou 2015; Dutta 2013; Falkenberg 2020). This is compounded by a lack of validated tools to identify perceptual disorders and poor epidemiological data to demonstrate that these are lasting problems worthy of research attention (Colwell 2021; Koohi 2019; Pollock 2011a; Rowe 2015). There is also limited guidance and training in this field (Pollock 2011a). It is also possible that in those with severe stroke, perceptual impairments may be masked by other conditions (e.g. cognitive disorder/aphasia) which may preclude formal assessments and limit self-report.

Second, there are difficulties in conducting research in this field. As we can see from the review, most interventions are rehabilitative in nature. Clinical rehabilitation services may not be well set up to do research, often involving disparate groups of professionals working in different services (NICE 2013). Clinical research needs critical mass and leadership, which is potentially lacking in this field. The specific interventions are also 'complex' in nature. There are a range of known challenges to conducting trials of complex interventions, which include fully understanding the mechanisms of action, standardising the interventions, population included and context of delivery, achieving required recruitment, and retention rates and choice of appropriate outcome measures (Datta 2013; Richards 2015; Skivington 2021; Tarquinio 2015). All of these are directly applicable to research into perceptual disorders in stroke, given the complex interventions, population heterogeneity, and variation in delivery setting across acute and rehabilitation services, forming clear barriers to the conduct of trials. There is additionally potential difficulty in achieving the funding needed to support appropriately powered, complex rehabilitation trials.

Quality of the evidence

We judged the quality of evidence using the GRADE approach and found the evidence included within the meta-analyses to be of very low quality. Key factors contributing to downgrading of the evidence within these comparisons included risk of bias, imprecision, and indirectness.

Risk of bias

We identified methodological concerns in the majority of included trials, with insufficient details available from published reports. We judged six of the 18 included trials to be at low risk of bias for allocation concealment, and none to be at low risk of bias for blinding of outcome assessment. Other potential sources of bias included poor reporting of group differences at baseline.

Imprecision

The number of participants within the included trials was small, ranging from 11 to 80 participants, with only two of the 18 trials including 50 participants or more. Across our review, we included 541 randomised participants, but trial variations limited the pooling of data which, in turn, limited the conclusions that could be drawn based on the evidence.

Indirectness

- Interventions: our review synthesised the available evidence relating to a wide range of different interventions for perceptual disorders after stroke. We found variations in the interventions evaluated, both between senses, and within individual senses.
- Outcomes: across included trials, there was inconsistency in the outcomes assessed by individual trials, and the outcome measurement instruments used. Notably, some of the outcomes that our stakeholder group identified as priorities, including extended activities of daily living and mental health and psychological well-being, were not reported by any of the included trials. The variations in outcome measure instruments limited the ability to pool data from individual trials in a meaningful way, and where measures were pooled, limited our certainty in the result.

In summary, we judged the quality of the evidence synthesised within this review to be very low, and this limits our confidence in the results. Currently, there is insufficient high-quality evidence to support any generalised conclusions about the effectiveness of any specific interventions for perceptual disorders after stroke. Future research needs to be designed to enhance trial quality and limit risk of bias, in order to produce results which are clinically useful and meaningful to people with perceptual disorders after stroke.

Potential biases in the review process

Publication bias

We conducted a thorough systematic search, which included multiple literature databases, trials databases, and grey literature sources, in an effort to identify all relevant published trials. Despite our efforts, there remains a risk that a relevant trial may have been missed in our screening process (especially at title screening

stage, which was the responsibility of one review author). Where uncertainties arose in the screening process, we contacted the trialists for further information; we thank all those who provided valuable information at this stage.

Categorisation of interventions

We categorised interventions using two main criteria: first, the sense targeted by the intervention, and second, the intervention approach (rehabilitation, non-invasive brain stimulation, pharmacological, surgery, screening and assessment). We further categorised rehabilitation interventions by whether they aimed to restore lost function, compensate for lost function, or use an external device or modification to substitute for that lost function. Two independent review authors classified all interventions, involving a third review author where discrepancies could not be resolved through discussion. While alternative approaches to intervention classifications exist, our approach was derived from perceptual disorder research by Kerkhoff 2000 and has been used in other Cochrane Reviews in associated disorders (Chung 2013; Pollock 2019b). The consistent use of a pre-planned, transparent, clinically-relevant approach to categorisation, applied by independent review authors, is a strength of this review.

Categorisation of comparisons

Comparisons in this review related to one of three options: active intervention, no treatment, or control (attention control/standard care/placebo). In some cases, our categorisation of an intervention differed from that reported by the trialists; for example, a physiotherapy intervention specific to Pusher Syndrome functioned as a control intervention in one trial (compared to robot-assisted gait training) (An 2020). For our purposes, however, we classified this as an active intervention. Two review authors independently performed categorisation, and consulted a third author where agreement could not be reached by discussion. We have clearly stated the definitions we used in this process (Types of interventions).

Inclusion criteria: participants

Defining perception is a challenge; application of that definition consistently across senses and trials is also challenging. Our review team, in collaboration with our stakeholder group, discussed, agreed, and voted on key issues relating to definitions in advance of undertaking this review update. These issues included:

- the definition of perception: we used the WHO ICF definition of “the specific mental functions of recognizing and interpreting sensory information” (World Health Organization 2001);
- the senses included: hearing, taste, touch, smell, somatosensation, and vision;
- the disorders included and excluded. We excluded balance and pain. We included one specific disorder, Pusher Syndrome, as we considered this a disorder of somatosensory perception.

At times, the lack of standardised terminology and reporting limitations resulted in challenging judgements relating to perceptual disorders. On occasion, it was difficult to reach consensus on whether disorders were perceptual, cognitive, sensory, or motor in nature, or a combination of these. In each case, we returned to our definition to provide clarity and support our decision making. We recognise other review authors may have made different decisions, and that some inadvertent exclusion of potentially relevant trials may have occurred. We are confident that our overall review conclusions are unlikely to have been impacted by the exclusion of those trials. A strength of our approach was the expertise and experience in conducting systematic reviews of complex interventions delivered to highly heterogeneous participant groups, working in partnership with clinical experts.

Our review included participants with a perceptual disorder. Thus, we excluded from this review trials that evaluated an intervention addressing perceptual function in a generalised stroke population (who may or may not have had a relevant disorder). The previous version of this review took an alternative approach (Bowen 2011).

Outcomes

Our review's primary outcome was participants' performance in activities of daily living. We identified seven trials that measured ADL. From our secondary outcomes of interest, eADL, quality of life and participation - mobility and navigation, perception, and adverse events were reported, while quality of life and participation - social activities and participation, QoL, and mental health and psychological well-being outcomes were absent. The outcome measures sought in this review update were identified and prioritised by the research team alongside our stakeholder group members, to ensure their relevance to stroke survivors and to understand the impact of perceptual disorders on their daily lives. We also noted measures of sensation, motor function, and cognition, but excluded these from our analysis. Classification of outcome measurement instruments rarely presented challenges. Where uncertainties arose, we consulted topic experts, specifically in relation to navigation and mobility outcomes versus those of motor function, and sensation versus perception in relation to touch or somatosensory function.

Given the breadth of senses included and the international trial activities we identified, we encountered several outcome measurement instruments not included in our predefined lists. In order to determine which of these should be included in analysis, we sought data on the tool development and prioritised those with the highest validity and reliability measures. We confirmed these decisions with a topic expert in the relevant field.

Only six out of 18 studies mentioned the occurrence of adverse events; in each case, none were reported. It was unclear whether collection of adverse event data was planned as part of the studies' methods and therefore how thorough the reporting process was. The exact nature of adverse event data collection was also unclear, meaning these data were difficult to interpret. Thus, we did not meta-analyse them. Adverse event data are known to often be handled with less rigour than other outcome measures (Peryer 2022), but they are important to consider within a review, to determine potential harms arising from an intervention and guide clinical practice. RCT data can provide important safety data, and standardised terminology is in place to support clarity of reporting relating to the nature and possible aetiology of adverse events.

Agreements and disagreements with other studies or reviews

Agreements and disagreements with the previous version of this review

The 2011 version of this review identified and included six trials (338 participants), each using sensory stimulation to address visual perceptual disorders. The authors concluded that "there is insufficient evidence to support or refute the view that perceptual interventions are effective" (Bowen 2011).

Our update changed the scope of this review by:

- limiting it to a stroke population, excluding those with other neurological impairments;
- including all interventions, not only those classified as “non-pharmacological”;
- broadening the scope of the searches, to make sure that disorders across all six senses were adequately addressed;
- extending the dates of the search to August 2021.

Our review included a larger number of trials and participants, across three senses rather than just vision, and with a larger range of intervention approaches. However, our conclusions remain similar: there remains insufficient evidence to reach generalised conclusions about the effectiveness of interventions for perceptual disorders.

Agreements and disagreements with other reviews

Several systematic reviews (Cochrane and non-Cochrane) are of relevance to our review and relate to vision, touch, and somatosensation: few reviews of the literature consider hearing, taste, and smell perceptual disorders due to stroke.

For vision, several Cochrane Reviews address related (but not overlapping) disorders, focused on sensory/sensorimotor function (Pollock 2011b; Pollock 2019b), or visual attention (Longley 2021). These may form a natural complement for clinicians who manage a range of disorders of the visual system. Reviews of interventions for visual perception also exist, typically focusing on interventions for visual neglect. Jutai 2003 conducted a "critical review and synthesis" of eight studies (six RCTs) of visual perceptual disorders following stroke, including both spatial neglect and apraxia. In contrast to our findings, they concluded there was "strong evidence" that specific treatment of perceptual disorders improved perceptual functioning based on summarising the original studies’ findings as three positive, one negative, and one mixed. Our systematic review differed in methods and conclusions from the Jutai 2003 review and had just two studies in common (Edmans 2000; Lincoln 1985). While we share the Jutai 2003 conclusion that no one intervention approach has proven efficacy over any other, based on our data, we concluded that there is insufficient evidence to support decisions relating to the effectiveness of specific treatments for visual perceptual disorders.

Cicerone 2005 updated a systematic review of the effectiveness of cognitive rehabilitation for people with traumatic brain injury or stroke to 2002. All studies identified considered neglect rehabilitation or interventions for visual field loss, making no recommendations relevant to the topic of this review. Similarly, Hanna 2017 included visual perception, but with a focus on visual neglect, with no studies in that review meeting our inclusion criteria.

In relation to touch and somatosensation perception disorders, a number of systematic reviews have addressed this topic. Doyle 2010 reviewed interventions for sensory impairment of the upper limb after stroke, including RCTs that addressed “any impairment that impacted on sensory registration, perception, or discrimination,” with a focus on the effect on measures of sensation. Doyle 2010 included a total of 13 studies, with no overlap in those included here; they found insufficient evidence to determine intervention effectiveness. Schaburn 2009 reviewed retraining of sensation after stroke, and this was expanded in 2019 to include 38 RCTs (Serrada 2019), conducting meta-analysis involving 13 comparisons. The review explored passive, active, or combined sensory training, aiming to quantify the effect on impairment and function. Whilst they do not explicitly state the definition of sensation they applied, the background section describes it as “the ability to accurately perceive and discriminate sensations of pain, temperature, pressure and vibration, as well as the ability to accurately locate body parts in space (proprioception)”. They found limited data, with some evidence to support the use of passive sensory training. There were clear differences in the inclusion criteria for the Schaburn 2009 and Serrada 2019 reviews compared to our Cochrane Review, including the: (1) nature of the intervention, (2) body part considered, and (3) nature of the disorder addressed. This review required a clear diagnosis of a post-stroke perceptual disorder, resulting in limited overlap of included studies and comparability of findings.

Only one review, with a very limited search strategy, unclear method of synthesis, and lack of quality appraisal, addressed Pusher Syndrome interventions (Thanaya 2019). The researchers identified 10 studies, exploring robot-assisted gait training, visual feedback, galvanic vestibular stimulation, and physiotherapy interventions. It identified two RCTs, both of which were included here (Bergmann 2018; Yun 2018), and also concluded that further RCTs in this field were required.

AUTHORS' CONCLUSIONS

Implications for practice

Currently, there is insufficient evidence to support or refute the view that any specific intervention is effective at reducing the impact of impaired perception after stroke. More evidence is required before decisions are made on the provision of these services. Absence of evidence is not evidence of absence; but at present it is not possible to make recommendations regarding specific interventions for specific senses nor specific disorders.

Implications for research

Future randomised controlled trials should:

- provide a sufficiently detailed theoretical rationale for, and description of, the interventions, including type and dose, to allow implementation into clinical practice and research replication;
- provide a standard care control group, carefully documenting the content and amount of standard care, which can be highly variable;

- include detailed diagnostic information on individuals' perceptual problems, given the heterogeneity in perceptual problems in terms of type, severity, and likely impact on everyday function;
- endeavour to conduct trials with a low risk of bias through rigorous methodological development and reporting (e.g. ensure allocation concealment; attempt to blind outcome assessors and report the success or failure of blinding; report all loss to follow-up; report results from all outcome measures; control for other possible sources of bias);
- be of sufficient size to have adequate statistical power to answer clinically important questions about long-term functional outcomes;
- ensure that key outcomes, such as activities of daily living, psychosocial benefits, and quality of life, are used;
- adopt an intention-to-treat approach to measurement of outcomes in all individuals as well as to analysis of measured outcomes by treatment group.

Guidance supporting stroke rehabilitation intervention development and trials of their effectiveness should be used (Bernhardt 2019), to ensure the appropriate research questions and study designs are used in any pretrial as well as randomised controlled trial work, and in turn to reduce research waste and address the clinical uncertainties relating to perceptual disorders after stroke.

We further suggest the development of standardised terminology for perceptual disorders, to aid clarity of reporting and understanding for researchers, clinicians, and stroke survivors, across all the senses.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

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

An 2019

Study characteristics	
Methods	**Design:** RCT **Country**: South Korea **Sense(s) addressed**: somatosensation (Pusher Syndrome) **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Pusher Syndrome (Burke Lateropulsion Scale ≥ 2) • Within 3 months post-stroke • 20 to 80 years old • K-MMSE score > 24 • Ability to stand for 30 minutes • Sufficient strength to use the body-tilt equipment • Height 145 cm to 195 cm • Weight < 150 kg **Exclusion criteria**

An 2019 *(Continued)*

- Medically unstable
- Lesions of the brain stem or cerebellum
- Heart disease, epilepsy, other medical conditions
- Neglect

Study population (number randomised): 14

Dropout details given in Table 4

Participant details given in Table 5

Interventions	**Comparison:** active intervention 1 vs active intervention 2 **Active intervention 1** **Name:** game-based vertical posture training **Classification of intervention:** rehabilitation (restitution) **Materials:** "Spine Balance 3D" a specialist tilt apparatus, consisting of tilting main body support, force plates, trunk sensor, and screen for visual feedback **Procedures:** the participant is placed in the Spine Balance 3D trainer, with pelvis, thigh and ankle fastened and trunk sensor attached. There were three stages of game-based training: • static postural training with visual feedback - no tilt, asked to maintain posture using information on monitor • dynamic postural training with visual feedback - weight is shifted to the non-paralytic side, stimulated by the instruction to grab an object on the non-paralytic side • dynamic postural training without visual feedback - as 2, with screen turned off **Who delivered:** not reported **Mode:** one-to-one **Where:** hospital inpatient **Session:** 30 minutes 2 times per day, 5 days per week **Duration:** 3 weeks **Tailoring:** difficulty level was adjusted relative to performance **Modification:** none noted **Active intervention 2** **Name:** standard vertical posture training **Classification of intervention:** rehabilitation (restitution) **Materials:** not reported **Procedures:** not reported **Who delivered:** not reported **Mode:** one-to-one **Where:** hospital inpatient **Session:** 30 minutes 2 times per day, 5 days per week **Duration:** 3 weeks **Tailoring:** not reported **Modification:** not reported **Does normal therapy continue?** Unclear
Outcomes	**ADL:** K-MBI **Perception:** Burke Lateropulsion Scale **Motor:** Postural Assessment Scale for Stroke, balance posture ratio **Timing:** immediately after the intervention For an overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** none reported **Conflict of interest statement:** none reported
Notes	**Trial registration details:** none reported **Published protocol:** none reported

An 2019 *(Continued)*

PPI: none reported
No statement on pilot/feasibility design; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information provided on method of randomisation
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants included in analysis
Selective reporting (reporting bias)	Low risk	All outcome measures accounted for
Other bias	Unclear risk	Unclear regarding baseline differences - had difficulty in securing homogeneity

An 2020

Study characteristics

Methods

Design: 2-arm RCT
Country: South Korea
Sense(s) addressed: somatosensation
Study recruitment and setting details: see Table 3

Participants

Inclusion criteria

- Unilateral hemiplegia after a first hemispheric stroke confirmed by CT or MRI
- Subacute stroke stage (< 2 months since onset)
- Age 20 to 80 years
- Lateropulsion with Scale for Contraversive Pushing (SCP) score > 0
- Orthostatic tolerance for 30 minutes on passive standing
- No severe cognitive impairment based on the K-MMSE (score > 24)
- 1.45 m to 1.95 m tall and body weight < 150 kg

Exclusion criteria

- Unstable medical conditions, such as cardiac disease, epilepsy, and vestibular disorders
- Pure brainstem or cerebellar lesion
- Severe visual or auditory impairments

Study population (number randomised): 30 stroke survivors

Dropout details given in Table 4

An 2020 *(Continued)*

	Participant details given in Table 5
Interventions	**Comparison:** active intervention 1 vs active intervention 2 **Active intervention 1** **Name:** whole-body tilting postural training (WTPT) (n = 15) **Classification of intervention:** rehabilitation (restitution) **Materials:** "Spine Balance 3D" a specialist tilt apparatus, consisting of tilting main body support, force plates, trunk sensor, and screen for visual feedback. **Procedures:** the participant is placed in the Spine Balance 3D trainer, with pelvis, thigh and ankle fastened and trunk sensor attached. There were four stages of exercise and game-based training: 1) static postural training with visual feedback - no tilt, asked to maintain posture using information on monitor; 2) dynamic postural training with visual feedback - as 1, but with tilt up to 30 degree for 5 seconds; 3) dynamic postural training without visual feedback - as 2, with screen turned off; 4) automated dynamic postural training using games **Who**: physiotherapists (with more than 5 years of experience) **Mode**: one-to-one **Where:** inpatient **Session:** 30 minutes 2 times per day, 5 days per week **Duration:** 3 weeks **Tailoring: "**The task difficulty was increased gradually by increasing the speed and range of trunk movement according to the performance. Depending on the performance, the participant was moved to the next stage. For the participant's safety or accurate training, verbal and physical assistance was provided by the physiotherapist when necessary" **Modification:** none stated **Active intervention 2** **Name:** general postural training (GPT) (n = 15) **Classification of intervention**: rehabilitation (restitution) **Materials:** physiotherapy tools including seat, treatment mat, mirror, balls **Procedures:** postural training using feedback and weight shifting to the non-paretic side. Four stages (with 1 and 2 incorporating verbal feedback from the therapist): 1) static training seated on a mat, using a mirror and vertical cues to maintain a vertical position; 2) whilst on the mat, moving to reach objects on the paretic side by weight shifting; 3) as stage 2, but without visual cues or verbal feedback; 4) remain in a vertical position while doing other tasks, such as counting **Who:** physiotherapists (with more than 5 years of experience) **Mode:** one-to-one **Where:** inpatient **Session:** 30 minutes 2 times per day, 5 days per week **Duration:** 3 weeks **Tailoring:** "We gradually increased the difficulty of the task by changing from the sitting to standing position according to the task performance in all training sessions. If the participant performed well, they moved to the next stage. For the participant's safety or accurate training, verbal and physical assistance by the physiotherapist was provided if necessary" **Modification:** none stated Participants in both groups received individual sessions of occupational, speech, and cognitive therapy during hospitalisation (5 days/week).
Outcomes	**ADL:** K-MBI **Adverse events:** number of events **Motor (including balance):** Fugl-Meyer Assessment of Motor Recovery after Stroke -Lower Extremity, Berg Balance Scale, Postural Assessment Scale for Stroke **Others:** Burke Lateropulsion Scale **Timing:** immediately after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** none reported **Conflict of interest statement:** "The authors declare that they have no competing interest"

An 2020 *(Continued)*

Notes	**Trial registration details:** Korea Centers for Disease Control and Prevention (registration no.: KCT0004242) **Published protocol:** none stated **PPI:** none stated No statement on pilot/feasibility design; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were randomly allocated using numbered cards
Allocation concealment (selection bias)	Low risk	Cards were drawn from a sealed box
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Two blinded evaluators but not reported for performance bias
Incomplete outcome data (attrition bias) All outcomes	Low risk	All randomised participants were included in the analysis
Selective reporting (reporting bias)	Low risk	All outcome measures reported in full
Other bias	Low risk	The groups did not differ in demographic or clinical characteristics at baseline. No other concerns noted

Bergmann 2018

Study characteristics

Methods	**Design:** RCT **Country**: Germany **Sense(s) addressed**: somatosensation **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Hemiparesis after first unilateral ischaemic or haemorrhagic stroke • 3 weeks to 6 months since onset • Age between 18 and 90 years • Pusher behaviour (Scale for Contraversive Pushing (SCP) > 0 per component) • Orthostatic tolerance for 30 minutes of passive standing **Exclusion criteria** • Extreme osteoporosis • Unstable fracture • Excessive spasticity • Acute diseases of the cardiovascular or respiratory system • Pressure sores on the lower extremities • Body weight was limited to 130 kg, body height to 200 cm, and maximum leg length difference 2 cm

Bergmann 2018 *(Continued)*

	Study population (number randomised): 38 **Dropout details** given in Table 4 **Participant details** given in Table 5
Interventions	**Comparison: active intervention 1 vs active intervention 2** **Active intervention 1** **Name:** robot-assisted gait training **Classification of intervention:** rehabilitation (restitution and substitution) **Materials:** Lokomat robotic device **Procedures:** use of a harness, which is attached to a body-weight support system, and by cuffs placed around legs. Elastic straps are used to passively lift participants' feet and prevent foot drop. Body-weight support was individually set for each participant but amounted to no more than 50% of the participant's body weight. Guidance force was set at 100% on both sides. After a short warming-up period, walking speed was increased to 2 km/h or faster. The target walking time was at least 20 minutes. **Who delivered:** therapists **Mode**: not reported **Where:** inpatient **Session:** 8 to 10 sessions **Duration:** 60 minutes, 5 days per week for 2 weeks **Tailoring:** not reported **Modification:** not reported **Does normal therapy continue?** No **Active intervention 2** **Name:** non-robotic physiotherapy **Classification of intervention:** rehabilitation (restitution) **Materials:** Lokomat robotic device **Procedures:** training of postural control including sensory feedback components. Active and dynamic exercises, such as shifting of the centre of gravity; no passive or static exercises were planned. Therapists and participants were allowed to use external references, such as a wall or a handrail on the non-paretic side, and visual feedback, such as the doorframe or a mirror. Training was performed while sitting or standing; movement transitions, such as transferring from sitting to standing, and walking if possible, were practised. **Who delivered:** therapists **Mode**: not reported **Where:** inpatient **Session:** 8 to 10 sessions **Duration:** 60 minutes, either 2 x 30 minutes or 1 x 30 minutes with "co-therapy" (2 therapists; the target was at least 20 minutes of active therapy) 5 days per week for 2 weeks **Tailoring:** not reported **Modification:** not reported
Outcomes	**Mobility and Navigation:** Performance Orientated Mobility Assessment, Functional Ambulation Classification **Perception:** subjective visual vertical **Other:** Scale for Contraversive Pushing, Burke Lateropulsion Scale **Timing:** immediately after intervention, 2 weeks after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** this work was supported by funds from the German Federal Ministry of Education and Research (BMBF IFB 01EO0901) **Conflict of interest statement:** the authors report no disclosures relevant to the manuscript
Notes	**Trial registration details:** this trial was registered at the German Clinical Trials Register (DRKS00003444) **Published protocol:** no **PPI:** none reported

Bergmann 2018 *(Continued)*

	An a priori sample size calculation was performed; effect size was estimated based on the data of the previous pilot study, assuming a 2-sided significance level of 0.05% and 80% power, sample-size calculation resulted in a sample size of 15 participants per group. To account for an anticipated dropout rate of 25%, the minimum number of participants required to enrol was increased to 38 for the entire study.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation sequence was computer-generated
Allocation concealment (selection bias)	Low risk	Sealed opaque envelopes used
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Assessor was blinded but not reported for performance bias
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants accounted for
Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	High risk	No statistically significant differences between the intervention and control groups were found. However, the study states that several participants had severe cognitive deficits and were unable to complete the cognitive examination. No correlation was found between the cognitive examination score and outcome measure score; however, these deficits may have influenced the participants' response to the interventions. This was particularly relevant to the control group as the intervention involved more explicit learning processes.

Carey 2011a

Study characteristics

Methods	**Design:** RCT with partial cross-over **Country**: Australia **Sense(s) addressed**: mixed (tactile and somatosensory) **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Stroke survivors, at least 6 weeks post-stroke • Impaired texture discrimination, limb position sense, and/or tactile object recognition • Medically stable • Adequate comprehension of instructions and perceptual ability for assessment • Able to commit time to participate in the rehabilitation programme **Exclusion criteria** • Evidence of unilateral spatial neglect, based on standard neuropsychological assessments • Prior history of other central nervous system dysfunction or peripheral neuropathy

Carey 2011a *(Continued)*

	Study population (number randomised): 50 **Dropout details** given in Table 4 **Participant details** given in Table 5
Interventions	**Comparison:** active intervention vs active intervention **Active intervention 1** **Name:** sensory discrimination training **Classification of intervention:** rehabilitation (restitution and compensation) **Materials:** "graded stimuli with varying surface characteristics" and "tactile object recognition training focused on discrimination of shape, size, weight, texture, hardness, and temperature using a range of multidimensional, graded objects" **Procedures:** the intervention applied the principles of generalised sensory discrimination training to 3 sensory tasks: texture discrimination, limb position sense, and tactile object recognition. Training employed a variety of stimuli within each sensory dimension trained, graded progression of discriminations from easy to difficult, attentive exploration with vision occluded, anticipation trials, cross-modal calibration via vision, feedback on sensation and method of exploration, intermittent feedback and self-checking of accuracy, feedback on ability to identify distinctive features in novel stimuli, tuition of training principles, and summary feedback and intensive training. During each session, participants were trained on each sensory task, in random sequence, for 15 to 20 minutes at a time. Texture discrimination training used graded stimuli with varying surface characteristics. Limb position sense was trained across a wide range of limb positions of the upper limb. Tactile object recognition training focused on discrimination of shape, size, weight, texture, hardness, and temperature using a range of multidimensional, graded objects. **Who delivered:** "therapist" **Mode**: one-to-one **Where:** not reported **Session:** 60 minutes 3 times per week **Duration:** 10 hours in total **Tailoring:** none reported, but it is possible exercises were tailored to individual ability **Modification:** none reported **Active intervention 2** **Name:** exposure to tactile stimuli **Classification of intervention:** rehabilitation (unclear) **Materials:** "stimuli varying in texture, shape, size, weight, hardness, and temperature" and "common objects" **Procedures:** non-specific repeated exposure to stimuli, via grasping of common objects, and passive movements of the upper limb **Who delivered:** "therapist" **Mode**: one-to-one **Where:** not reported **Session:** 60 minutes 3 times per week **Duration:** 10 hours in total **Tailoring:** none reported **Modification:** none reported **Does normal therapy continue?** No. "Patients were recruited to the study after they had completed their inpatient and outpatient therapy or community-based follow-up, to minimize any confound with co-therapies"
Outcomes	**Perception**: standardised somatosensory deficit (composite of texture discrimination (Fabric Matching Test; FMT), limb position sense (Wrist Position Sense Test; WPST), and tactile object recognition (functional Tactile Object Recognition Test; fTORT) **Adverse events:** numbers affected **Timing:** immediately after intervention (and time points after partial cross-over) For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** the author(s) disclosed receipt of the following financial supports for the research and/or authorship of the article: "This work was supported by the National Health and Medical Re-

Carey 2011a *(Continued)*

	search Council (NHMRC) of Australia [project grant number 191214, and Career Development Award number 307905 to L.M.C]; an Australian Research Council Future Fellowship awarded to L.M.C. [number FT0992299]; the National Stroke Research Institute of Australia and by the Victorian Government's Operational Infrastructure Support Program." The funding sources had no role in conduct of the study or writing of the report. **Conflict of interest statement:** the author(s) declared no potential conflicts of interest with respect to the authorship and/or publication of the article.
Notes	**Trial registration details:** Australian New Zealand Clinical Trials Registry (ACTRN012605000609651) **Published protocol:** none reported **PPI:** none reported No statement on pilot/feasibility design; power calculation conducted: "power estimates were based on our prior study investigating generalized training effects. Outcome data were extracted at phase transitions to mimic the proposed design. The very large standardized effect sizes indicated by that analysis (Cohen's d > 5) yielded powers in excess of 99% for even quite small samples (eg, n = 20). Inclusion of 50 allowed for some attrition and investigation of therapeutic effects on a larger sample."

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation was computer generated with proportional sampling to control for side of lesion and gender
Allocation concealment (selection bias)	Low risk	Sequence of allocation was concealed from recruiting and treating therapists
Blinding (performance bias and detection bias) All outcomes	High risk	Blinding of outcome assessor but blinding of treatment providers was not guaranteed as therapists may have understood the difference between protocols
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants were included in the initial analysis
Selective reporting (reporting bias)	High risk	Secondary outcome measure was not reported and no additional paper was identified
Other bias	Low risk	Baseline demographic and clinical characteristics of the groups were similar at baseline

Chen 2012

Study characteristics

Methods	**Design:** RCT **Country**: USA **Sense(s) addressed**: vision **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • First stroke during the past 6 months, with lesions in the right cerebral cortical or subcortical regions without involving the brain stem or any left-brain region

Chen 2012 *(Continued)*

- No history of brain tumour, neurological disorder other than stroke, or brain injury followed by loss of consciousness
- Right-handed, as determined by a 17-item handedness questionnaire
- No difficulty in reading or using writing instruments within the arm-reach distance
- No impairment in ocular vision indicated by medical records
- Deficits in visuospatial memory (immediate recall accuracy of Modified Taylor Complex Figure MTCF ≤ 9/36)

Exclusion criteria: see above
Study population (number randomised): 11
Dropout details given in Table 4
Participant details given in Table 5

Interventions	**Comparison: active intervention 1 vs active intervention 2** **Active intervention 1** **Name:** image drawing - global processing training **Classification of intervention:** rehabilitation (restitution) **Materials:** Rey–Osterrieth Complex Figure, printed on 11 x 8.5 inch paper **Procedures:** Rey–Osterrieth Complex Figure was presented broken down into five subunits, moving from those presenting the global structure to the local details. Participants had to trace each using a pencil, being told to "please trace all the dashed lines on the paper." Upon completion, the examiner replaced it with the subsequent subunit. Once the entire complex figure was traced and easily visible at the presentation of the last subunit, it was replaced with a blank paper sheet, and participants were asked to reproduce the figure. This was repeated five times. **Who delivered:** not stated **Mode**: one-to-one **Where:** inpatient **Session:** 1 **Duration:** 90 minutes **Tailoring:** no tailoring **Modification:** no modification **Active intervention 2** **Name:** image drawing - rote repetition training **Classification of intervention:** rehabilitation (restitution) **Materials:** Rey–Osterrieth Complex Figure, printed on 11 x 8.5 inch paper **Procedures:** a rote tracing exercise of the entire Rey–Osterrieth Complex Figure printed with dashed lines, repeated five times and receiving the same verbal instruction and producing the same number of drawings as the global processing training group **Who delivered:** not stated **Mode:** one-to-one **Where:** inpatient **Session:** 1 **Duration:** 90 minutes **Tailoring:** no tailoring **Modification:** no modification Participants in both groups continued with their regular physical and occupational therapy (one session of each per day) without interruption
Outcomes	**Perception:** Rey–Osterrieth Complex Figure, Modified Taylor Complex Figure, Medical College of Georgia Complex Figure 1 and Figure 2 **Timing:** immediately after the intervention, 2 weeks, 4 weeks For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** "This work was supported by the Kessler Foundation and the Eunice Kennedy Shriver National Institute of Child Health & Human Development (1R03HD063177 to P.C.)" **Conflict of interest statement:** "None declared"

Chen 2012 *(Continued)*

Notes	**Trial registration details:** none reported **Published protocol:** none reported **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Allocation via playing cards - blindly drew one of 16 cards without knowledge of any association
Allocation concealment (selection bias)	Low risk	Allocation was blinded
Blinding (performance bias and detection bias) All outcomes	High risk	Raters were blinded; however, examiners were not
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Unclear if 2 lost participants were included in analysis
Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Low risk	The groups did not differ significantly at baseline; no other concerns noted

Cho 2015

Study characteristics

Methods	**Design:** RCT **Country**: South Korea **Sense(s) addressed**: vision **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Hemiparalytic from a stroke within the previous 3 months to 1 year • Able to follow verbal instructions • Able to communicate at a certain level • Able to perform all the tests • Cognitive function between 18 and 23 on the MMSE **Exclusion criteria** • Diplegia • Never attended school • "Was biased" • Experienced neurofeedback within the past year **Study population (number randomised):** unclear - 27 "eventually completed the intervention and testing" **Dropout details** given in Table 4

Cho 2015 *(Continued)*

	Participant details given in Table 5
Interventions	**Comparison:** active intervention vs no intervention **Active intervention** **Name:** neurofeedback (NFB) training **Classification of intervention:** rehabilitation (restitution) **Materials:** NeuroComp System (Neurocybernetics Inc., Encino, California, USA), composed of a repeater, a monitor for the clinician and the participant, computer, electroencephalography (EEG) sensor, cables, and poles. **Procedures:** NFB poles were attached to the scalp, and data were recorded on an oscillograph. The location of the poles followed the International 10–20 Electrode System, and the distance between each pole was 10% to 20% of the whole circumference; the NFB training method used was a beta-SMR method with the participant's eyes open. For monopolar type training, a pole or NFB sensor was attached to the scalp within the lesion area, and the remaining 2 poles attached to both ears with the participant seated on a comfortable chair. The participant played 4 games, displayed on the monitor (including Space Race, Mazes, Island, and Boxlight); for example, in the Space Race game, the spaceship was set to move forward and backward depending on his/her level of brain wave activation. **Who delivered:** not reported **Mode**: one-to-one **Where:** inpatient **Session:** 30 minutes 5 times a week **Duration:** 6 to 9 weeks **Tailoring:** the location of poles was tailored to the participant's lesion **Modification:** none stated Both groups received occupational and physical therapy for 30 minutes 5 times a week for 6 weeks. The NFB group received the same number of traditional rehabilitation sessions as the control group with extra NFB training.
Outcomes	**Perception:** Motor-Free Visual Perception Test **Other:** Brain waves - electroencephalography **Timing:** immediately after the intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** none given **Conflict of interest statement:** none given
Notes	**Trial registration details:** none reported **Published protocol:** none reported **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information provided
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	No information provided

Cho 2015 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Unclear risk	It is unclear how many participants were initially recruited
Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Unclear risk	No commentary on any baseline differences between groups

Choi 2018

Study characteristics	
Methods	**Design:** RCT **Country**: South Korea **Sense(s) addressed**: vision. Study also addressed postural balance and walking **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • At least a year after first stroke • MMSE 32 score > 24 points • Motor-Free Visual Perception Test-3 score < 45 points • Ability to understand instructions • Ability to stand for 30 minutes independently • No spatial neglect **Exclusion criteria** • Prescribed drugs that affect balance • Diagnosed with orthopedic diseases, such as arthritis, fracture, and low back pain • Receiving parallel treatments in other medical institutions, such as moxa and acupuncture treatments • Those with cerebellar or vestibular dysfunction • Visual problem, such as glaucoma, cataract, and double vision **Study population (number randomised):** 28 **Dropout details** given in Table 4 **Participant details** given in Table 5
Interventions	**Comparison: active intervention 1 vs active intervention 2** **Active intervention 1** **Name:** Wii Fit virtual reality training (WVRT) **Classification of intervention:** rehabilitation (restitution) **Materials:** Wii Fit Plus software and Wii Balance Board System (Nintendo Co. Ltd, Kyoto, Japan) **Procedures:** "composed of six games, selected on the basis of interest, motivation, and difficulty level. The difficulty level of a game was gradually increased to require more multidirectional movement in the center of mass. The first stage (1 to 2 weeks) programme consisted of tightrope walking and soccer heading, in which the center of mass shifted to the left and right. The second stage (3 to 4 weeks) programme consisted of the penguin slide and ski slalom, requiring forward and backward weight transfer in addition to left and right weight transfer. The third stage (5 to 6 weeks) programme consisted of the snowboard slalom and table tilt, requiring multidirection weight shifting". **Who delivered:** physical therapist (with more than 3 years experience) **Mode**: one-to-one **Where:** inpatient **Session:** 30 minutes 5 times per week

Choi 2018 *(Continued)*

	Duration: 6 weeks **Tailoring:** unclear - it is not clear if the level of training difficulty increased at a set rate, or in relation to individual performance **Modification:** none stated **Active intervention 2** **Name:** general balance training **Classification of intervention:** rehabilitation (restitution) **Materials:** a board of the same dimensions (51 x 27 x 5 cm) as the Wii Fit balance board; a mirror **Procedures:** the participant stood on the board and was asked to look at their image in a mirror placed 2 m away. In the first stage (1 to 2 weeks), the participants had to transfer their body weight in the left and right directions while standing in front of the mirror. The second stage (3 to 4 weeks) required forward and backward weight shifting in addition to left and right weight shifting. In the third stage (5 to 6 weeks), weight shifting was carried out by placing a square plate on top of the head of participants to facilitate control of the multidirectional fine weight transfer. **Who delivered:** not stated **Mode**: one-to-one **Where:** inpatient **Session:** 30 minutes 5 times per week **Duration:** 6 weeks **Tailoring:** none stated **Modification:** none stated Both groups received conventional physical and occupational therapy for 90 minutes, five times a week for 6 weeks
Outcomes	**Perception:** Motor-Free Visual Perception Test **Motor:** Berg Balance Scale **Mobility & Navigation:** 10-Metre Walk Test, Timed Up and Go Test **Timing:** 1 week after intervention, 8-week follow-up For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** "This work was supported by Sahmyook University, and this research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2017 R1D1A1B03035018)." **Conflict of interest statement:** "No competing financial interests exist."
Notes	**Trial registration details:** none reported **Published protocol:** none reported **PPI:** none reported Study is a 'pilot' RCT but no further detail on this is given; no power calculation reported.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Random number table used
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	High risk	Blinded assessors. Participants may have spoken to one another, which may have led to unblinding. Unclear if treating therapists were blinded
Incomplete outcome data (attrition bias)	Low risk	All participants included in analysis

Choi 2018 *(Continued)*
All outcomes

Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Low risk	No significant differences between groups; no other concerns noted

De Bruyn 2018

Study characteristics	
Methods	**Design:** multicentre RCT **Country**: Belgium **Sense(s) addressed**: somatosensory function **Study recruitment and setting details:** see Table 3
Participants	**Inclusion Criteria:** within 8 weeks of first stroke, < 52/57 Action Research Arm Test (ARAT), sensory composite score of < 0.00, 18 years or older **Exclusion Criteria**: other neurological or musculoskeletal disorders affecting upper limb, severe cognitive or communication deficit, contraindications to MRI **Study population (number randomised):** 30 **Dropout details** given in Table 4 **Participant details** given in Table 5
Interventions	**Comparison: active intervention 1 vs active intervention 2** **Active intervention 1** **Name:** sensorimotor group in addition to conventional rehabilitation **Classification of intervention:** rehabilitation (restitution) **Materials:** different textures (fabric, wallpaper, plastic, and sandpaper), different objects of varying shape, size, and materials **Procedures:** 30 minutes of sensory retraining based on the Study of the Effectiveness of Neurorehabilitation on Sensation (SENSe) training programme and 30 minutes somatosensory integrated motor exercises, including texture discrimination, limb position sense, and tactile object recognition **Who delivered:** therapist **Mode**: one-to-one **Where:** inpatient **Session:** 16 training sessions in addition to conventional rehabilitation **Duration:** 1 hour each (16 hours) over 4 weeks **Tailoring:** not reported **Modification:** not reported **Does normal therapy continue?** Yes **Active intervention 2** **Name:** motor group in addition to conventional rehabilitation **Classification of intervention:** rehabilitation (restitution) **Materials:** not stated, but materials required to perform the activities below would be needed **Procedures:** 30 minutes of cognitive and attention-based table top games and 30 minutes of motor training. The cognitive attention-based therapy consisted of table top games, such as chess, Rush Hour (a sliding block logic game), or other smart games, all performed with the unaffected upper limb. 30-minute motor arm training based on a set of standardised exercises, including task-related practice for gross movements and dexterity, including different grips and selective finger movements, and training in daily life activities, but without any attention to sensory discrimination training **Who delivered:** therapist **Mode**: one-to-one **Where:** inpatient **Session:** 16 training sessions in addition to conventional rehabilitation **Duration:** 1 hour each (16 hours) over 4 weeks

De Bruyn 2018 *(Continued)*

	Tailoring: individually tailored motor therapy, including a unilateral motor exercise programme for the affected upper limb **Modification:** not reported **Does normal therapy continue?** Yes
Outcomes	**Perception:** Erasmus modified Nottingham Sensory Assessment, Perceptual Threshold of Touch, Texture Discrimination Test, Wrist Position Sense Test, Functional Tactile Object Recognition Test **Adverse events:** number **Motor:** Action Research Arm Test, Fugl-Meyer Assessment of Motor Recovery after Stroke - Upper Extremity, Stroke Upper Limb Capacity Scale **Timing:** immediately after intervention, 4 weeks follow-up For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** this work was supported by Flanders Research Fund (FWO) (1189819N and 1519719N) **Conflict of interest statement:** the authors report no competing interests
Notes	**Trial registration details:** NCT03236376 **Published protocol:** 2018 **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Block randomisation
Allocation concealment (selection bias)	Low risk	Allocation concealed with opaque envelopes
Blinding (performance bias and detection bias) All outcomes	High risk	Not reported for performance bias. Blinding of the assessor was not always achieved due to participant reaction
Incomplete outcome data (attrition bias) All outcomes	High risk	3 participants were excluded from both primary and follow-up analysis
Selective reporting (reporting bias)	High risk	3 outcome measures were not fully reported
Other bias	High risk	Participants in the experimental group were significantly older and had more right hemispheric lesions

Edmans 2000

Study characteristics

Methods	**Design:** RCT **Country**: UK **Sense(s) addressed**: vision **Study recruitment and setting details:** see Table 3

Edmans 2000 *(Continued)*

Participants	**Inclusion criteria** • Admitted to the stroke unit • Perceptual problems - a RPAB score two standard deviations or more below the mean on four or more subtests (assessed within 2 weeks of admission) Note: participants were assessed for an evaluation study prior to consideration for the RCT. The criteria for this were: • medically stable; • able to transfer with a maximum of two nurses; • no discharge date planned; • able to tolerate 30-minute treatment sessions; • able to do two out of four specified activities (able to eat, able to drink, able to wash their face, and able to toilet themselves). **Exclusion criteria** • Not well enough to be assessed on the Rivermead Perceptual Assessment Battery (RPAB) (being able to see and hear; being able to understand the English language enough to complete the assessments and follow the instructions; being free of marked psychiatric problems that would affect their ability to complete the RPAB) • Sufficient functional use of one hand to complete the RPAB and to carry out perceptual treatment activities, i.e. sufficient ability to pick up and move objects/cards with one hand **Study population (number randomised):** 80 **Dropout details** given in Table 4 **Participant details** given in Table 5
Interventions	**Comparison: active intervention 1 vs active intervention 2** **Active intervention 1** **Name:** transfer of training perceptual treatment **Classification of intervention:** rehabilitation (restitution) **Materials:** not reported **Procedures:** not reported **Who delivered:** occupational therapist **Mode**: one-to-one **Where:** inpatient (stroke unit) **Session:** unclear, 2.5 hours in total **Duration:** 6 weeks **Tailoring:** not reported **Modification:** none reported **Active intervention 2** **Name:** functional perceptual treatment **Classification of intervention:** rehabilitation (compensation) **Materials:** not reported **Procedures:** not reported **Who delivered:** occupational therapist **Mode**: one-to-one **Where:** inpatient (stroke unit) **Session:** unclear, 2.5 hours in total **Duration:** 6 weeks **Tailoring:** not reported **Modification:** none reported Intervention was "in addition to their general OT treatment".
Outcomes	**ADL:** Barthel ADL Index, Edmans ADL Index **Perception:** Rivermead Perceptual Assessment Battery

Edmans 2000 *(Continued)*

	Motor: Rivermead Motor Assessment Gross Function Scale **Other:** length of stay, OT attendances, OT treatment time **Timing:** immediately after treatment For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** "We would like to thank the Stroke Association for funding this study, through a project grant to JA Edmans." **Conflict of interest statement:** none reported
Notes	**Trial registration details:** none reported **Published protocol:** none reported **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported Personal communication and primary data provided by Dr Edmans

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Random number tables
Allocation concealment (selection bias)	Low risk	Personal communication. Dr Edmans prepared sequentially numbered, sealed envelopes, opened at recruitment with witness. Not adequate in that researcher prepared list, but assessed as low risk of bias from assurance of inability to remember sequence
Blinding (performance bias and detection bias) All outcomes	High risk	Trialists intended to have independent assessment of the outcomes covered by this review, but did not report how successfully this was achieved.
Incomplete outcome data (attrition bias) All outcomes	Low risk	No withdrawals and only 1 (1%) death
Selective reporting (reporting bias)	Low risk	Outcomes described at both impairment and disability levels, and reported in equal detail regardless of statistical significance
Other bias	Low risk	No statistically significant differences between the two groups and no other concerns noted

Kang 2009

Study characteristics

Methods	**Design:** pilot RCT **Country**: South Korea **Sense(s) addressed**: vision **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Left hemiplegia after stroke (infarction or haemorrhage) on right middle cerebral artery territory • MMSE > 18 points

Kang 2009 *(Continued)*

- Motor-Free Visual Perception Test standard score < 109

Exclusion criteria

- Significant multiple small lacunar infarct
- Significantly decreased visual acuity or visual impairment from diabetic retinopathy or senile cataract
- Hearing difficulty or cranial nerve dysfunction

Study population (number randomised): 16
Dropout details given in Table 4
Participant details given in Table 5

Interventions	**Comparison:** active intervention 1 vs active intervention 2 **Active intervention 1** **Name:** computerised visual perception rehabilitation with motion tracking **Classification of intervention:** rehabilitation (restitution) **Materials:** not reported **Procedures:** all the tasks were performed with the participants in a relaxed seated position in front of the monitor, with an interactive patient–computer interface. Motion-tracking technology, using the CAMSHIFT (continuously adaptive mean shift) algorithm, was used to recognise and track the hand motions of participants through a computer camera, and display these movements on the computer screen. It was programmed to show visual images of various tasks on the computer screen, and the participants were asked to perform these tasks with their hand instead of a computer mouse. Twelve tasks were designed to improve visual perceptual function: 1) visual reactions, 2) visual differential reactions, 3) visual tracking and targeting, and 4) visual spatial and motor challenges, and were comparable to the similar groupings of the Foundation and Visuospatial parts of the Psychological Software Service (PSS) CogRehab programme **Who delivered:** occupational therapist **Mode**: one-to-one **Where:** inpatient **Session:** 30 minutes 3 times per week **Duration:** 4 weeks **Tailoring:** none reported **Modification:** none reported **Active intervention 2** **Name:** computer-based cognitive rehabilitation programme **Classification of intervention:** rehabilitation (restitution) **Materials:** foundation and visuospatial sections of PSS CogRehab software (Psychological Software Service, USA) **Procedures:** they performed the tasks with the right (not hemiplegic) hand. No other detail given **Who delivered:** occupational therapist **Mode**: one-to-one **Where:** inpatient **Session:** 30 minutes 3 times per week **Duration:** 4 weeks **Tailoring:** none reported **Modification:** none reported **Does normal therapy continue?** Not stated, but likely, given the inpatient setting
Outcomes	**ADL:** Modified Barthel Index **Perception:** Motor-Free Visual Perception Test **Cognition**: Modified Mini-Mental State Examination **Other:** Interest in intervention questionnaire **Timing:** immediately after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** none reported **Conflict of interest statement:** none reported

Kang 2009 *(Continued)*

Notes	**Trial registration details:** none reported **Published protocol:** none reported **PPI:** none reported Stated to be a pilot study; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Block randomisation process
Allocation concealment (selection bias)	Unclear risk	Not enough detail provided to establish if concealment was achieved
Blinding (performance bias and detection bias) All outcomes	High risk	Evaluators and data analysts were blinded; however, participants and treating therapist were not
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants included in the analysis
Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Low risk	No significant differences between the two groups; no other cause for concern noted

Kim 2015

Study characteristics

Methods	**Design:** RCT **Country**: South Korea **Sense(s) addressed**: tactile **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Experienced a unilateral stroke at least 6 months ago • Able to maintain a standing position on the balance mat over 30 seconds • Capable of standing without any assistance over 30 seconds • Not training in any interventions from other institutions • Sufficient cognition to participate in the training; that is, an MMSE score of 24 or higher • Semmes Weinstein Monofilament Exam, "size up to 5.07 discrimination of the foot pressure" **Exclusion criteria** • Any comorbidity or disability (other than the stroke) that precludes training • Any uncontrolled health conditions for which training is contraindicated **Study population (number randomised):** unclear, but data for 30 participants was analysed **Dropout details** given in Table 4 **Participant details** given in Table 5

Kim 2015 *(Continued)*

Interventions	**Comparison (across 3 arms): active intervention 1 vs active intervention 2 vs no intervention** **Comparison in Kim 2015 (stable): active intervention 1 vs no intervention** **Comparison in Kim 2015 (unstable): active intervention 2 vs no intervention** **Active intervention 1** **Name:** pressure sense perception training on stable surface **Classification of intervention:** rehabilitation (restitution) **Materials:** stable foam (50 cm × 41 cm × 6 cm) **Procedures:** participants were asked to keep both feet parallel and to forward weight shift in the standing position. Participants were then asked to shift weight forward to the more affected side. After weight shifting, this position was maintained for 5 seconds. When the participants were tired, they had a break of 3 minutes in the sitting position. The forefoot on both sides was attached to foam (equal to the height:weight ratio). Pressure was measured into the heel in order to avoid compensatory plantar flexion. Knee joint of the more affected side showed slight flexion. Immediately after the participant's response, verbal feedback was given if the participant failed to reproduce the required pressure. Each training session was performed step by step. **Who delivered:** physiotherapist **Mode**: one-to-one **Where:** hospital (inpatient or outpatient unclear) **Session:** 30 minutes 3 times per week **Duration:** 4 weeks **Tailoring:** before training, participants were measured both at minimum and maximum pressure. Minimum pressure was measured when training in a standing position. Maximal pressure was measured when training position with weight bearing to affected side. Therapists set up the target weight which was between minimum pressure and maximum pressure. Stage 1 was trained by pressing the scales lower than the average of the minimum and maximum pressure. Stage 2 was trained by pressing the scales higher than the average of the minimum and maximum pressure. Where the error from the target weight was within 1 kg, it was marked as 60% successful and the participant proceeded to the next stage. **Modification:** none reported **Active intervention 2** **Name:** pressure sense perception training on unstable surface **Classification of intervention:** rehabilitation (restitution) **Materials:** balance pad **Procedures:** participants were asked to keep both feet parallel and to forward weight shift in the standing position. Participants were then asked to shift weight forward to the more affected side. After weight shifting, this position was maintained for 5 seconds. When the participants were tired, they had a break of 3 minutes in the sitting position. The forefoot on both sides was attached to the balance pad (equal to the height:weight ratio). Pressure was measured into the heel in order to avoid compensatory plantar flexion. Knee joint of the more affected side showed slight flexion. Immediately after the participant's response, verbal feedback was given if the participant failed to reproduce the required pressure. Each training session was performed step by step. **Who delivered:** physiotherapist **Mode**: one-to-one **Where:** hospital (inpatient or outpatient unclear) **Session:** 30 minutes 3 times per week **Duration:** 4 weeks **Tailoring:** before training, participants were measured both at minimum and maximum pressure. Minimum pressure was measured when training in a standing position. Maximal pressure was measured when training position with weight bearing to affected side. Therapists set up the target weight which was between minimum pressure and maximum pressure. Stage 1 was trained by pressing the scales lower than the average of the minimum and maximum pressure. Stage 2 was trained by pressing the scales higher than the average of the minimum and maximum pressure. Where the error from the target weight was within 1 kg, it was marked as 60% successful and the participant proceeded to the next stage. **Modification:** none reported **No intervention**

Kim 2015 *(Continued)*

	Name: n/a **Materials:** n/a **Procedures:** n/a **Who delivered:** n/a **Mode**: n/a **Where:** n/a **Session:** n/a **Duration:** n/a **Tailoring:** n/a **Modification:** n/a **Does normal therapy continue?** All groups received general physiotherapy alongside the trialled intervention "which included ordinary postural control exercises, such as maintenance of standing, and shift of the weight loads to both sides"
Outcomes	**Mobility:** 10-Metre Walk Test, Timed Up and Go Test **Perception:** pressure error (dynamometer) **Motor:** balance, Functional Reach Test **Timing:** immediately after intervention (implied) For overview of included outcomes measured, see Table 6.
Funding statement	**Funding statement:** none reported **Conflict of interest statement:** none reported
Notes	**Trial registration details:** none reported **Published protocol:** none reported **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Table of random numbers used
Allocation concealment (selection bias)	Unclear risk	Not clear if there was adequate concealment
Blinding (performance bias and detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants included in the analysis
Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Low risk	No significant differences between the two groups; no other concerns noted

Koo 2018

Study characteristics

Koo 2018 *(Continued)*

Methods	**Design:** RCT **Country**: Korea **Sense(s) addressed**: somatosensation **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Within 1 month of their first-ever unilateral ischaemic or haemorrhagic stroke • Impairment in at least one of the pinprick, light touch, or proprioception parameters during a bedside screening evaluation • Motor strength of the affected upper extremity at least grade 1 on the Medical Research Council Scale • Sufficient cognitive function to follow simple commands (MMSE score ≥ 20) **Exclusion criteria** • Difficulty communicating and with aphasia or severe dysarthria • Moderate to severe spasticity in all joints of the affected limb (Modified Ashworth Scale score ≥ 2) • Serious vision or visual perception impairments • History of diabetic neuropathy and/or other peripheral neuropathies • Other severe psychologic, neuromuscular, or orthopaedic diseases **Study population (number randomised):** 24 **Dropout details** given in Table 4 **Participant details** given in Table 5
Interventions	**Comparison: active intervention vs control** **Active intervention** **Name:** anodal transcranial direct current stimulation **Classification of intervention:** non-invasive brain stimulation (NIBS) **Materials:** Iontophor II 6111 PM/DX with 2 conductive rubber electrodes placed in saline-soaked sponges (5x5cm^2) **Procedures:** the electrodes were placed according to the international 10–20 electroencephalogram system. For right cerebral hemisphere stroke, the anodal electrode was placed over the right S1 (CP4) and S1 (CP3) for left. The reference electrode was placed above the contralateral supraorbital region. The stimulation intensity was 1 mA. **Who delivered:** experimenter **Mode**: not reported **Where:** inpatient **Session:** 10 sessions **Duration:** 20 minutes per session for 10 days **Tailoring:** not reported **Modification:** not reported **Does normal therapy continue?** Not reported **Control** **Name:** sham stimulation **Materials:** Iontophor II 6111 PM/DX with 2 conductive rubber electrodes placed in saline-soaked sponges (5x5cm^2) **Procedures:** the electrodes were placed according to the international 10–20 electroencephalogram system. For right cerebral hemisphere stroke, the anodal electrode was placed over the right S1 (CP4) and S1 (CP3) for left. The reference electrode was placed above the contralateral supraorbital region. To mimic the skin sensation experienced at the initiation of anodal stimulation, the stimulator was programmed to ramp up over 10 seconds and immediately ramp down to 0 mA over 10 seconds **Who delivered:** experimenter **Mode**: not reported **Where:** inpatient **Session:** 10 sessions **Duration:** 20 minutes per session for 10 days **Tailoring:** not reported

Koo 2018 *(Continued)*

	Modification: not reported
Outcomes	**ADL:** K-MBI **Mobility and navigation:** Functional Ambulation Category **Perception:** Erasmus MC modifications to the revised Nottingham Sensory Assessment, Stereognosis Subscale **Adverse events:** number **Motor:** Manual Function Test, Brunnstrom Classification **Sensory:** Semmes Weinstein Monofilament Exam **Timing:** immediately after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** financial disclosure statements have been obtained **Conflict of interest statement:** no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article
Notes	**Trial registration details:** the study was registered in the Korean Clinical Trials Register (KCT0002496) **Published protocol:** not reported **PPI:** none reported "Because of the lack of previous studies, it was difficult to calculate the appropriate sample size."

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Simple randomisation but no further details provided
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Examiners were blinded but masking of treatment providers not reported. Participants were blinded via use of a sham intervention.
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants included in the analysis
Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Low risk	No significant difference in the general characteristics between the two groups; no other concerns noted

Lee 2021

Study characteristics

Methods	**Design:** RCT **Country**: Taiwan **Sense(s) addressed**: somatosensation **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria**

Lee 2021 *(Continued)*

- First stroke with hemiplegia
- Subacute (3 to 6 months) or chronic (> 6 months) stroke
- Could understand instructions
- Were in Brunnstrom Stages II–V of recovery
- Had sensory impairment (revised Nottingham Sensory Assessment (rNSA) Tactilescore < 2 and Kinesthetic score < 3)
- Muscle tone allowing movement (Modified Ashworth Scale score < 3)

Exclusion criteria

- Aged < 20 years or > 75 years
- Unable to clearly see or hear the feedback from the device
- Other medical symptoms affecting movement

Study population (number randomised): 25
Dropout details given in Table 4
Participant details given in Table 5

Interventions	**Comparison: active intervention 1 vs active intervention 2** **Active intervention 1** **Name:** robot-assisted therapy **Classification of intervention:** rehabilitation (restitution and substitution) **Materials:** Gloreha Sinfonia device - a glove that detects individual finger movement and supports practice of finger movement. The device focuses on the distal part of the upper limb with a dynamic support system to support the proximal part of the limb against gravity. Motor exercise is enriched by multisensory stimulation and the simultaneous display of 3D animation on a screen. **Procedures:** warm-up included weight-bearing and rhythm activities. Robotic therapy consisted of 10 minutes of continuous whole-hand and individual-finger passive range of motion exercises with visual cues displayed on the screen and 30 minutes of active-assist activities which included task-oriented bimanual activities and games. **Who delivered:** occupational therapist **Mode**: one-to-one **Where:** outpatient **Session:** 12 sessions **Duration:** 60 minutes including 20 minutes warm-up and 40 minutes robotic therapy **Tailoring:** settings adjusted according to participants' ability **Modification:** not reported **Does normal therapy continue?** No **Active intervention 2** **Name:** conventional therapy **Classification of intervention:** rehabilitation (restitution) **Materials:** not reported **Procedures:** warm-up included weight-bearing and rhythm activities. Conventional therapy consisted of task-oriented bilateral hand, grasp-and-release, and pinch activities **Who delivered:** occupational therapist **Mode**: one-to-one **Where:** outpatient **Session:** 12 sessions **Duration:** 60 minutes including 20 minutes warm-up and 40 minutes conventional therapy **Tailoring:** not reported **Modification:** not reported
Outcomes	**ADL:** modified Barthel Index **Perception:** rNSA Kinesthetic subtest **Adverse Events:** number **Motor:** Fugl-Meyer Assessment of Motor Recovery after Stroke (FMA), grip dynamometer, Box and Block Test **Sensory:** Semmes Weinstein Monofilament Exam

Lee 2021 *(Continued)*

	Other: surface electromyography **Timing:** immediately after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** this research was supported by the study projects of Taipei Medical University Shuang Ho Hospital (106 SHH HCP-11) **Conflict of interest statement:** not reported
Notes	**Trial registration details:** not reported **Published protocol:** not reported **PPI:** none reported "A power calculation performed for a previous study indicated that 23 participants per group would provide 80% power with an α of 0.05 to detect a within-groups difference in FMA–UE scores"

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Simple randomisation via a computer programme
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Assessors were blinded but no information provided for detection bias
Incomplete outcome data (attrition bias) All outcomes	Low risk	One participant's data was not included in the final analysis as they dropped out but an intention-to-treat analysis was conducted
Selective reporting (reporting bias)	Low risk	All outcome measures accounted for
Other bias	Low risk	No significant differences between groups in relation to demographic, clinical, or electromyography (EMG) data; no other points of concern

Lincoln 1985

Study characteristics

Methods	**Design:** RCT **Country**: UK **Sense(s) addressed**: vision **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** (not reported clearly) • Deficits on the Rivermead Perceptual Assessment Battery - scores more than 2 SD below the mean normal score **Exclusion criteria**: not reported **Study population (number randomised):** 33 **Dropout details** given in Table 4

Lincoln 1985 *(Continued)*

	Participant details given in Table 5
Interventions	**Comparison: active intervention vs control** **Active intervention** **Name:** perceptual training **Classification of intervention:** rehabilitation (restitution) **Materials:** not detailed in full but included coloured squares, sticks, picture cards, dominoes, parquetry, perceptual games **Procedures:** practice on perceptual tasks of the kind commonly used in occupational therapy departments. Simple perceptual activities included stick length sorting, picture lotto, colour matching squares, and shape recognition games; moderately difficult activities included colour category sorting, cylinder sequencing, and symmetry dominoes; difficult activities included 'what's in a square', space race game, parquetry mosaic, and perceptual association lotto **Who delivered:** occupational therapist (implied) **Mode**: one-to-one **Where:** inpatient (rehabilitation centre) **Session:** 60 minutes 4 times per week **Duration:** 4 weeks **Tailoring:** yes, tasks were selected for content and difficulty on the basis of initial perceptual test performance **Modification:** none stated **Control** **Name:** conventional therapy **Materials:** not detailed in full but included games, craft materials, gardening materials **Procedures:** practice on activities, not specifically designed to improve perceptual ability. They included activities to improve physical ability, games, craft, and gardening. A simple game was solitaire, and a moderately difficult one was battleships. **Who delivered:** occupational therapist (implied) **Mode**: one-to-one **Where:** inpatient (rehabilitation centre) **Session:** 60 minutes 4 times per week **Duration:** 4 weeks **Tailoring:** yes: tasks were selected for content and difficulty on the basis of initial perceptual test performance **Modification:** none stated **Does normal therapy continue?** Normal OT therapy continued for both groups, focusing on gross motor performance
Outcomes	**ADL:** Rivermead ADL scale **Perception:** Rivermead Perceptual Assessment Battery **Timing:** immediately after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** "We thank ... Oxford Regional Health authority for financial support" **Conflict of interest statement:** none reported
Notes	**Trial registration details:** none reported **Published protocol:** none reported **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported Personal communication with the original author

Risk of bias

Bias	Authors' judgement	Support for judgement

Lincoln 1985 *(Continued)*

Random sequence generation (selection bias)	Unclear risk	No detail beyond "patients were randomly allocated"
Allocation concealment (selection bias)	Unclear risk	No information on process
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Blinded outcome assessment, but no details provided of performance bias
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Not clear if all participants were included in analysis
Selective reporting (reporting bias)	Low risk	No suggestion of unreported outcomes
Other bias	Unclear risk	Original eligibility criteria restricted entry to right-hemisphere stroke patients. Later extended to head injury, subarachnoid haemorrhage, and left hemisphere stroke "to obtain reasonable numbers within the time". Not clear what interim analyses were undertaken, and possible consequences for interpretation of the final data

Park 2015

Study characteristics	
Methods	**Design:** RCT **Country**: South Korea **Sense(s) addressed**: vision **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** "We screened the volunteers by using the following study criteria derived from a previous computer-based cognitive rehabilitation study: • history of no more than one stroke • stroke with an onset duration of < 3 months • a score of ≤ 23 on the K-MMSE • ability to understand instructions • ability to use the controller with the unaffected upper limb • without unilateral hemispatial neglect and hemianopsia **Exclusion criteria**: none stated **Study population (number randomised):** 30 **Dropout details** given in Table 4 **Participant details** given in Table 5
Interventions	**Comparison: active intervention 1 vs active intervention 2** **Active intervention 1** **Name:** computer-based cognitive rehabilitation training (CoTras) **Classification of intervention:** rehabilitation (restitution) **Materials:** CoTras training programme, with joystick and large button on the CoTras panel **Procedures:** "CoTras consists of a diverse training program including visual perception, attention, memory, orientation, and others (categorization, sequencing). A joystick and a large button on the Co-

Park 2015 *(Continued)*

	Tras panel make the training easy for patients who are unfamiliar with computer use". No further detail given. Participants received the visual perception training consisting of object recognition, object constancy, figure-ground organisation, visual discrimination, and visual organisation. **Who delivered:** not reported **Mode**: one-to-one **Where:** hospital (outpatient/inpatient not clear) **Session:** 30 minutes 5 times per week **Duration:** 4 weeks **Tailoring:** "the training allows adjusting to individual patient's abilities at all levels of the program" and it is assumed this tailoring was done for participants **Modification:** none reported **Active intervention 2** **Name:** conventional cognitive rehabilitation **Classification of intervention:** rehabilitation (restitution) **Materials:** pencil and paper **Procedures:** conventional cognitive rehabilitation with a pencil and paper with emphasis on visual perception ability **Who delivered:** not reported **Mode**: not reported, likely one-to-one **Where:** hospital (outpatient/inpatient not clear) **Session:** 30 minutes 5 times per week **Duration:** 4 weeks **Tailoring:** none reported **Modification:** none reported **Does normal therapy continue?** Yes: "all subjects participated in a standard rehabilitation program according to a daily inpatient treatment schedule"
Outcomes	**Perception:** Motor-Free Visual Perception test **Cognition**: Lowenstein Ocupational Therapy Cognitive Assessment **Timing:** immediately after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** none reported **Conflict of interest statement:** none reported
Notes	**Trial registration details:** none reported **Published protocol:** none reported **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Random numbers table used
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	No information provided
Incomplete outcome data (attrition bias)	Low risk	All participants included in analysis

Park 2015 *(Continued)*
All outcomes

Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Unclear risk	Unclear if the two groups differed at baseline

Seim 2021

Study characteristics

Methods

Design: feasibility RCT
Country: USA
Sense(s) addressed: tactile
Study recruitment and setting details: see Table 3

Participants

Inclusion criteria

- History of stroke > 1 year prior
- Impaired touch sensation in the hand (Semmes Weinstein Monofilament Exam score of ≥ 0.2 grams on 3 of 20 measured locations on the hand)
- Passive range of motion allows user to don a glove
- English speaker, age 18 or older

Exclusion criteria

- Intact sensation in the hand (determined by Semmes Weinstein Monofilament Exam)
- Active range of motion within normal limits for all joints of the fingers
- Cognitive deficits, dementia or aphasia (MMSE score of < 22) that prevent informed consent
- Other neurological condition that may affect motor response (e.g. Parkinson's, amyotrophic lateral sclerosis (ALS), or multiple sclerosis (MS))
- Pain in the limb that substantially interferes with ADLs or prior arm injury
- Enrolment in a conflicting study, Botox treatment, or other upper extremity rehabilitation programme during the study period

Study population (number randomised): 16
Dropout details given in Table 4
Participant details given in Table 5

Interventions

Comparison: active intervention vs control

Active intervention
Name: vibrotactile stimulation glove
Classification of intervention: rehabilitation (restitution)
Materials: a wearable computing glove providing vibrotactile stimulation. A vibration motor was attached to each dorsal phalanx, allowing a designated actuator for each finger while stimulating a region where vibrations can reach the glabrous skin of the palm and the finger extensor tendons. A circuit board and micro-controller activates motors in a pre-programmed sequence when the switch is turned "on." Small, coin-shaped vibration motors from Precision Microdrives (ERM-type, Model #310-113) provide the stimulation
Procedures: stimulation transmitted at a frequency range of 10 Hz to 400 Hz (ideally 250 Hz). Stimulation pattern and timing was designed to be intensive but not uncomfortable by using many vibration pulses with a changing location across the fingers. Vibration motors were driven at a voltage of 3.3 V for an approximate amplitude of 1.5 g and 210 Hz vibration frequency (measured in a laboratory setting for validation at 1.3 g and 175 Hz when attached to the glove). Two stimulation sequences were used, each based on the finger pattern for a piano song which provided a framework for pseudo-random stimulation. The protocol includes no required exercises.

Seim 2021 *(Continued)*

	Who delivered: self-delivery **Mode**: not reported **Where:** participant's home **Session:** 56 sessions (daily for 8 weeks) **Duration:** 3 hours per day for 8 weeks (21 hours per week) **Tailoring:** not reported **Modification:** not reported **Does normal therapy continue?** Participants continued their standard of care **Control** **Name:** sham **Materials:** a wearable computing glove **Procedures:** participants in the sham control condition receive a glove with vibration disabled. They were instructed to wear the glove on their affected hand, switched on, for three hours daily while awake. **Who delivered:** self-delivery **Mode**: not reported **Where:** participant's home **Session:** 56 sessions (daily for 8 weeks) **Duration:** 3 hours per day for 8 weeks (21 hours per week) **Tailoring:** not reported **Modification:** not reported
Outcomes	**Motor:** voluntary angular range of motion **Sensory:** Semmes Weinstein Monofilament Exam **Other:** Modified Ashworth Scale **Timing:** immediately after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** this research was supported, in part, by the National Science Foundation (NSF) Graduate Research Fellowship program, a grant from the Georgia Tech Graphics, Visualization, and Usability (GVU) consortium, and a Microsoft Research PhD Fellowship **Conflict of interest statement:** the authors declare that they have no competing interests
Notes	**Trial registration details:** as a feasibility study, the trial was not listed with clinicaltrials.gov **Published protocol:** no **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information provided
Allocation concealment (selection bias)	Unclear risk	No information provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Outcome assessors blinded and sham intervention used. Not clear if treatment providers were blinded
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants included in analysis

Seim 2021 *(Continued)*

Selective reporting (reporting bias)	Low risk	All outcomes measures reported
Other bias	Unclear risk	No information provided on baseline differences; no other concerns noted

Yang 2015

Study characteristics	
Methods	**Design:** pilot RCT **Country**: Taiwan **Sense(s) addressed**: somatosensation **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Unilateral hemiparesis secondary to cerebrovascular accident confirmed by computerised tomography or magnetic resonance neuroimaging • Greater than zero point scores in each section of the scale for contraversive pushing (sitting plus standing) • Ability to follow simple verbal instructions **Exclusion criteria** • Unstable medical conditions, such as severe heart attack and/or seizure • Visual and/or auditory impairment • History of other diseases known to interfere with study participation **Study population (number randomised):** 12 **Dropout details** given in Table 3 **Participant details** given in Table 5
Interventions	**Comparison: active intervention 1 vs active intervention 2** **Active intervention 1** **Name:** computer-generated interactive visual feedback training **Classification of intervention:** rehabilitation (restitution) **Materials:** Nintendo Wii balance board (wireless model, connects to the training programme on a personal computer) and a customised, interactive visual feedback training programme (a LabVIEW-based software) **Procedures:** prior to each training session, the programme auto-checked the centre position of the Wii balance board along the frontal and sagittal axes, and set the middle. A physical therapist helped each participant to sit or stand on the Wii balance board as symmetrically as possible and to adjust centre of pressure to the middle in as upright a posture as possible. The locations of the centre of pressure in the frontal, sagittal, and transverse planes were displayed real-time on a monitor while participants shifted their body weight in the medial-lateral, anterior-posterior, or oblique directions. Feedback included vertical body posture. **Who delivered:** physiotherapist **Mode**: not reported **Where:** outpatient **Session:** 3 times per week for 3 weeks **Duration:** 40 minutes (20 minutes on computer + 20 minutes physiotherapy) **Tailoring:** not reported **Modification:** not reported **Active intervention 2** **Name:** mirror visual feedback training **Classification of intervention:** rehabilitation (restitution)

Yang 2015 *(Continued)*

	Materials: whole-body mirror **Procedures:** the general training protocols used for the control group were the same as those used for the experimental group **Who delivered:** physiotherapist **Mode**: not reported **Where:** outpatient **Session:** 3 times per week for 3 weeks **Duration:** 40 minutes (20 minutes of mirror feedback training + 20 minutes physiotherapy) **Tailoring:** not reported **Modification:** not reported **Does normal therapy continue?** Yes, regular physical therapy (i.e. mat exercises and upper and lower extremity exercises)
Outcomes	**Adverse events:** number **Motor:** Berg Balance Scale, Fugl-Meyer Assessment of Motor Recovery after Stroke **Other:** Scale for Contraversive Pushing **Timing:** immediately after intervention For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** this study is funded partly by grants from the National Science Council [NSC100-2314-B-010- 022-MY2] and the Ministry of Education, Aim for the Top University Plan [102AC-P508] of the Republic of China **Conflict of interest statement:** the authors declare that there is no conflict of interest
Notes	**Trial registration details:** not reported **Published protocol:** no **PPI:** none reported No statement on pilot/feasibility design; no power calculation reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomly generated group allocation
Allocation concealment (selection bias)	Unclear risk	Use of a sealed envelope but no further details provided
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Assessors were blinded but no information provided for performance bias
Incomplete outcome data (attrition bias) All outcomes	Low risk	All participants included in analysis
Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Low risk	No baseline differences; no other concerns noted

Yun 2018

Study characteristics	
Methods	**Design:** RCT **Country**: Korea **Sense(s) addressed**: somatosensation **Study recruitment and setting details:** see Table 3
Participants	**Inclusion criteria** • Participants diagnosed with lateropulsion, with a Burke Lateropulsion Scale (BLS) score over 2 points after stroke • Subacute stroke (unilateral ischaemic or haemorrhagic stroke, duration after stroke < 3 months) documented by CT or MRI **Exclusion criteria** • Unable to walk before the stroke • Significant cardiopulmonary disease, severe cognitive dysfunction, or musculoskeletal disease that might limit exercise participation **Study population (number randomised):** 38 **Dropout details** given in Table 4 **Participant details** given in Table 5
Interventions	**Comparison:** a**ctive intervention 1 vs active intervention 2** **Active intervention 1** **Name:** robot-assisted gait training **Classification of intervention:** rehabilitation (restitution and substitution) **Materials:** Lokomat **Procedures:** a harness, which is attached to the body-weight support system, was placed on the participant, the robot-driven gait orthosis was then positioned on the participant's hip and knee joints to adjust joint movements at individualised gait speeds. Depending on the participant's functional level, levels of body-weight support, treadmill speed, and guidance force were adjusted to maintain the knee extensor on the weak side during the stance phase. Initially, the guidance force was set to 100%. As function improved, the guidance force was decreased to 10%. The level of body-weight support steadily decreased from 50% to 0%. The treadmill speed (starting at 1.0 to 1.5 km/h) was increased by 0.2 to 0.4 km/h per session as soon as possible in accordance with the most comfortable gait for each participant. Augmented performance feedback was via virtual reality with game-like exercises. The avatar moves at the same time according to the participant's movement and performs repetitive tasks, such as avoiding obstacles and catching animals. **Who delivered:** not reported **Mode**: not reported **Where:** inpatient **Session:** 5 sessions per week for 3 weeks (15 sessions) **Duration:** 30 minutes per session **Tailoring:** all parameters were individually adjusted for each session **Modification:** not reported **Does normal therapy continue?** Yes, in addition, both groups received conventional physiotherapy for 4 weeks after 15 sessions of intervention. The usual treatments for acute stroke patients, such as occupational therapy, cognitive, and speech therapy, in the inpatient rehabilitation clinic of a tertiary hospital were performed equally in both groups according to the condition of each participant. **Active intervention 2** **Name:** conventional physical therapy **Classification of intervention:** rehabilitation (restitution) **Materials:** not reported **Procedures:** neurodevelopmental and physiotherapy techniques as proposed by Bobath and others. The focus is to enable weight transfer to the nonhemiparetic side and to perform upright activities and

Yun 2018 *(Continued)*

	balance correction. Transfer, sit-to-stand training, and strengthening exercises, as function improved, functional gait training, including trunk stability exercise, weight support on the paretic leg, and step initiation. **Who delivered:** physiotherapist **Mode**: not reported **Where:** inpatient **Session:** 5 sessions per week for 3 weeks (15 sessions) **Duration:** 30 minutes per session **Tailoring:** as function improved, the programme was adjusted **Modification:** not reported
Outcomes	**ADL:** K-MBI **Motor:** Berg Balance Scale, Fugl-Meyer Assessment of Motor Recovery after Stroke **Adverse events:** number **Other:** Burke Lateropulsion Scale, Postural Assessment for Stroke, Somatosensory Evoked Potentials **Timing:** immediately after intervention, 4 weeks follow-up For overview of included outcome measures, see Table 6.
Funding statement	**Funding statement:** this study was supported by Wonkwang University in 2018 **Conflict of interest statement:** the authors certify that there is no conflict of interest with any financial organisation regarding the material discussed in the manuscript.
Notes	**Trial registration details:** not reported **Published protocol:** no **PPI:** none reported G*power (version 3.1.9.2, Heinrich-Heine-Universität, Düsseldorf, Germany) was used to calculate the required sample size.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomly allocated via use of numbered tickets
Allocation concealment (selection bias)	Unclear risk	Use of sealed envelopes but not clear if concealment was achieved
Blinding (performance bias and detection bias) All outcomes	Unclear risk	Not clearly reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	2 participants (1 from each group) were not included in the analysis; reasons provided were not linked to the intervention
Selective reporting (reporting bias)	Low risk	All outcome measures reported
Other bias	Low risk	No significant difference at baseline; no other cause for concern

ADL: activities of daily living
CT: computed tomography
CVA: cerebrovascular accident
FMA-UE: Fugl-Meyer Assessment of Motor Recovery after Stroke - Upper Extremity
K-MBI: Korean version of the Modified Barthel Index
K-MMSE: Korean Version of Mini-Mental State Examination

MMSE: Mini-Mental State Examination
MRI: magnetic resonance imaging
n/a: not applicable
OT: occupational therapy
PCMF: Percept-concept-motor function
PPI: Patient and Public Involvement
QoL: quality of life
RCT: randomised controlled trial
RMA: Rivermead Motor Assessment
RPAB: Rivermead Perceptual Assessment Battery
SD: standard deviation
vs: versus

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

Study	Reason for exclusion
Afzal 2020	The intervention was for balance, not perceptual disorder
Cho 2013	Participants did not have a perceptual disorder
Derakhshanfar 2020	Intervention was for balance, not perceptual disorder
Dirette 1999	Email communication with the author identified that: (i) participants did not all have diagnoses of visual perceptual disorders. The diagnosing was done collaboratively between the neuropsychologist and the occupational therapist following an intensive assessment process; (ii) data specific to those with stroke were not available. All of the participants had acquired brain injuries that were related to traumatic injuries or brain tumour. Note: this study was included in the prior version of this review.
Fujimoto 2016	Participants were not allocated randomly
Hajek 1993	Participants did not have a confirmed diagnoses of a perceptual problem, as identified by the inclusion criteria. Note: this study was included in the prior version of this review.
Hsu 2021	The inclusion criteria state no major cognitive or perceptual deficits; the intervention is addressing motor function rather than perception.
Kattenstroth 2018	It was not possible to confirm that the participants had a perceptual disorder.
Kim 2011	Email communication with the authors identified that having a perceptual disorder was not an inclusion criterion for participants.
Krewer 2013	Not an RCT, but an n-of-1 study with multiple treatment phases and assessments; the order of interventions is randomised, not the participants.
Kumar 2016	The population does not have a perceptual disorder (it appears to be sensory).
Lee 2015	There are no measures of perceptual function to determine if participants had a perceptual deficit prior to intervention.
Lindvall 2014	The population does not have a perceptual impairment.
Lynch 2007	We could not confirm that the population had a perceptual deficit.

Study	Reason for exclusion
Maier 2020	There was no confirmed diagnosis of a perceptual disorder in the population.
Mazer 2003	According to the inclusion criteria, participants did not need to have a perceptual disorder to take part in the study. Note: this study was included in the prior version of this review.
Moon 2020	The population did not have a perceptual disorder (was considered sensory by clinical expert).
NCT01545138	Participants were excluded if they had any visual problems.
NCT04326205	The intervention was focused on motor dysfunction.
Strelnikova 2020	The population and intervention is for cognition; there was no statement of randomisation.
Taylor 1971	According to the inclusion criteria, participants did not need to have a perceptual disorder to take part in the study. Note: this study was included in the prior version of this review.
Tsai 2020	The intervention was for cognitive dysfunction.
Tzorakoleftherakis 2015	There were no tests of perceptual function used as a study inclusion criterion.
Vahdat 2019	The population did not appear to have a perceptual deficit.
Wang 2016	Communication confirmed the study did not meet the randomisation criteria.

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

Chiu 2020

Methods	Pilot RCT
Participants	n = 24 Inclusion criteria: 1) diagnosis of stroke; 2) age above 20 years; 3) score of 3-4 on the modified Rankin Scale; 4) able to understand instructions and follow them; and 5) willing to participate in the study Exclusion criteria: 1) orthopedic disorder (e.g. joint deformation); 2) progressive disease (e.g. dementia and Parkinsonism); and 3) peripheral nerve injury
Interventions	ADL training vs traditional rehabilitation
Outcomes	MMSE, TVPS-3
Notes	Unsure if participants have a perceptual disorder; no reply to email contact 2021

Kim 2016

Methods	CCT

Kim 2016 *(Continued)*

Participants	10 participants with Pusher Syndrome
Interventions	Robot-assisted gait training vs control
Outcomes	Scale for contraversive pushing, BBS, falling index, TUG
Notes	While the study has two groups, it does not state that participants were randomised; there has been no reply to email communication to clarify this.

Kim 2020

Methods	RCT
Participants	n = 30 Inclusion criterion: 1) a stroke at least 6 months prior to enrolment; 2) impairment of the affected upper limb; 3) without cognitive impairment; 4) without orthopaedic injuries; 5) manual muscle test/extension within appropriate levels Exclusion criteria: none listed
Interventions	Sensory motor stimulation training vs conservative treatment
Outcomes	Upper limb range of movement, Jebsen-Taylor test, Stroop test, Trail making test
Notes	Unclear if participants had a perceptual disorder; there was no response to 2021 email communication to clarify this.

Kitisomprayoonkul 2012

Methods	RCT
Participants	Inclusion criteria: ischaemic stroke Exclusion criteria: none listed
Interventions	Anodal transcranial direct current stimulation vs sham
Outcomes	Hand sensation tests, Moberg recognition test, and Semmes-Weinstein monofilament
Notes	It was not clear from the published abstract if/how participants were diagnosed with a perceptual disorder, nor the method of randomisation, and there was no response to email communication to clarify in 2021.

Koval'chuk 2011

Methods	Unclear
Participants	Stroke patients with Push Syndrome
Interventions	Mexidol

Koval'chuk 2011 *(Continued)*

Outcomes	Presence/absence of Push[er] Syndrome, balance
Notes	The methods used are unclear; we have not received a reply to email communication.

Leer 1984

Methods	Not yet known
Participants	Stroke patients with visual perceptual problems
Interventions	Not yet known
Outcomes	Not yet known
Notes	Student thesis from 26 years ago; difficult to obtain Still not able to access in October 2021

Matz 2007

Methods	Pilot randomised trial
Participants	32 people with first acute (within 2 weeks) lacunar stroke and various types of cognitive problems, possibly including some with perceptual problems
Interventions	3 months of regular cognitive training by a neuropsychologist versus standard care without cognitive training
Outcomes	An extensive neuropsychological test battery was administered 3 months after baseline assessments, including assessment of visuospatial functions. Physiological measures were also taken but are not relevant to this review.
Notes	Unable to obtain confirmation from authors on whether any of the 32 participants met our eligibility criteria. Still not able to access in October 2021

Morioka 2003

Methods	RCT
Participants	n = 28 Inclusion criteria: stroke patients with hemiplegia Exclusion criteria: higher brain dysfunction and dementia
Interventions	Perceptual learning exercises on hardness discrimination vs ordinary care
Outcomes	Postural sway via a stabilometer
Notes	Although the presence of a potential perceptual disorder in the study population is noted in the discussion, it is not clear if this was an inclusion criterion. It has not been possible to contact the author to clarify this.

Muffel 2020

Methods	Standardised, cross-over, double-blind, sham-controlled clinical trial
Participants	24 participants
Interventions	Unilateral and bilateral tDCS
Outcomes	Reaching tasks, proprioceptive tasks, bimanual tasks
Notes	It is not clear whether the population has a perceptual disorder, and whether the intervention targeted a perception disorder. No reply to attempted email communication.

NCT04446273

Methods	Single-blind randomised comparative efficacy study
Participants	Inclusion criteria: 1) age between 20 and 75 years old; 2) more than 3 months after the onset of a first unilateral ischaemic or haemorrhagic stroke; 3) moderate to severe upper extremity motor impairment (i.e. total upper extremity score of the Fugl-Meyer Assessment score between 18 and 56); 4) no severe spasticity in any joints of the affected arm (modified Ashworth Scale score < 3 in any of the affected shoulder, elbow, wrist, and fingers); 5) able to follow instructions (MMSE total score > 24); 6) no UE fractures in the past 3 months; 7) not simultaneously participating in other medication or rehabilitation studies Exclusion criteria: 1) other neurologic, neuromuscular, or orthopedic disease, such as epilepsy, or severe health or physical conditions that might impede participation in this study
Interventions	Robotic training for 45 minutes and impairment-oriented training for 45 minutes
Outcomes	• Fugl-Meyer Assessment of Motor Recovery after Stroke • Medical Research Council Scale • revised Nottingham Sensory Assessment • Wolf Motor Function Test. • 10-Metre Walk Test • MyotonPRO Digital Palpation Device • Actigraphy • Functional Independence Measure Motor Scale • Functional Independence Measure Cognitive Scale • Motor Activity Log • ABILHAND Questionnaire • Nottingham Extended Activities of Daily Living Scale • Stoke Impact Scale 3.0. • Goal Attainment Scale • Stroke Self-Efficacy Questionnaire
Notes	It is not clear if participants have a perceptual disorder.

Weinberg 1982

Methods	RCT

Weinberg 1982 *(Continued)*

Participants	Inclusion criteria: paper states that "patients were selected on the basis of their evidenced deficits in performing complex visuo-cognitive tasks" but it is not clear how this was assessed. "Right brain-damaged [RBD] stroke patients undergoing active rehabilitation who met the following criteria upon clinical neurological examination were eligible to participate in this study: at least 4 weeks post onset of CVA [cerebrovascular accident]; at least 45 years of age; to have been rendered RBD secondary to a CVA (excluding aneurysm) with no significant local impairment of vision (i.e. glaucoma, cataracts); no severe impairment of general mentation." Exclusion criteria: projected length of stay insufficient to complete 20 hours of training and post-psychometric evaluations; scheduled for, but had not yet begun, an unrelated experimental training programme; gross unilateral neglect of space on at least one of the screening tasks
Interventions	Training systematic visual organisation vs rehabilitation therapy (occupational therapy)
Outcomes	**Perception:** Raven's: Perceptual, Raven's: Conceptual, Visual Synthesis, Embedded Figures, Visual Simultaneity, Conditional Cancellation, Wechsler Adult Intelligence Scale Performance Scale, Knox Cubes Imitation Test **Cognition:** WAIS Verbal Scale, Paragraph Titling, Management Aptitude Test (Reading) Comprehension, Digit Span Forward, Digit Span Backward
Notes	The paper states that "patients were selected on the basis of their evidenced deficits in performing complex visuo-cognitive tasks" but it is not clear how this was assessed. It has not been possible to contact the author to clarify this.

ADL: activities of daily living
BBS: Berg Balance Scale
CCT: controlled clinical trial
MMSE: Mini-Mental State Examination
RCT: randomised controlled trial
tDSC: transcranial direct current stimulation
TUG: Timed Up and Go Test
TVPS-3: Test of Visual Perceptual Skills-Third Edition
UE: upper extremity
vs: versus

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

CTRI201804013372

Study name	Immediate effect of ipsilesional head tilt on balance in patients with altered perception of verticality secondary to acute hemispheric stroke
Methods	Randomised, parallel group, placebo-controlled trial
Participants	• Adults with first ever hemispheric stroke (medically diagnosed on the basis of radiological findings) • Subjective visual vertical (SVV) deviation "more than 30 to contralesional side" • People within 3 months post stroke with ability to comprehend and follow simple verbal instructions
Interventions	Participants in experimental group will receive 10 minutes of intervention wherein they will be seated on chair/wheelchair and then their head will be passively tilted laterally to the side of the lesion at 60 degrees by the therapist while participants look straight. Control group will receive "no treatment"
Outcomes	Postural Assessment Scale for Stroke

CTRI201804013372 *(Continued)*

Starting date	24 January 2017
Contact information	ivanjoy67@gmail.com
Notes	After initial email contact with the author, we have been unable to clarify the current status of this study.

DRKS00021654

Study name	Effects of end-effector controlled gait training compared to balance training on postural stability, walking ability and subjective visual vertical (SVV) in non-ambulatory patients with left-sided neglect
Methods	Randomised controlled trial
Participants	**Inclusion criteria** • Ischaemic or haemorrhagic right hemispheric stroke (confirmed by imaging) • Early subacute phase (7 to 80 days after stroke) • "Age = 18 years" • Presence of visual-spatial neglect • Walking ability: Functional Ambulation Categories 0-2 • Ability for aided standing for 15 minutes under stable cardiovascular conditions • SVV > 2° • Ability to comprehend or follow instructions and willing and able to give consent
Interventions	Lyra-THERA Trainer vs THERA-Trainer standing and balance trainer
Outcomes	Functional Ambulation Categories
Starting date	25 June 2020
Contact information	Anna Gorsler Email:gorsler@kliniken-beelitz.de
Notes	

Mazer 2009

Study name	
Methods	
Participants	
Interventions	
Outcomes	
Starting date	
Contact information	

Mazer 2009 *(Continued)*

Notes	Personal communication with Mazer in 2009 for her earlier study (Mazer 2003) revealed she had a relevant ongoing study at that time. In 2021, there was no reply to an email to obtain more information on this study.

NCT02524015

Study name	Novel treatment for Pusher Syndrome using physical therapy
Methods	RCT
Participants	Inclusion criteria • Recent (within 2 months) unilateral stroke • Burke Lateropulsion Scale ≥ 2 • Age 21 to 89 years • Ability to provide informed consent • English-speaking Exclusion criteria • Prior stroke within the past 6 months • Cerebellar stroke • Stroke-related brain imaging (MRI or CT) unavailable • Global or receptive aphasia • Prior documented neurologic disorder (e.g. multiple sclerosis, Parkinson's)
Interventions	Novel physical therapy vs standard physical therapy
Outcomes	Burke Lateropulsion Scale
Starting date	September 2015
Contact information	Mary Kim, Assistant Professor, Residency Program Director, PM&R, Loma Linda University, California, USA
Notes	Stated completion date July 2017, but unable to confirm this or find any further details

NCT03154138

Study name	Prismatic adaptation for rehabilitation of postural imbalance after stroke (PEQUIE)
Methods	RCT
Participants	Inclusion criteria • Adult, over 18 years old, and less than 80 years old • Stroke: right supratensorial, unilateral, haemorrhagic or ischaemic, chronic (over 12 months) • Ability to remain for over 30 seconds in standing static position with open eyes and closed eyes • Show a postural imbalance, determined by a body weight bearing on right lower limb ≥ 60% during at least one posturographic evaluation with open eyes, and which requires an inpatient rehabilitation • Covered by a Health System where applicable, and/or in compliance with the recommendations of the national laws in force relating to biomedical research

NCT03154138 *(Continued)*

	• Free, enlightened and written consent of the individual Exclusion criteria • Cerebellar lesion • Brainstem lesion • Bilateral cerebral lesion • All orthopaedic or rheumatologic diseases, retinal visual impairments or other diseases interfering with assessments in accordance with the investigator's judgement • Pregnant or breastfeeding • Under administrative or legal supervision
Interventions	Prismatic adaptation vs sham
Outcomes	Berg Balance Scale, static posturographic variable; spatial reference frame assessment, Scale for Contraversive Pushing; Barthel Index, Magnetic Resonance Imaging
Starting date	4 December 2017
Contact information	Gilles Rode, gilles.rode@chu-lyon.fr
Notes	Need to determine if the intervention is for a perceptual disorder or a postural one

NCT03888326

Study name	Robot and tDCS based proprioceptive rehabilitation after stroke (RoboStim)
Methods	RCT
Participants	Inclusion criteria • Sex: both men and women • Age: 18 years and older • Stroke onset: > 6 months prior to enrolment • Stroke type: haemorrhagic and ischaemic • Evidence of proprioceptive deficits as determined by a robotic assessment • Ability to follow simple 3-step commands Exclusion criteria • Other comorbid neurologic diagnoses (e.g. Parkinson's disease) • Seizure disorder • Enrolment in concurrent upper extremity intervention trial • Metal implants in head • Significant upper extremity orthopedic issues
Interventions	Robotic Rehabilitation plus 1x1 anodal tDCS Receive 10 days of 1-hour robotic rehabilitation with the KINARM Exoskeleton, in addition to 20 minutes, 2 mA anodal tDCS (Soterix 1x1 tDCS) over the ipsilesional sensory cortex during the first 20 minutes of each robotic session. Current is ramped up to 2 mA over 30 seconds and ramped back down over 30 seconds at the end of the 20 minutes.
Outcomes	• Robotic limb position matching standardised score • Robotic kinaesthesia standardised score

NCT03888326 *(Continued)*

	• Change in Fugl-Meyer Assessment of Motor Recovery after Stroke (FMA) Upper Extremity • Change in Nottingham Sensory Assessment scores • Change in Functional Independence Measure score • tDCS Tolerability • Attention/Motivation Questionnaire
Starting date	6 March 2018
Contact information	matthew.chilvers@ucalgary.ca
Notes	

NCT03991390

Study name	Effectiveness of balance exercise program for stroke patients with Pusher Syndrome
Methods	RCT
Participants	Inclusion criteria • People ≥ 18 years admitted to an intermediate care unit after suffering from subacute stroke, for functional recovery • Diagnosis of ischaemic or haemorrhagic stroke confirmed by MRI or CT scan • Pusher Syndrome identified by the Scale for Contraversive Pushing with a score of ≥ 2 and by Burke Lateropulsion Scale with a value of ≥ 3 Exclusion criteria • Severe previous functional dependence (Barthel Index ≤ 60) • Diagnosed with dementia GDS-4 or previous severe cognitive impairment • Diagnosed with delirium • Diagnosed with Wernicke's aphasia • Previous severe visual deficit that prevents individual from continuing activity (retinopathy, cataracts, etc.) • History of other causes of balance impairment • Orthopaedic conditions that make difficult the performance of the proposed rehabilitation treatment • Enrolled in other research studies
Interventions	Core stability and feedback visual laser exercises vs control
Outcomes	• Scale for Contraversive Pushing • Burke Lateropulsion Scale • Balance (Spanish-Postural Assessment Scale for Stroke) • Newcastle Stroke-Specific Quality of Life Measure (NEWSQOL) • Barthel Index
Starting date	20 November 2018
Contact information	No author information provided
Notes	

NCT04490655

Study name	Active somatosensory exercise for chronic stroke (ActSens)
Methods	RCT
Participants	Inclusion criteria • First-time ischaemic or haemorrhagic stroke survivors • At least 6 months post stroke • Severe to moderate sensory impairment as assessed by Erasmus Nottingham Sensory Assessment (each category ≤ 6/8) • Arm motor impairment, shoulder abduction and elbow extension Medical Research Council motor power grade 3-5 Exclusion criteria • Bilateral impairment • High upper-limb spasticity (Ashworth scale > 2) • Unilateral neglect as assessed by Star Cancellation Test (score < 44) • Cognitive impairment as assessed by 2-step instructions from the modified Mini-Mental State Examination • Known history of mental disorders • Inability to perform upper arm activity due to excessive pain
Interventions	Active somatosensory training group vs active somatosensory training
Outcomes	Change in motor behavioral scores; change in somatosensory acuity; Fugl-Meyer Assessment of Motor Recovery after Stroke - Upper Extremity; Wolf Motor Function Test; Erasmus Nottingham Sensory Assessment
Starting date	1 March 2021
Contact information	Ananda Sidarta, PhD ananda.sidarta@ntu.edu.sg
Notes	

NCT04703218

Study name	Re-education of olfactory disorders after a cerebral vascular accident in adults (RE-OLF)
Methods	RCT
Participants	Inclusion criteria • "Adult under 65 in order to avoid presbyosmia bias • Suffering from an ischaemic and/or haemorrhagic stroke dating at least 3 months • Followed in the SRH department and/or in post-stroke consultation • French-speaking • Affiliated with the social security scheme • Has signed the informed consent" Exclusion criteria

NCT04703218 *(Continued)*

	• "TDI score greater than 30.5 on the SST • Global aphasia: score < 25 on the oral comprehension subtest of MT86 sentences • Person under legal protection (guardianship, curatorship, safeguard of justice) • Person treated with corticosteroids, steroids, antihistamines, and antibiotics which may have repercussions on olfaction • History of trauma to the face • History of ENT surgery • Chronic rhinitis • Infection of the ENT sphere in the 15 days preceding inclusion • Neurodegenerative pathology • Parosmia, phantosmia, or cacosmia • History of systemic chemotherapy or radiotherapy to the head"
Interventions	Specific olfaction training, consisting of smelling 4 scents twice a day using scent sticks, for 12 weeks.
Outcomes	• "TDI score obtained in SST after the training period (12 weeks) • Score obtained on the ASOF quality of life questionnaire modified after training (12 weeks) • T, D and I sub-scores obtained in SST after training (12 weeks) • Number of complaints about side effects and possible discomfort related to training • Number of training stops (training < 12 weeks) • Score obtained in the SST after training (12 weeks) • TDI score obtained at SST 3 months after the end of training (at 24 weeks) • Percentage of participants changing category according to the thresholds validated by the SST (anosmia, hyposmia, normosmia)"
Starting date	1 September 2021
Contact information	None provided
Notes	

NCT04818073

Study name	Determinants of the effectiveness of robot-assisted hand movement training
Methods	Randomised single-blinded trial
Participants	Inclusion criteria • Age 18 to 85 years • Suffered from a single ischaemic stroke (radiologically confirmed) at least 6 months prior to enrolment • An ability to score at least 3 blocks on the Box and Block Test Exclusion criteria • A substantial decrease in alertness, language reception, or attention • Pregnant or lactating • Advanced liver, kidney, cardiac, or pulmonary disease • Plan to alter any current participation in other rehabilitation therapy in the time period of the study • A terminal medical diagnosis consistent with survival < 1 year

NCT04818073 *(Continued)*

	• Coexistent major neurological disease • Coexistent major psychiatric disease • A history of significant alcohol or drug abuse in the prior 3 years • Current enrolment in another study related to stroke or stroke recovery • Any other medical contraindication to participation in this study evaluated by our team physician
Interventions	FINGER robotic training: FINGER exoskeleton is a robotic device that can provide assistance and resistance to thumb and finger movement
Outcomes	• Box and Blocks Test • Fugl-Meyer Assessment of Motor Recovery after Stroke - Upper Extremity • Motor Activity Log • Changes in finger proprioception measured using the Crisscross Assessment
Starting date	July 2021
Contact information	vchan2@uci.edu
Notes	

NCT04911738

Study name	VIrtual reality glasses use to improve lateropulsion and the post-stroke postural vertical
Methods	Randomised cross-over study
Participants	Inclusion criteria 20 stroke participants • Hospitalised in neurorehabilitation • HemispheDashboard [https://revman.cochrane.org/#/6062031119152431 57/dashboard#characteristics]re stroke (right or left) • Stroke delay < 6 months • Presence of lateropulsion assessed by the Scale for Contraversive Pushing > 0.5 20 healthy participants • No history of stroke or other neurological pathologies • No balance disorders • No history of vestibular or dizziness disorders Exclusion Criteria All participants • History of psychiatric disorders • Nyctophobia • Advanced heart failure • Severe trunk deformation with C7 lateral > 30 mm due to an independent cause beyond the stroke (i.e. scoliosis) or history of postural disorder 20 stroke participants • Medical instability making the assessment impossible • Comprehension deficits with Boston Diagnostic Aphasia Examination gravity score ≥ 3

NCT04911738 *(Continued)*	• History of vestibular or dizziness disorders • No previous neurological history interfering with balance • Inability to understand and execute simple orders • Severe untreated depression (Aphasic Depression Rating Scale score > 15)
Interventions	VIrtual reality glasses
Outcomes	• Changes in the postural perception of the vertical (PV) • Changes in the visual perception of the vertical (VV) • Post-effect on PV • Post-effect on VV • Modulation of active vertical trunk orientation • Modulation of active vertical head orientation • Effect on lateropulsion • Effect on postural capacities • Responders to virtual reality • Changes in weight-bearing asymmetry • Awareness of the changes in active vertical body orientation • Relationship between the trunk tilt and the weight bearing on the paretic side • Quantification of a possible virtual reality sickness • Description of symptoms in case of virtual reality sickness
Starting date	15 June 2021
Contact information	DPerennou@chu-grenoble.fr
Notes	

CT: computed tomography
ENT: Ear, nose and throat
GDS: Global Deterioration Scale
mA: milliampere
MRI: magnetic resonance imaging
RCT: randomised controlled trial
tDCS: transcranial direct current stimulation

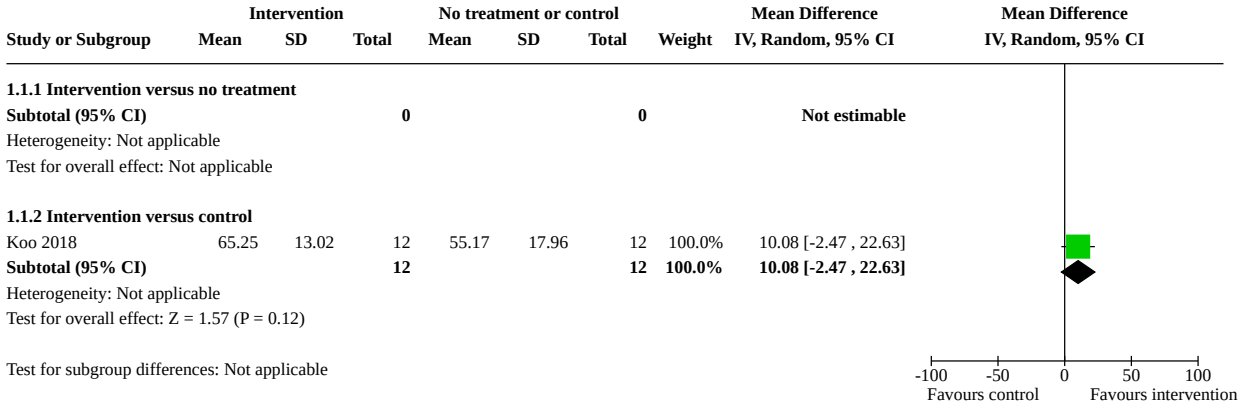
DATA AND ANALYSES

Comparison 1. Somatosensory perception (not Pusher Syndrome): intervention versus no treatment or control

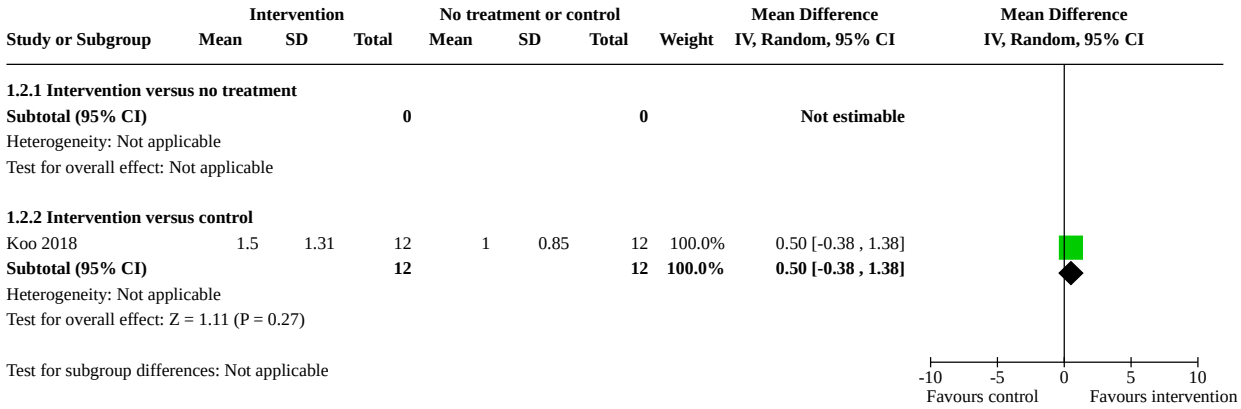
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.1 Activities of daily living	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
1.1.1 Intervention versus no treatment	0	0	Mean Difference (IV, Random, 95% CI)	Not estimable
1.1.2 Intervention versus control	1	24	Mean Difference (IV, Random, 95% CI)	10.08 [-2.47, 22.63]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.2 Quality of life and participation - mobility and navigation	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
1.2.1 Intervention versus no treatment	0	0	Mean Difference (IV, Random, 95% CI)	Not estimable
1.2.2 Intervention versus control	1	24	Mean Difference (IV, Random, 95% CI)	0.50 [-0.38, 1.38]

Analysis 1.1. Comparison 1: Somatosensory perception (not Pusher Syndrome): intervention versus no treatment or control, Outcome 1: Activities of daily living



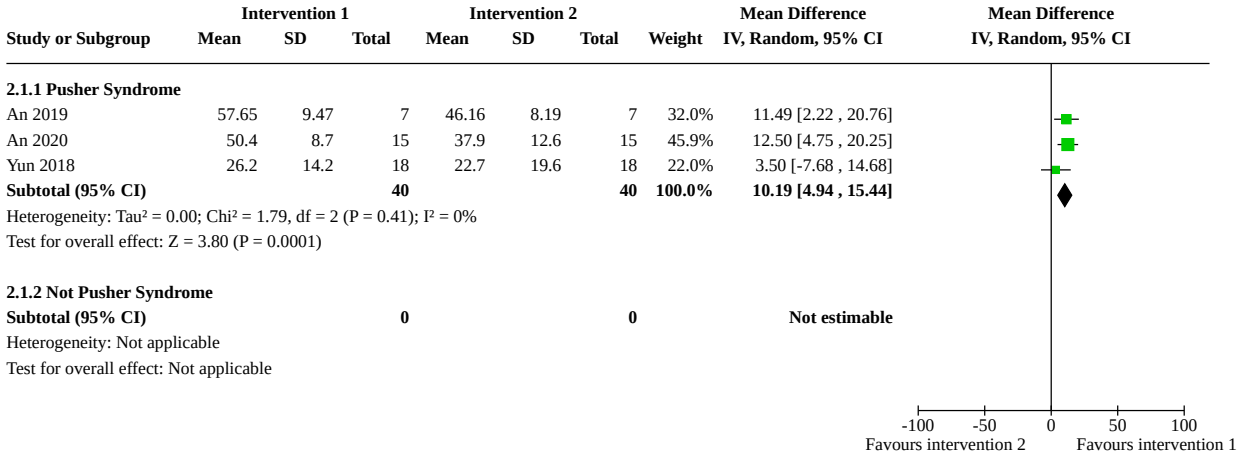
Analysis 1.2. Comparison 1: Somatosensory perception (not Pusher Syndrome): intervention versus no treatment or control, Outcome 2: Quality of life and participation - mobility and navigation



Comparison 2. Somatosensory perception: active intervention 1 versus active intervention 2

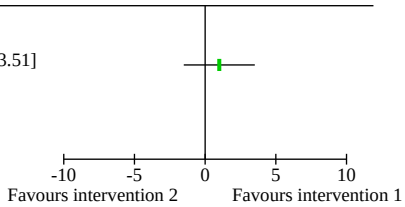
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.1 Activities of daily living	3		Mean Difference (IV, Random, 95% CI)	Subtotals only
2.1.1 Pusher Syndrome	3	80	Mean Difference (IV, Random, 95% CI)	10.19 [4.94, 15.44]
2.1.2 Not Pusher Syndrome	0	0	Mean Difference (IV, Random, 95% CI)	Not estimable
2.2 Quality of life and participation - mobility and navigation	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
2.2.1 Pusher Syndrome	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
2.2.2 Not Pusher Syndrome	0		Mean Difference (IV, Random, 95% CI)	Totals not selected
2.3 Perception	2		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected
2.3.1 Pusher Syndrome	1		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected
2.3.2 Not Pusher Syndrome	1		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected
2.4 Pusher syndrome outcomes	4		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
2.4.1 Pusher Syndrome	4	86	Std. Mean Difference (IV, Random, 95% CI)	1.03 [0.33, 1.73]

Analysis 2.1. Comparison 2: Somatosensory perception: active intervention 1 versus active intervention 2, Outcome 1: Activities of daily living



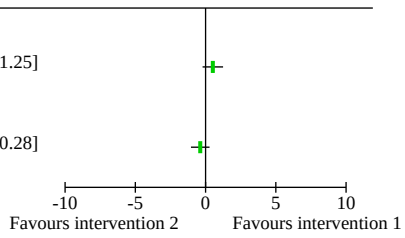
Analysis 2.2. Comparison 2: Somatosensory perception: active intervention 1 versus active intervention 2, Outcome 2: Quality of life and participation - mobility and navigation

Study or Subgroup	Intervention 1 Mean	SD	Total	Intervention 2 Mean	SD	Total	Mean Difference IV, Random, 95% CI
2.2.1 Pusher Syndrome							
Bergmann 2018	1	2.22	15	0	4.44	15	1.00 [-1.51 , 3.51]
2.2.2 Not Pusher Syndrome							



Analysis 2.3. Comparison 2: Somatosensory perception: active intervention 1 versus active intervention 2, Outcome 3: Perception

Study or Subgroup	Intervention 1 Mean	SD	Total	Intervention 2 Mean	SD	Total	Std. Mean Difference IV, Random, 95% CI
2.3.1 Pusher Syndrome							
Bergmann 2018	0	2.15	15	-1.9	4.59	15	0.52 [-0.21 , 1.25]
2.3.2 Not Pusher Syndrome							
De Bruyn 2018	1.48	1.37	19	2.01	1.36	17	-0.38 [-1.04 , 0.28]

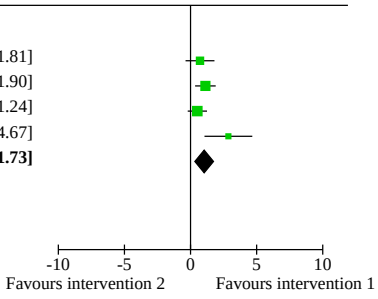


Analysis 2.4. Comparison 2: Somatosensory perception: active intervention 1 versus active intervention 2, Outcome 4: Pusher syndrome outcomes

Study or Subgroup	Intervention 1 Mean	SD	Total	Intervention 2 Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
2.4.1 Pusher Syndrome								
An 2019	-4.57	1.62	7	-6.14	2.41	7	23.1%	0.72 [-0.38 , 1.81]
An 2020	-3.3	1.4	15	-5.5	2.3	15	31.8%	1.12 [0.35 , 1.90]
Bergmann 2018	-5	4.44	15	-7	2.96	15	33.4%	0.52 [-0.21 , 1.24]
Yang 2015	-0.8	0.5	7	-3.1	1	5	11.7%	2.86 [1.05 , 4.67]
Subtotal (95% CI)			**44**			**42**	**100.0%**	**1.03 [0.33 , 1.73]**

Heterogeneity: Tau² = 0.25; Chi² = 6.01, df = 3 (P = 0.11); I² = 50%
Test for overall effect: Z = 2.87 (P = 0.004)

Test for subgroup differences: Not applicable



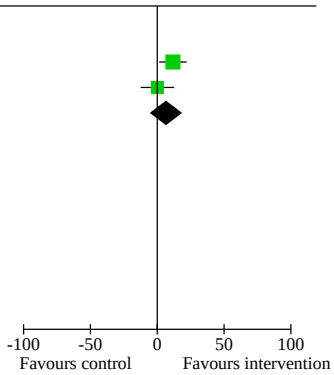
Comparison 3. Tactile perception: intervention versus no treatment or control

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
3.1 Quality of life and participation - mobility and navigation	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
3.1.1 Intervention versus no treatment	1	30	Mean Difference (IV, Random, 95% CI)	6.50 [-4.81, 17.81]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
3.1.2 Intervention versus control	0	0	Mean Difference (IV, Random, 95% CI)	Not estimable
3.2 Perception	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
3.2.1 Intervention versus no treatment	1	30	Mean Difference (IV, Random, 95% CI)	4.64 [3.06, 6.21]
3.2.2 Intervention versus control	0	0	Mean Difference (IV, Random, 95% CI)	Not estimable

Analysis 3.1. Comparison 3: Tactile perception: intervention versus no treatment or control, Outcome 1: Quality of life and participation - mobility and navigation

	Intervention			No treatment or control				Mean Difference	Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**	**IV, Random, 95% CI**
3.1.1 Intervention versus no treatment									
Kim 2015 (1)	-13.15	3.78	10	-24.87	11.37	5	55.0%	11.72 [1.48 , 21.96]	
Kim 2015 (2)	-24.75	12.17	10	-24.87	11.37	5	45.0%	0.12 [-12.38 , 12.62]	
Subtotal (95% CI)			**20**			**10**	**100.0%**	**6.50 [-4.81 , 17.81]**	
Heterogeneity: Tau² = 33.30; Chi² = 1.98, df = 1 (P = 0.16); I² = 50%									
Test for overall effect: Z = 1.13 (P = 0.26)									
3.1.2 Intervention versus control									
Subtotal (95% CI)			**0**			**0**		**Not estimable**	
Heterogeneity: Not applicable									
Test for overall effect: Not applicable									
Test for subgroup differences: Not applicable									



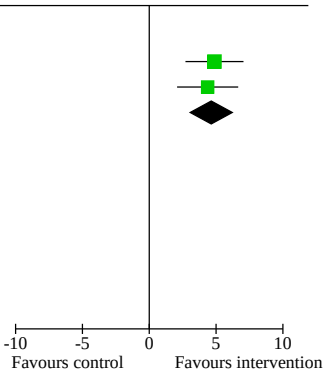
Footnotes

(1) this comparison relates to training on an unstable surface versus no treatment

(2) this comparison relates to training on a stable surface versus no treatment

Analysis 3.2. Comparison 3: Tactile perception: intervention versus no treatment or control, Outcome 2: Perception

Study or Subgroup	Intervention Mean	SD	Total	No treatment or control Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
3.2.1 Intervention versus no treatment								
Kim 2015 (1)	-1.88	1.06	10	-6.76	2.36	5	52.6%	4.88 [2.71 , 7.05]
Kim 2015 (2)	-2.39	1.6	10	-6.76	2.35	5	47.4%	4.37 [2.08 , 6.66]
Subtotal (95% CI)			**20**			**10**	**100.0%**	**4.64 [3.06 , 6.21]**
Heterogeneity: Tau² = 0.00; Chi² = 0.10, df = 1 (P = 0.75); I² = 0%								
Test for overall effect: Z = 5.78 (P < 0.00001)								
3.2.2 Intervention versus control								
Subtotal (95% CI)			**0**			**0**		**Not estimable**
Heterogeneity: Not applicable								
Test for overall effect: Not applicable								
Test for subgroup differences: Not applicable								



Footnotes

(1) this comparison relates to training on a stable surface versus no treatment

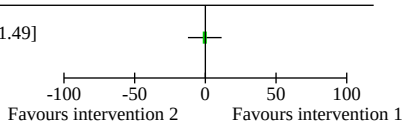
(2) this comparison relates to training on an unstable surface versus no treatment

Comparison 4. Tactile perception: active intervention 1 versus active intervention 2

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
4.1 Activities of daily living	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
4.2 Quality of life and participation - mobility and navigation	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
4.3 Perception	2		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected

Analysis 4.1. Comparison 4: Tactile perception: active intervention 1 versus active intervention 2, Outcome 1: Activities of daily living

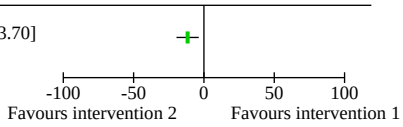
Study or Subgroup	Active intervention 1 Mean	SD	Total	Active intervention 2 Mean	SD	Total	Mean Difference IV, Random, 95% CI
Lee 2021	82.92	14.59	14	83.33	14.72	10	-0.41 [-12.31 , 11.49]



Analysis 4.2. Comparison 4: Tactile perception: active intervention 1 versus active intervention 2, Outcome 2: Quality of life and participation - mobility and navigation

Study or Subgroup	Active intervention 1 Mean	SD	Total	Active intervention 2 Mean	SD	Total	Mean Difference IV, Random, 95% CI
Kim 2015 (1)	-24.75	12.17	10	-13.15	3.78	10	-11.60 [-19.50 , -3.70]

Test for subgroup differences: Not applicable

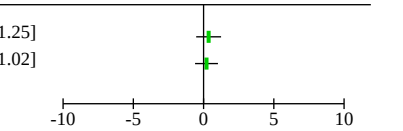


Footnotes

(1) active intervention 1 is training on a stable surface, active intervention 2 is training on an unstable surface

Analysis 4.3. Comparison 4: Tactile perception: active intervention 1 versus active intervention 2, Outcome 3: Perception

Study or Subgroup	Active intervention 1 Mean	SD	Total	Active intervention 2 Mean	SD	Total	Std. Mean Difference IV, Random, 95% CI
Kim 2015 (1)	-1.88	1.06	10	-2.39	1.6	10	0.36 [-0.53 , 1.25]
Lee 2021	6.92	2.28	14	6.38	2.79	10	0.21 [-0.61 , 1.02]



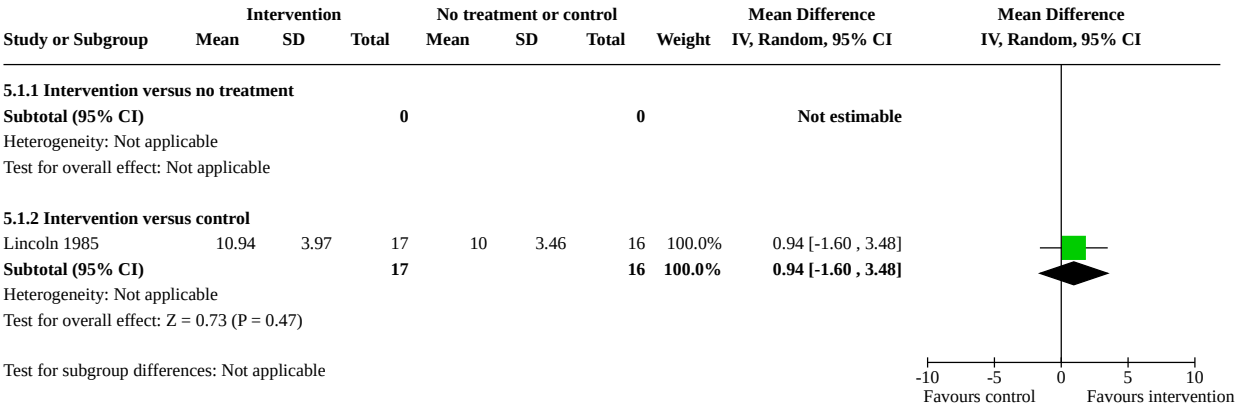
Footnotes

(1) active intervention 1 is training on a stable surface, active intervention 2 is training on an unstable surface

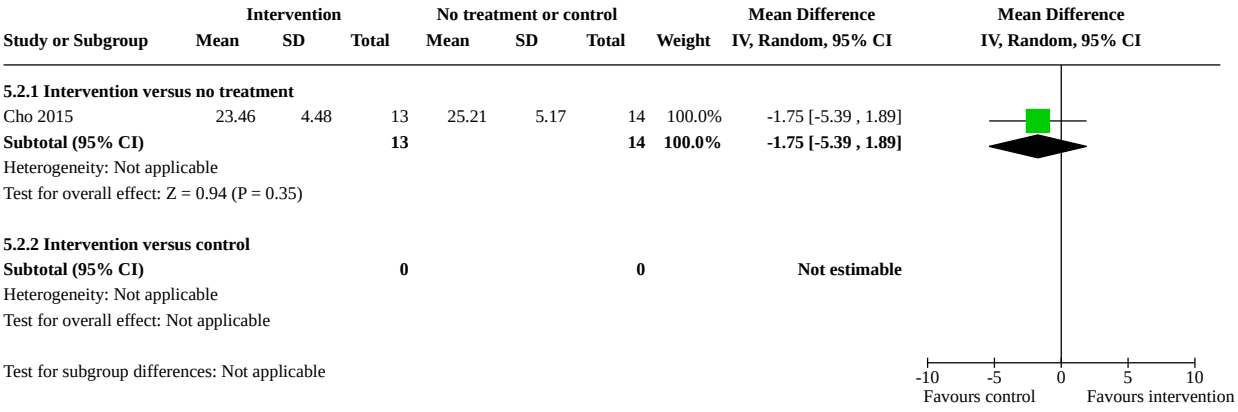
Comparison 5. Vision perception: intervention versus no treatment or control

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
5.1 Extended activities of daily living	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
5.1.1 Intervention versus no treatment	0	0	Mean Difference (IV, Random, 95% CI)	Not estimable
5.1.2 Intervention versus control	1	33	Mean Difference (IV, Random, 95% CI)	0.94 [-1.60, 3.48]
5.2 Perception	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
5.2.1 Intervention versus no treatment	1	27	Mean Difference (IV, Random, 95% CI)	-1.75 [-5.39, 1.89]
5.2.2 Intervention versus control	0	0	Mean Difference (IV, Random, 95% CI)	Not estimable

Analysis 5.1. Comparison 5: Vision perception: intervention versus no treatment or control, Outcome 1: Extended activities of daily living



Analysis 5.2. Comparison 5: Vision perception: intervention versus no treatment or control, Outcome 2: Perception

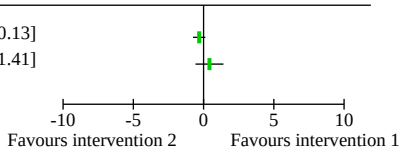


Comparison 6. Vision perception: active intervention 1 versus active intervention 2

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
6.1 Activities of daily living	2		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected
6.2 Quality of life and participation - mobility and navigation	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
6.3 Perception	5		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected

Analysis 6.1. Comparison 6: Vision perception: active intervention 1 versus active intervention 2, Outcome 1: Activities of daily living

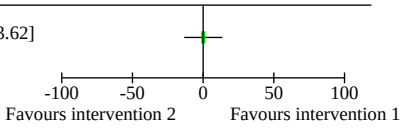
Study or Subgroup	Intervention 1 Mean	SD	Total	Intervention 2 Mean	SD	Total	Std. Mean Difference IV, Random, 95% CI
Edmans 2000	11.5	4.44	40	13	5	40	-0.31 [-0.76 , 0.13]
Kang 2009	56.4	21.5	8	47.3	19.6	8	0.42 [-0.58 , 1.41]



Analysis 6.2. Comparison 6: Vision perception: active intervention 1 versus active intervention 2, Outcome 2: Quality of life and participation - mobility and navigation

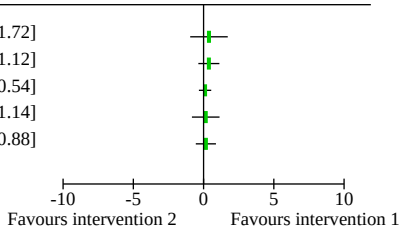
Study or Subgroup	Intervention 1 Mean	SD	Total	Intervention 2 Mean	SD	Total	Mean Difference IV, Random, 95% CI
Choi 2018	-17.42	10.98	14	-17.54	23.32	14	0.12 [-13.38 , 13.62]

Test for subgroup differences: Not applicable



Analysis 6.3. Comparison 6: Vision perception: active intervention 1 versus active intervention 2, Outcome 3: Perception

Study or Subgroup	Intervention 1 Mean	SD	Total	Intervention 2 Mean	SD	Total	Std. Mean Difference IV, Random, 95% CI
Chen 2012	6.5	4.1	5	4.9	3.1	4	0.38 [-0.95 , 1.72]
Choi 2018	39	12.25	14	34	13.5	14	0.38 [-0.37 , 1.12]
Edmans 2000	126.3	60.99	40	120.7	42.28	40	0.11 [-0.33 , 0.54]
Kang 2009	77.8	28.7	8	74.1	14.8	8	0.15 [-0.83 , 1.14]
Park 2015	42.8	11.6	15	41.4	2.3	15	0.16 [-0.55 , 0.88]



ADDITIONAL TABLES

Table 1. Rehabilitation modes of action

Rehabilitation category	Definition
Restitution	Direct training of the impaired function
Compensation	Compensation for a deficit by use of a spared function
Substitution	Use of techniques or equipment external to the individual, such as optics, prosthetics, environmental design

Classifications come from Kerkhoff 2000

Table 2. Definitions of potential comparators

Name	Definition
No treatment	Where no additional intervention for the perceptual disorder(s) was received by the comparison group, compared to the active intervention group. This includes trials with a waiting-list control group, for whom treatment is delayed until after the trial period (i.e. no treatment is administered during the trial period).
Placebo	An intervention that is similar to, but omits a key therapeutic element of, the perceptual treatment or procedure under investigation. These may be described as “sham” interventions (Faltinsen 2019).
Standard care (usual care)	An intervention that reflects the usual care practice before the trial start for a given perceptual disorder (Faltinsen 2019).
Attention Control	An intervention used to balance attention, treatment contact, social support, and nonspecific therapist effects across treatment groups. (Kazdin 1980)

Table 3. Summary of study recruitment and setting

Study ID	Participant recruitment details from trial report	Number of centres	Type of centre	Location
An 2019	Study was conducted on participants "who had been hospitalised"	1	University hospital	"J city", South Korea
An 2020	"All 30 subjects in the study were in-patient with stroke who were hospitalised... between June 2018 and May 2019" in the Department of Rehabilitation Medicine	1	University hospital	Jeonju, Korea
Bergmann 2018	Participants were recruited from an inpatient rehabilitation setting	1	Rehabilitation hospital	Munich, Germany
Carey 2011	Participants were recruited to the study after they had completed their inpatient and outpatient therapy or community-based follow-up. Most were living at home or in supported accommodation at the time of the study. Potential participants, referred by hospital clinicians, were screened by research therapists for eligibility. They were recruited consecutively as they became available.	6	Hospitals (including rehabilitation and long-term community-based facilities associated with the hospitals)	Melbourne, Australia
Chen 2012	Persons with a right-brain stroke were recruited based on referrals from physicians and therapists of two acute inpatient rehabilitation hospitals.	2	Rehabilitation hospitals	USA
Cho 2015	Participants were recruited from among 28 stroke patients who received occupational and physical therapy and were hospitalised.	1	General hospital	Kyeongki province, South Korea
Choi 2018	Individuals with chronic stroke who were admitted to an inpatient rehabilitation hospital were re-	1	Rehabilitation hospital	Not stated, South Korea

Table 3. Summary of study recruitment and setting *(Continued)*

	cruited through screening by physical therapists according to eligibility criteria. The participants provided written informed consent.			
De Bruyn 2020	Participants were recruited from inpatient rehabilitation centres.	4	Rehabilitation ward	Antwerp, Belguim
Edmans 2000	"... patients were selected from those admitted consecutively to the Nottingham Stroke Unit.... If perceptual problems were identified, an explanation was given to the patient about what these problems were and how they might affect the patient in everyday life. An explanation of the study was given and consent obtained."	1	Hospital stroke unit	Nottingham, England
Kang 2009	"... recruited from an inpatient rehabilitation unit"	1	Hospital rehabilitation unit	Seoul, South Korea
Kim 2015	Participants were "undergoing hospital rehabilitation"	Unclear	Hospital rehabilitation setting	Not stated, South Korea
Koo 2018	Participants were recruited from a rehabilitation unit. All provided written, informed consent.	1	University hospital	Ulsan, South Korea
Lee 2021	Participants were recruited from a medical university hospital.	1	University hospital	Taipei, Taiwan
Lincoln 1985	Participants were identified from those admitted to a hospital rehabilitation centre.	1	Hospital rehabilitation centre	Oxford, England
Park 2015	Participants were recruited from a local rehabilitation hospital.	1	Rehabilitation hospital	Not stated, South Korea
Seim 2021	Participants were recruited through stroke support groups; all provided written consent.	1	Outpatient clinical setting	Atlanta, USA
Yang 2015	Participants were recruited from an outpatient department of rehabilitation. All provided written informed consent.	1	Medical centre	Taipei, Taiwan
Yun 2018	Participants were recruited through an inpatient rehabilitation clinic service.	1	Rrehabilitation centre	Busan, South Korea

Table 4. Details of dropouts

Study ID	Group	Number of dropouts during intervention	Reason provided	Number lost during follow-up period	Reason provided
An 2019	1. Game-based vertical posture training	0	n/a	No follow-up period	-
	2. Standard vertical posture training	0	n/a	No follow-up period	-

Table 4. Details of dropouts *(Continued)*

An 2020	1. Whole-body tilting postural training	0	n/a	No follow-up period	-
	2. General postural training	0	n/a	No follow-up period	-
Bergmann 2018	1. Robot-assisted gait training	6 did not begin intervention, 3 did not complete	6 did not begin treatment: no pusher behaviour at baseline visit (3), second stroke (2), isolation due to infection (1). 3 did not complete the intervention due to lower extremity pain.	1	Transfer to another hospital
	2. Physiotherapy	2	Pusher behaviour at baseline visit (1), severe infection (1)	0	-
Carey 2011	1. Sensory discrimination training	0	n/a	n/a - post crossover	-
	2. Exposure to tactile stimuli	0	n/a	n/a - post crossover	-
Chen 2012	1. Image drawing - global processing training	0	n/a	1	"Schedule incompliance"
	2. Image drawing - rote repetition training	0	n/a	1	"Lost contact"
Cho 2015	1. Neurofeedback training	Not reported	Not reported	No follow-up period	-
	2. No intervention	Not reported	Not reported	No follow-up period	-
Choi 2018	1. Wii Fit virtual reality training	0	n/a	1	Voluntarily stopped training
	2. Control - general balance training	0	n/a	2	Discharged
De Bruyn 2018	1. Sensorimotor therapy	1	Acute hospitalisation	2	Medically unstable
	2. Motor exercises	1	Stopped rehabilitation against medical advice	0	-
Edmans 2000	1. Transfer of training perceptual treatment	0	None	No follow-up period	-

Table 4. Details of dropouts *(Continued)*

	2. Functional perceptual treatment	1	Participant died	No follow-up period	-
Kang 2009	1. Computerised visual perception rehabilitation with motion tracking	0	n/a	No follow-up period	-
	2. Computer-based cognitive rehabilitation program	0	n/a	No follow-up period	-
Kim 2015	1. Pressure sense perception training on stable surface	0	n/a	No follow-up period	-
	2. Pressure sense perception training on unstable surface	0	n/a	No follow-up period	-
	3. No treatment	0	n/a	No follow-up period	-
Koo 2018	1. Transcranial direct current stimulation	0	n/a	No follow-up period	-
	2. Sham transcranial direct current stimulation	0	n/a	No follow-up period	-
Lee 2021	1. Robot-assisted therapy	1	Medical reason	1	Moved house
	2. Conventional therapy	0	n/a	0	-
Lincoln 1985	1. Perceptual training	0	None reported	No follow-up period	-
	2. Conventional therapy	0	None reported	No follow-up period	-
Park 2015	1. Computer-based cognitive rehabilitation training	0	None reported	No follow-up period	-
	2. Conventional cognitive rehabilitation	0	None reported	No follow-up period	-
Seim 2021	1. Vibrotactile stimulation glove	0	n/a	No follow-up period	-
	2. Sham vibrotactile stimulation glove	0	n/a	No follow-up period	-
Yang 2015	1. Computer-generated visual feedback training	0	n/a	No follow-up period	-
	2. Mirror visual feedback training	0	n/a	No follow-up period	-
Yun 2018	1. Robot-assisted gait training	1	Recurrence of stroke	0	-
	2. Conventional physical therapy	1	Aggravation of pneumonia	0	-

n/a: not applicable

Table 5. Characteristics of participants in included studies

Study ID	Group	Participants randomised (n)	Male/Female (n)	Age in years Mean (SD)	Stroke details Type: Hemisphere (r/): Severity: Time post onset:	Perceptual impairment Sense(s) Name: Diagnosis: Severity:	Concurrent impairments reported Mean (SD) and method of diagnosis
An 2019	1. Game-based vertical posture training	7	4/3	59.3 (4.6)	Ischaemic/haemorrhage: 5/2 Hemisphere (r/l): 6/1 Severity: not reported Time post onset: 31.4 (7.4) days	Somatosensation: Pusher Syndrome Diagnosis: Burke Lateropulsion Scale (> 2) Severity: not stated	Not stated
	2. Standard vertical posture training	7	3/4	64.4 (7.5)	Ischaemia/haemorrhage: 4/3 Hemisphere (r/l): 7/0 Severity: not reported Time post onset:29.0 (6.1) days	Somatosensation: Pusher Syndrome Diagnosis: Burke Lateropulsion Scale (> 2) Severity: not stated	Not stated
An 2020	1. Whole-body tilting postural training	15	11/4	60.5 (6.0)	Ischaemia/haemorrhage: 8/7 Hemisphere (r/l): 12/3 Time post onset: 21.5 (3.4) days	Somatosensation: Pusher Syndrome Severity: 4.3 (1.4) (SCP)	Neglect %: 53% (method of diagnosis unclear) K-MMSE: 26.3 (2.1)
	2.General postural training	15	10/5	64.7 (6.9)	Ischaemia/haemorrhage: 7/8 Hemisphere (r/l): 11/4 Time post onset: 21.9 (5.9) days?	Somatosensation: Pusher Syndrome Severity: 4.3 (1.4) (SCP)	Neglect %: 60% (method of diagnosis unclear) K-MMSE: 25.7 (1.5)

Table 5. Characteristics of participants in included studies *(Continued)*

Bergmann 2018	1. Robot-assisted gait training	21	10/5 (data not provided for 6 participants who did not complete the intervention)	72 (9)	Ischaemia/haemorrhage: 8/7 Hemisphere (r/l): 11/4 Severity: not reported Time post onset: 7.5 (2.6) weeks	Somatosensation: Pusher Syndrome Diagnosis: Scale for Contraversive Pushing > 0 per component assessed by physiotherapist Severity: not stated	All participants showed cognitive deficits with ACE-R scores < 84. Several participants had severe cognitive deficits.
	2. Physiotherapy	17	7/8 (data not provided for 2 participants who did not complete the intervention)	71 (10)	Ischaemia/haemorrhage: 9/6 Hemisphere (r/l): 12/3 Severity: not reported Time post onset: 8.0 (3.8) weeks	Somatosensation: Pusher Syndrome Diagnosis: Scale for Contraversive Pushing > 0 per component assessed by physiotherapist Severity: not stated	All participants showed cognitive deficits with ACE-R scores < 84 Several participants had severe cognitive deficits particularly in control group.
Carey 2011	1. Sensory discrimination training	25	17/8	61.08 (14.38)	Infarct/haemorrhage/infarct and haemorrhage (%): 64/3 6/0 Hemisphere (r/l): 18/0 Severity (NIHSS): median 4, (IQR 2-7.25) Time post onset: median 32.57 (IQR 16.29-148.29) weeks	Mixed: tactile and somatosensory Diagnosis: unclear Severity: -41.14 (35.79) (standardised somatosensory deficit)	None stated
	2. Exposure to tactile stimuli	25	20/5	60.96 (11.17)	Infarct/haemorrhage/infarct and haemorrhage (%): 64/3 6/0 Hemisphere (r/l): 18/0	Mixed: tactile and somatosensory Diagnosis: unclear Severity: -31.24 (27.07) (standardised somatosensory deficit)	None stated

Table 5. Characteristics of participants in included studies *(Continued)*

					Severity (NIHSS): median 4, (IQR 2-7.25) Time post onset: median 32.57 (IQR 16.29-148.29) weeks		
Chen 2012	1. Image drawing - global processing training	6	2/4	73.8 (8.8)	Type not stated (see inclusion criteria) hemisphere (r/l): 6/0 (inclusion criterion) Severity: not stated Time: 48.0 (17.2) days	Vision: visuospatial memory deficit Diagnosis: IR of MTCF ≤ 9/36 Severity unclear	GDS (≤ 10/30): 4.8 (3.5) BIT (≥ 129/126): 139.5 (5.6) MMSE (≥ 24/30): 27.5 (2.1) (none meet criteria for depression, spatial neglect or dementia)
	2. Image drawing - rote repetition training	5	3/2	74.0 (8.4)	Type not stated (see inclusion criteria) Hemisphere (r/l): 5/0 (inclusion criterion) Severity: not stated Time: 35.0 (20.2) days	Vision: visuospatial memory deficit Diagnosis: IR of MTCF ≤ 9/36 Severity unclear	GDS (≤ 10/30): 5.4 (4.4) BIT (≥ 129/126): 136.8 (7.7) MMSE (≥ 24/30): 26.6 (1.8) (none meet criteria for depression, spatial neglect or dementia)
Cho 2015	1. Neurofeedback training	13	8/5	62.9 (7.2)	Type: not stated Hemisphere (r/l): 9/4 Severity: not stated Time post-onset: 10.6 (3.2) months	Vision: visual perceptual deficit Diagnosis: MMSE Severity:19.8 (2.5)	None stated

Table 5. Characteristics of participants in included studies *(Continued)*

	2. No intervention	14	11/3	63.6 (9.3)	Type: not stated Hemisphere (r/l): 8/5 Severity: not stated Time post-onset: 12.5 (2.7) months	Vision: visual perceptual deficit Diagnosis: MMSE Severity: 20.5 (3.7)	None stated
Choi 2018	1. Wii Fit virtual reality training	14	9/5	49.50 (23.00)	Infarction/haemorrhage: 10/4 Hemisphere (r/l): 8/6 Severity: not stated Time post onset: not stated	Vision: visual perceptual deficit Diagnosis: MVPT score < 45 Severity: not stated	MAS (G0/G1/G1+ /G2/G3): 1/7/6/0/0 MMSE-K (score): 28.50 (3.25)
	2. Control - general balance training	14	8/6	51.00 (13.75)	Infarction/haemorrhage: 8/6 Hemisphere (r/l): 9/8 Severity: not stated Time post onset: not stated	Vision: visual perceptual deficit Diagnosis: MVPT score < 45 Severity: not stated	MAS (G0/G1/G1+ /G2/G3): 2/4/8/0/0 MMSE-K (score): 28.50 (3.50)
De Bruyn 2020	1. Sensorimotor therapy	22	12/10	75.5 median (60.8 to 80.3) IQR	Ischaemia/haemorrhage: 19/3 Hemisphere (r/l): 17/5 Severity: not reported Time post onset: 38.5 median (30.8–48.3) days IQR	Somatosensation: somatosensory and motor impairment Diagnosis: Action Research Arm Test (ARAT) score < 52 out of 57 and a negative composite standardised somatosensory deficit index Severity: ARAT 8/57	Not stated
	2. Motor exercises	18	9/9	61.5 median (54–70) IQR	Ischaemia/haemorrhage: 14/4 Hemisphere (r/l): 8/10 Severity: not reported Time post onset: 40 median (28.8–53.5) days IQR	Somatosensation: somatosensory and motor impairment Diagnosis: Action Research Arm Test score < 52 out of 57 and a negative composite standardised somatosensory deficit index	Not stated

Table 5. Characteristics of participants in included studies *(Continued)*

						Severity: ARAT 12/57	
Edmans 2000	1. Transfer of training perceptual treatment	40	18/22	69.75 (9.10)	Type: not stated Hemisphere (r/l): unclear Severity: not stated Time post onset: 37.68 (16.60) days	Vision: visual perceptual deficit Diagnosis: RPAB, score > 2 SD below mean on four+ subtests Severity: median 100.50 (IQR 52.95-124.73)	Dysphasia (present/absent): 12/28 Dysarthria (present/absent): 9/31 Articulatory dyspraxia (present/absent): 6/34 Reasoning problems (present/absent): 25/7 Memory problems (present/absent): 32/4 Depression (present/absent): 8/24 Anxiety (present/absent): 14/18 Limb dyspraxia (present/absent): 3/33 Sensory problems (present/absent): 28/9
	2. Functional perceptual treatment	40	22/18	67.85 (11.38)	Type: not stated Hemisphere (r/l): unclear Severity: not stated Time post onset: 31.15 (10.13) days	Vision: visual perceptual deficit Diagnosis: RBAB, score > 2 SD below mean on four+ subtests Severity: median 99.90 (IQR 76.35-124.68)	Dysphasia (present/absent): 14/36 Dysarthria (present/absent): 6/34

Table 5. Characteristics of participants in included studies *(Continued)*

							Articulatory dyspraxia (present/absent): 5/35 Reasoning problems (present/absent): 23/11 Memory problems (present/absent): 31/6 Depression (present/absent): 13/21 Anxiety (present/absent): 9/25 Limb dyspraxia (present/absent): 6/31 Sensory problems (present/absent): 27/7
Kang 2009	1. Computerised visual perception rehabilitation with motion tracking	8	Not reported	59.5 (10.7)	Ischaemia/haemorrhage: 8/8 (whole group data) Hemisphere (r/l): 8/0 Severity: not stated Time post onset: 64.3 (37.4) days	Vision: visual perceptual deficit NB: all participants had hemiplegia (inclusion criterion) Diagnosis: Motor Free Visual Perception Test standard score 5 < 109. Severity: 65.8 (19.5) MVPT score	None stated
	2. Computer-based cognitive rehabilitation programme	8	Not reported	62.5 (9.6)	Ischaemia/haemorrhage: 8/8 (whole group data) Hemisphere (r/l): 8/0 Severity: not stated	Vision: visual perceptual deficit NB: all participants had hemiplegia (inclusion criterion) Diagnosis: Motor Free Visual Perception Test standard score 5 < 109	None stated

Table 5. Characteristics of participants in included studies *(Continued)*

					Time post onset: 58.1 (29.9) days	Severity: 68.3 (11.4) MVPT score	
Kim 2015	1. Pressure sense perception training on stable surface	10	4/6	54.70 (3.09)	Infarct/haemorrhage: 4/6 Hemisphere (r/l): 3/7 Severity: not reported Time post onset: 42.20 (21.61) months	Touch: pressure perception dysfunction Diagnosis: Semmes-Weinstein monofilaments Severity: not stated	Not stated
	2. Pressure sense perception training on unstable surface	10	8/2	59.40 (8.63)	Infarct/haemorrhage: 4/6 Hemisphere (r/l): 4/6 Severity: not reported Time post onset: 37.80 (22.40) months	Touch: pressure perception dysfunction Diagnosis: Semmes-Weinstein monofilaments Severity: not stated	Not stated
	3. No treatment	10	8/2	56.40 (11.87)	Infarct/haemorrhage: 3/7 Hemisphere (r/l): 5/5 Severity: not reported Time post onset: 50.70 (13.83) months	Touch: pressure perception dysfunction Diagnosis: Semmes-Weinstein monofilaments Severity: not stated	Not stated
Koo 2018	1. Transcranial direct current stimulation	12	6/6	52.42 (3.23)	Ischaemia/haemorrhage: 4/8 Hemisphere (r/l): 6/6 Severity: not reported Time post onset: 18.67 (8.10) days	Somatosensation: somatosensory dysfunction Diagnosis: patients with impairment in at least one of the pin prick, light touch, or proprioception parameters during a bedside screening evaluation Severity: not stated	Hypertension, diabetes and moderate (2) or severe impairment (10) score on Modified Barthel Index
	2. Sham transcranial direct current stimulation	12	5/7	58.67 (3.40)	Ischaemia/haemorrhage: 7/5 Hemisphere (r/l): 4/8 Severity: not reported	Somatosensation: somatosensory dysfunction Diagnosis: patients with impairment in at least one of the pin prick, light touch, or proprioceptive-	Hypertension, diabetes and moderate (3) or severe impairment (9) score on Modi-

Table 5. Characteristics of participants in included studies *(Continued)*

					Time post onset: 19.67 (7.76) days	tion parameters during a bedside screening evaluation Severity: not stated	fied Barthel Index
Lee 2021	1. Robot-assisted therapy	14	9/5	59.56 (8.29)	Ischaemia/haemorrhage: 9/5 Hemisphere (r/l): 5/9 Severity: not reported Time post onset: 882.00 (957.67) days	Touch: tactile dysfunction Diagnosis: revised Nottingham Sensory Assessment Tactile Score < 2 and Kinesthetic score < 3. Modified Ashworth Scale score < 3. Brunnstrom Stages II-V Severity: not stated	Not stated
	2. Conventional therapy	10	7/3	53.50 (12.33)	Ischaemia/haemorrhage:4/6 Hemisphere (r/l): 2/8 Severity: not reported Time post onset: 883.30 (1020.49) days	Touch: tactile dysfunction Diagnosis: revised Nottingham Sensory Assessment Tactile Score < 2 and Kinesthetic score < 3. Modified Ashworth Scale score < 3. Brunnstrom Stages II-V Severity: not stated	Not stated
Lincoln 1985	1. Perceptual training	17 (3 head injury)	9/8	48.76 (14.58)	Stroke/subarachnoid haemorrhage: 9/5 Hemisphere (r/l/both/neither): 8/7/1/1 Severity: not stated Time post onset: 2.35 (0.95) months	Vision: visual perceptual deficit Diagnosis: RPAB Severity: not stated	Not stated
	2. Conventional Therapy	16 (3 head injury)	8/8	51.44 (16.04)	Stroke/subarachnoid haemorrhage: 12/1 Hemisphere (r/l/both/neither): 7//81/0 Severity: not stated Time post onset: 3.06 (2.43) months	Vision: visual perceptual deficit Diagnosis: RPAB Severity: not stated	Not stated

Table 5. Characteristics of participants in included studies *(Continued)*

Park 2015	1. Computer-based cognitive rehabilitation training	15	6/9	64.7 (8.9)	Type: not stated Hemisphere (r/l): not stated Severity: not stated Time post onset: 1.5 (0.5) months	Vision: visual perceptual deficit Diagnosis: MMSE Severity: 20.6 (2.3) MMSE score	Not stated
	2. Conventional cognitive rehabilitation	15	8/7	65.2 (8.0)	Type: not stated Hemisphere (r/l): not stated Severity: not stated Time post onset: 1.8 (0.6) months	Vision: visual perceptual deficit Diagnosis: MMSE Severity: 20.5 (2.0) MMSE score	Not stated
Seim 2021	1. VTS Glove	8	5/3	54.1	Ischaemia/haemorrhage: not reported Hemisphere (r/l): 3/5 Severity: not reported Time post onset: 4.3 years mean	Touch: tactile discrimination disorder Diagnosis: impaired touch sensation in the hand (Semmes-Weinstein monofilament exam score of ≥ 0.2 grams on 3 of 20 measured locations on the hand) Severity: not stated	Not stated
	2. Sham	8	6/2	54.5	Ischaemia/haemorrhage: not reported Hemisphere (r/l): 5/3 Severity: not reported Time post onset: 3 years	Touch: tactile discrimination disorder Diagnosis: impaired touch sensation in the hand (Semmes-Weinstein monofilament exam score of ≥ 0.2 grams on 3 of 20 measured locations on the hand) Severity: not stated	Not stated
Yang 2015	1. Computer-generated visual feedback training	7	4/3	62.4 (12.9)	Ischaemia/haemorrhage: 7/0 Hemisphere (r/l): 0/7	Somatosensation: Pusher Syndrome Diagnosis: greater than zero point scores in each section of the scale	Not stated

Table 5. Characteristics of participants in included studies *(Continued)*

					Severity: not reported Time post onset: 6.0 (4.0) months	for contraversive pushing (sitting plus standing) Severity: not stated	
	2. Mirror visual feedback training	5	5/0	57.6 (17.3)	Ischaemia/haemorrhage): 3/2 Hemisphere (r/l): 2/3 Severity: not reported Time post onset: 5.8 (3.3) months	Somatosensation: Pusher Syndrome Diagnosis: greater than zero point scores in each section of the scale for contraversive pushing (sitting plus standing) Severity: not stated	Not stated
Yun 2018	1. Robot-assisted gait training	19	10/8	63.6 (8.3)	Ischaemia/haemorrhage: 12/6 Hemisphere (r/l): 3/15 Severity: 12.7 (1.5) NIHSS Time post onset: 31.3 (7.5) days	Somatosensation: Pusher Syndrome Diagnosis: Burke Lateropulsion scale score over 2 points Severity: not stated	10 participants had neglect; 2 aphasia
	2. Conventional physical therapy	19	9/9	64.3 (8.4)	Ischaemia/haemorrhage): 13/5 Hemisphere (r/l): 4/14 Severity: 12.9 (1.6) NIHSS Time post onset: 28.8 (6.8) days	Somatosensation: Pusher Syndrome Diagnosis: Burke Lateropulsion scale score over 2 points Severity: not stated	10 participants had neglect; 3 aphasia

ACE-R: Addenbrooke's Cognitive Examination-Revised**; BIT:** Behavioral Inattention Test; **G:** grade; **GDS:** Geriatric Depression Scale; **IQR:** interquartile range; **IR:** immediate recall; **K-MMSE:** Korean Mini-Mental State Examination; **MAS:** Modified Ashworth Scale; **MMSE:** Mini-Mental State Examination; **MTCF:** Modified Taylor Complex Figure; **MVPT:** motor free visual perception test; **NIHSS:** National Institutes of Health Stroke Scale; **RPAB:** Rivermead Perceptual Assessment Battery; **SCP:** Scale for Contraversive Pushing; **SD:** standard deviation

Table 6. Overview of outcome measures gathered from included studies

Study ID	Primary outcomes	Secondary outcomes

Table 6. Overview of outcome measures gathered from included studies *(Continued)*

	ADL	eADL	Quality of life and participation includes: social activities and participation, QoL mobility and navigation	Mental health and psychological well-being (for stroke survivors, family, friends and carers) Stroke survivor	Perceptual function	Adverse events	Sensation, motor (including balance), cognition (including attention)	Others
Notes	1/2/3 refer to the total number of tests in each outcome category							
An 2019	1 Korean-modified Barthel Index	-	-	-	-	-	2 Motor: Postural Assessment Scale for Stroke; Balance posture ratio	Burke Lateropulsion Scale
An 2020	1 Korean-modified Barthel Index	-	-	-	-	1 number reported	3 Motor: Fugl-Meyer Assessment of Motor Recovery after Stroke -Lower Extremity Balance; Berg Balance Scale; Postural Assessment Scale for Stroke	Burke Lateropulsion Scale
Bergmann 2018	-	-	2	-	1	-	-	Burke Lateropulsion

Table 6. Overview of outcome measures gathered from included studies *(Continued)*

			Performance Oriented Mobility Assessment; Functional Ambulation Classification		Subjective visual vertical			Scale; Scale of Contraversive Pushing
Carey 2011	-	-	-	-	1 Standardized somatosensory deficit (combines limb position sense and tactile object recognition)	1 number reported	-	-
Chen 2012	-	-	-	-	3 Rey-Osterrieth Complex Figure; Modified Taylor Complex Figure; Medical College of Georgia Complex Figure 1 and Figure 2	-	-	-
Cho 2015	-	-	-	-	1 Motor-Free Visual Perception Test	-	-	Brainwaves (EEG)
Choi 2018	-	-	2 10-Metre Walk Test; Timed Up and Go Test	-	1 Motor-Free Visual Perception Test	-	1 Motor: Berg Balance Scale	-
De Bruyn 2018	-	-	-	-	4 Nottingham Sensory Assessment perceptual threshold of touch; Texture discrimina-	1 number reported	4 Motor: Action Research Arm Test; Fugl-Meyer Assessment of Motor Recovery after Stroke; Stroke	-

Table 6. Overview of outcome measures gathered from included studies *(Continued)*

					tion test; Wrist position sense test; Functional tactile object recognition test		upper limb capacity scale; ABILHAND questionnaire	
Edmans 2000	2 Barthel ADL Index; Edmans ADL Index	-	-	-	1 Rivermead Perceptual Assessment Battery	-	1 Motor: Rivermead Motor Assessment Gross Function Scale	Length of Hospital stay; OT attendances; OT treatment time
Kang 2009	1 Modified Barthel Index	-	-	-	1 Motor-Free Visual Perception Test	-	1 Cognitive: modified Mental State Examination	Interest in Intervention
Kim 2015	-	-	2 Walking speed: 10-Metre Walk Test; Timed Up and Go Test	-	1 Pressure Error (dynamometer)	-	2 Motor: Balancia, Functional Reach test	-
Koo 2018	1 Korean-modified Barthel Index	-	1 Functional Ambulation Category	-	2 Erasmus MC modifications to the revised Nottingham Sensory Assessment; stereognosis subscale	1 number reported	3 Sensory: Semmes Weinstein Monofilament Exam Motor: Manual Function Test; Brunnstrom Classification	-
Lee 2021	1 Modified Barthel Index	-	-	-	1 rNSA Kinesthetic subtest	-	4 Sensory: Semmes Weinstein Monofilament Exam Motor: Fugl-Meyer Assessment; grip dynamometer; Box and Block Test	1 Surface electromyography

Table 6. Overview of outcome measures gathered from included studies *(Continued)*

Lincoln 1985	-	1 Rivermead ADL scale	-	-	1 Rivermead Perceptual Assessment Battery	-	-	-
Park 2015	-	-	-	-	1 Motor-Free Visual Perception Test	-	1 Cognitive: Lowenstein Occupational Therapy Cognitive Assessment	-
Seim 2021	-	-	-	-	-	-	2 Sensory: Semmes Weinstein Monofilament Exam Motor: Voluntary angular range of motion	1 Modified Ashworth Scale
Yang 2015	-	-	-	-	-	1 number reported	2 Motor: Berg Balance Scale; Fugl-Meyer Assessment of Motor Recovery after Stroke	1 Scale for Contraversive Pushing
Yun 2018	1 Korean-modified Barthel Index	-	-	-	-	1 number reported	2 Motor: Berg Balance Scale; Fugl-Meyer Assessment of Motor Recovery after Stroke	3 Burke Lateropulsion Scale; Postural Assessment for Stroke; Somatosensory Evoked Potentials

APPENDICES

Appendix 1. CENTRAL search strategy

#1 MeSH descriptor: [Cerebrovascular Disorders] this term only
#2 MeSH descriptor: [Basal Ganglia Cerebrovascular Disease] this term only
#3 MeSH descriptor: [Brain Ischemia] explode all trees
#4 MeSH descriptor: [Carotid Artery Diseases] explode all trees
#5 MeSH descriptor: [Cerebral Small Vessel Diseases] explode all trees
#6MeSH descriptor: [Intracranial Arterial Diseases] explode all trees
#7 MeSH descriptor: [Intracranial Embolism and Thrombosis] explode all trees
#8 MeSH descriptor: [Intracranial Hemorrhages] explode all trees
#9 MeSH descriptor: [Stroke] explode all trees
#10 MeSH descriptor: [Stroke, Lacunar] this term only
#11 MeSH descriptor: [Brain Infarction] explode all trees
#12 MeSH descriptor: [Vasospasm, Intracranial] this term only
#13 MeSH descriptor: [Vertebral Artery Dissection] this term only
#14 MeSH descriptor: [Carotid Artery Injuries] explode all trees
#15 MeSH descriptor: [Intracranial Arterial Diseases] this term only
#16 MeSH descriptor: [Cerebral Arterial Diseases] this term only
#17 MeSH descriptor: [Infarction, Anterior Cerebral Artery] this term only
#18 MeSH descriptor: [Infarction, Middle Cerebral Artery] this term only
#19 MeSH descriptor: [Infarction, Posterior Cerebral Artery] this term only
#20 MeSH descriptor: [Carotid Arteries] explode all trees
#21 MeSH descriptor: [Endarterectomy, Carotid] this term only
#22 (stroke* or poststroke or apoplex* or cerebral vasc* or brain vasc* or cerebrovasc* or cva* or SAH):ti,ab,kw
#23 ((brain* or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or middle cerebral arter* or MCA* or anterior circulation or posterior circulation or basilar arter* or vertebral arter* or space-occupying) NEAR/5 (isch?emi* or infarct* or thrombo* or emboli* or occlus* or hypoxi*)):ti,ab,kw
#24 (((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal or putamen or posterior fossa or hemispher* or subarachnoid) NEAR/5 (h?emorrhag* or h?ematoma* or bleed*))):ti,ab,kw
#25 {or #1-#24}
#26 MeSH descriptor: [Perceptual Disorders] explode all trees
#27 MeSH descriptor: [Perception] explode all trees
#28 MeSH descriptor: [Hearing Disorders] this term only
#29MeSH descriptor: [Hearing Loss] this term only
#30 MeSH descriptor: [Deafness] this term only
#31MeSH descriptor: [Hearing Loss, Central] this term only
#32 MeSH descriptor: [Hearing Loss, Sudden] this term only
#33 MeSH descriptor: [Hyperacusis] this term only
#34 MeSH descriptor: [Olfaction Disorders] this term only
#35 MeSH descriptor: [Somatosensory Disorders] explode all trees
#36 MeSH descriptor: [Taste Disorders] explode all trees
#37 MeSH descriptor: [Vision Disorders] this term only
#38 MeSH descriptor: [Alice in Wonderland Syndrome] this term only
#39 MeSH descriptor: [Amblyopia] this term only
#40 MeSH descriptor: [Blindness] this term only
#41 MeSH descriptor: [Blindness, Cortical] this term only
#42 MeSH descriptor: [Color Vision Defects] this term only
#43 MeSH descriptor: [Diplopia] this term only
#44 MeSH descriptor: [Hemianopsia] this term only
#45MeSH descriptor: [Photophobia] this term only
#46 MeSH descriptor: [Scotoma] this term only
#47 MeSH descriptor: [Vision, Low] this term only
#48 (percept* NEAR/3 (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*)):ti,ab,kw
#49 (agnosis or agnosia or anosognosia or prosopagnosia or prosophthalmia or Alice in Wonderland syndrome or Todd syndrome or all?esthesia* or syn?esthesia* or hypoesthesia or hyperesthesia):ti,ab,kw
#50 MeSH descriptor: [Sensation] this term only
#51 MeSH descriptor: [Hearing] this term only

#52 MeSH descriptor: [Smell] this term only
#53 MeSH descriptor: [Taste] this term only
#54 MeSH descriptor: [Touch] this term only
#55 MeSH descriptor: [Vision, Ocular] this term only
#56 MeSH descriptor: [Color Vision] this term only
#57 MeSH descriptor: [Mesopic Vision] explode all trees
#58 MeSH descriptor: [Night Vision] this term only
#59 ((somatosensory* or (sensor* NEAR/3 (input* or stimul* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or processing or percept* or hallucination* or pathway* or evoked potentials or feedback or discriminat* or dysfunction* or recogn* or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body NEAR/3 schema) or (body NEAR/3 orientation))):ti,ab,kw
#60 MeSH descriptor: [Proprioception] explode all trees
#61 (propriocep* or (kin?esthetic NEAR/3 (percept* or discriminat*))):ti,ab,kw
#62 (((odo?r* or smell* or olfact* or scent* or aroma or flavo?r) NEAR/3 (memory or acuity or function* or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hedonics or deprivation or hallucinat*))):ti,ab,kw
#63 ((anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia)):ti,ab,kw
#64 (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia):ti,ab,kw1806
#65 (((gustat* or tast*) NEAR/3 (acuity or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or loss or an?esthesia or absence or phantom))):ti,ab,kw
#66 (((speech or speak* or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) NEAR/3 (percept* or processing or stimul* or distinguish* or discriminat*)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or King Kopetsky syndrome):ti,ab,kw
#67 (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop* or polyop* or metamorphopsia or m?cropsia or ((vision or visual or visual?percept* or visuo?spatial or visuo?construct* or ocular or optokinetic or optic* or oculomotor spatial) NEAR/3 (illusion or blurry or overload or double or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or disorientation or allachethesia or deficit* or defect* or disabilit* or disorder* or processing or dysfunction* or recogn* or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia):ti,ab,kw
#68 (entomopia or palinopsia or asteropsis or strabismus or Anton syndrome or Balint syndrome or blindsight or achromatopsia or hyperchromatosis or ((facial or face) NEAR/3 intermetamorphosis) or (visual NEAR/3 anoneria)):ti,ab,kw
#69 (((figure or shape or orientation or form or colo?r or textur* or crowding or contour or object or face or faces) NEAR/3 recogn*)):ti,ab,kw
#70 (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic* or touch) NEAR/3 (stimul* or memory or acuity or sens* or percept* or processing or stimul* or distinguish* or discriminat* or anisotropy or locali?ation))):ti,ab,kw
#71 {or #26-#70}

Appendix 2. MEDLINE search strategy

1. cerebrovascular disorders/ or basal ganglia cerebrovascular disease/ or exp brain ischemia/ or exp carotid artery diseases/ or exp cerebral small vessel diseases/ or exp intracranial arterial diseases/ or exp "intracranial embolism and thrombosis"/ or exp intracranial hemorrhages/ or stroke/ or exp brain infarction/ or stroke, lacunar/ or vasospasm, intracranial/ or vertebral artery dissection/ or carotid stenosis/ or exp carotid artery injuries/ or intracranial arterial diseases/ or cerebral arterial diseases/ or infarction, anterior cerebral artery/ or infarction, middle cerebral artery/ or infarction, posterior cerebral artery/ or exp carotid arteries/ or endarterectomy, carotid/

2. (stroke$ or poststroke or apoplex$ or cerebral vasc$ or brain vasc$ or cerebrovasc$ or cva$ or SAH).ti,ab.

3. ((brain$ or cerebr$ or cerebell$ or vertebrobasil$ or hemispher$ or intracran$ or intracerebral or infratentorial or supratentorial or middle cerebral arter$ or MCA$ or anterior circulation or posterior circulation or basilar arter$ or vertebral arter$ or space-occupying) adj5 (isch? emi$ or infarct$ or thrombo$ or emboli$ or occlus$ or hypoxi$)).ti,ab.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracran$ or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli$ or putaminal or putamen or posterior fossa or hemispher$ or subarachnoid) adj5 (h?emorrhag$ or h? ematoma$ or bleed$)).ti,ab.
5. or/1-4
6. exp perceptual disorders/ or exp perception/
7. hearing disorders/ or hearing loss/ or deafness/ or hearing loss, central/ or hearing loss, sudden/ or hyperacusis/ or olfaction disorders/ or exp somatosensory disorders/ or exp taste disorders/ or vision disorders/ or alice in wonderland syndrome/ or amblyopia/ or blindness/ or blindness, cortical/ or color vision defects/ or diplopia/ or hemianopsia/ or photophobia/ or scotoma/ or vision, low/
8. (percept$ adj3 (impair$ or problem$ or abilit$ or deficit$ or distortion$ or defect$ or disabilit$ or disturbance$ or disorder$ or discriminat $ or deaf$)).ti,ab.

9. (agnosis or agnosia or prosopagnosia or prosophthalmia or Alice in Wonderland syndrome or Todd syndrome or all?esthesia$ or syn?esthesia$ or hypoesthesia or hyperesthesia).ti,ab.
10. sensation/ or hearing/ or smell/ or taste/ or touch/ or vision, ocular/ or color vision/ or exp mesopic vision/ or night vision/
11. (somatosensory$ or (sensor$ adj3 (input$ or stimul$ or deficit$ or distortion$ or defect$ or disabilit$ or disturbance$ or disorder$ or discriminat$ or processing or percept$ or hallucination$ or feedback or discriminat$ or dysfunction$ or recogn$ or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body adj3 (schema or orientation))).ti,ab.
12. exp Proprioception/
13. (propriocep$ or (kin?esthetic adj3 (percept$ or discriminat$))).ti,ab.
14. ((odo?r$ or smell$ or olfact$ or scent$ or aroma or flavo?r) adj3 (memory or acuity or function$ or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hedonics or deprivation or hallucinat$)).ti,ab.
15. (anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia).ti,ab.
16. (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia).ti,ab.
17. ((gustat$ or tast$) adj3 (acuity or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hallucination$ or abnormalit$ or distortion$ or disturbance$ or anomal$ or loss or an?esthesia or absence or phantom)).ti,ab.
18. (((speech or speak$ or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) adj3 (percept$ or processing or stimul$ or distinguish$ or discriminat$)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or King Kopetsky syndrome).ti,ab.
19. (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop$ or polyop$ or metamorphopsia or m?cropsia or ((vision or visual or visual?percept$ or visuo?spatial or visuo?construct$ or ocular or optokinetic or optic$ or oculomotor spatial) adj3 (illusion or blurry or overload or double or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hallucination$ or abnormalit$ or distortion$ or disturbance$ or anomal$ or disorientation or allachethesia or deficit$ or defect$ or disabilit$ or disorder$ or processing or dysfunction$ or recogn$ or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia).ti,ab.
20. (entomopia or palinopsia or asteropsis or strabismus or Anton syndrome or Balint syndrome or blindsight or achromatopsia or hyperchromatosis or ((facial or face) adj3 intermetamorphosis) or (visual adj3 anoneria)).ti,ab.
21. ((figure or shape or orientation or form or colo?r or textur$ or crowding or contour or object or face or faces) adj3 recogn$).ti,ab.
22. (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic$ or touch) adj3 (stimul$ or memory or acuity or sens$ or percept$ or processing or stimul$ or distinguish$ or discriminat$ or anisotropy or locali?ation))).ti,ab.
23. or/6-22
24. 5 and 23
25. randomized controlled trial.pt.
26. controlled clinical trial.pt.
27. randomized.ab.
28. placebo.ab.
29. clinical trials as topic.sh.
30. random$.ab.
31. trial.ti.
32. or/25-31
33. exp animals/ not humans.sh.
34. 32 not 33
35. 34 and 24

Appendix 3. EMBASE search strategy

1. cerebrovascular disease/ or brain disease/ or exp basal ganglion hemorrhage/ or exp brain hemangioma/ or exp brain hematoma/ or exp brain hemorrhage/ or exp brain infarction/ or exp brain ischemia/ or exp cerebral artery disease/ or exp cerebrovascular accident/ or exp cerebrovascular malformation/ or exp intracranial aneurysm/ or exp occlusive cerebrovascular disease/ or exp vertebrobasilar insufficiency/
2. exp carotid artery disease/ or exp carotid artery/ or exp carotid artery surgery/ or carotid endarterectomy/ or carotid artery thrombosis/ or carotid artery bruit/ or exp carotid artery obstruction/ or exp carotid atherosclerosis/
3. (stroke$ or poststroke or apoplex$ or cerebral vasc$ or brain vasc$ or cerebrovasc$ or cva$ or SAH).ti,ab.
4. ((brain$ or cerebr$ or cerebell$ or vertebrobasil$ or hemispher$ or intracran$ or intracerebral or infratentorial or supratentorial or middle cerebral arter$ or MCA$ or anterior circulation or posterior circulation or basilar arter$ or vertebral arter$ or space-occupying) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$ or hypoxi$)).ti,ab.
5. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracran$ or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli$ or putaminal or putamen or posterior fossa or hemispher$ or subarachnoid) adj5 (h?emorrhag$ or h?ematoma$ or bleed$)).ti,ab.
6. or/1-5

7. perception/ or depth perception/ or distance perception/ or interoception/ or loudness perception/ or movement perception/ or exp perceptive discrimination/ or exp perceptive threshold/ or exp pitch perception/ or spatial summation/ or perception deafness/ or exp perceptive discrimination/
8. perception disorder/ or exp agnosia/ or alice in wonderland syndrome/ or allesthesia/
9. (percept$ adj3 (impair$ or problem$ or abilit$ or deficit$ or distortion$ or defect$ or disabilit$ or disturbance$ or disorder$ or discriminat$ or deaf$)).ti,ab.
10. (agnosis or agnosia or prosopagnosia or prosophthalmia or Alice in Wonderland syndrome or Todd syndrome or all?esthesia$ or syn?esthesia$ or hypoesthesia or hyperesthesia).ti,ab.
11. somatosensory stimulation/ or somatosensory disorder/ or exp hyperesthesia/
12. (somatosensory$ or (sensor$ adj3 (input$ or stimul$ or deficit$ or distortion$ or defect$ or disabilit$ or disturbance$ or disorder$ or discriminat$ or processing or percept$ or hallucination$ or feedback or discriminat$ or dysfunction$ or recogn$ or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body adj3 (schema or orientation))).ti,ab.
13. proprioception/ or proprioceptive feedback/
14. (propriocep$ or (kin?esthetic adj3 (percept$ or discriminat$))).ti,ab.
15. "smelling and taste"/ or olfactory discrimination/ or olfactory memory/ or taste acuity/ or taste discrimination/ or "smell and taste parameters"/ or exp smelling disorder/
16. ((odo?r$ or smell$ or olfact$ or scent$ or aroma or flavo?r) adj3 (memory or acuity or function$ or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hedonics or deprivation or hallucinat$)).ti,ab.
17. (anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia).ti,ab.
18. exp taste disorder/ or taste/
19. (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia).ti,ab.
20. ((gustat$ or tast$) adj3 (acuity or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hallucination$ or abnormalit$ or distortion$ or disturbance$ or anomal$ or loss or an?esthesia or absence or phantom)).ti,ab.
21. speech perception/ or speech discrimination/
22. auditory system function/ or auditory stimulation/ or optokinetic stimulation/ or subliminal stimulation/ or vestibular stimulation/ or hearing/
23. (((speech or speak$ or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) adj3 (percept$ or processing or stimul$ or distinguish$ or discriminat$)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or King Kopetsky syndrome).ti,ab.
24. tactile discrimination/ or tactile memory/ or tactile stimulation/ or vibration sense/
25. visual disorder/ or amblyopia/ or aniseikonia/ or diplopia/ or macropsia/ or metamorphopsia/ or micropsia/ or oscillopsia/ or visual hallucination/ or visual illusion/ or visual stimulation/ or visual system function/
26. (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop$ or polyop$ or metamorphopsia or m?cropsia or ((vision or visual or visual?percept$ or visuo?spatial or visuo?construct$ or ocular or optokinetic or optic$ or oculomotor spatial) adj3 (illusion or blurry or overload or double or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hallucination$ or abnormalit$ or distortion$ or disturbance$ or anomal$ or disorientation or allachethesia or deficit$ or defect$ or disabilit$ or disorder$ or processing or dysfunction$ or recogn$ or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia).ti,ab.
27. (entomopia or palinopsia or asteropsis or strabismus or Anton syndrome or Balint syndrome or blindsight or achromatopsia or hyperchromatosis or ((facial or face) adj3 intermetamorphosis) or (visual adj3 anoneria)).ti,ab.
28. ((figure or shape or orientation or form or colo?r or textur$ or crowding or contour or object or face or faces) adj3 recogn$).ti,ab.
29. (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic$ or touch) adj3 (stimul$ or memory or acuity or sens$ or percept$ or processing or stimul$ or distinguish$ or discriminat$ or anisotropy or locali?ation))).ti,ab.
30. or/7-29
31. 6 and 30
32. Randomized Controlled Trial/ or "randomized controlled trial (topic)"/
33. Randomization/
34. Controlled clinical trial/ or "controlled clinical trial (topic)"/
35. control group/ or controlled study/
36. clinical trial/ or "clinical trial (topic)"/ or phase 1 clinical trial/ or phase 2 clinical trial/ or phase 3 clinical trial/ or phase 4 clinical trial/
37. crossover procedure/
38. single blind procedure/ or double blind procedure/ or triple blind procedure/
39. placebo/ or placebo effect/
40. (random$ or RCT or RCTs).tw.
41. (controlled adj5 (trial$ or stud$)).tw.
42. (clinical$ adj5 trial$).tw.
43. clinical trial registration.ab.
44. ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).tw.
45. (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).tw.

46. ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).tw.
47. ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).tw.
48. (cross-over or cross over or crossover).tw.
49. (placebo$ or sham).tw.
50. trial.ti.
51. (assign$ or allocat$).tw.
52. controls.tw.
53. or/32-52
54. (exp animal/ or animal.hw. or nonhuman/) not (exp human/ or human cell/ or (human or humans).ti.)
55. 53 not 54
56. 31 and 55

Appendix 4. ERIC search strategy

S1 TI (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)
S2 TI ((brain or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or middle cerebral artery or MCA* or anterior circulation or posterior circulation or basilar artery or vertebral artery or space-occupying) N5 (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus*)) OR AB ((brain or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or middle cerebral arter* or MCA* or anterior circulation or posterior circulation or basilar arter* or vertebral arter* or space-occupying) N5 (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus*))
S3 TI ((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal or putamen or posterior fossa or hemispher* or subarachnoid) N5 (haemorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*)) OR AB ((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal or putamen or posterior fossa or hemispher* or subarachnoid) N5 (h*emorrhage* or hemorrhage* or haematoma* or hematoma* or bleed*))
S4 S1 or S2 or S3
S5 DE "Perception" OR DE "Perception Tests" OR DE "Perceptual Impairments" OR DE "Perceptual Motor Coordination" OR DE "Perceptual Development" OR DE "Perceptual Motor Learning" OR DE "Cognitive Processes" OR DE "Auditory Perception" OR DE "Auditory Discrimination" OR DE "Auditory Stimuli" OR DE "Kinesthetic Perception" OR DE "Olfactory Perception" OR DE "Tactual Perception" OR DE "Visual Perception" OR DE "Depth Perception" OR DE "Visual Acuity" OR DE “Visual Stimuli” OR DE "Visual Discrimination" OR DE "Cognitive Mapping" OR DE "Sensory Experience" OR DE "Sensory Integration"
S6 TI (percept* N5 (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*)) OR AB (percept* N5 (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*))
S7 TI (agnosis or agnosia or prosopagnosia or prosophthalmia or somatoparaphrenia or (body N3 (schema or orientation)) or “Alice in Wonderland syndrome” or “Todd syndrome” or all?esthesia* or syn?esthesia* or hypoesthesia or hyperesthesia) OR AB (agnosis or agnosia or prosopagnosia or prosophthalmia or somatoparaphrenia or (body N3 (schema or orientation)) or “Alice in Wonderland syndrome” or “Todd syndrome” or all?esthesia* or syn?esthesia* or hypoesthesia or hyperesthesia)
S8 TI (somatosensory* or (sensor* N3 (input* or stimul* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or processing or percept* or hallucination* or pathway* or evoked potentials or feedback or discriminat* or dysfunction* or recogn* or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body adj3 (schema or orientation))) OR AB (somatosensory* or (sensor* N3 (input* or stimul* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or processing or percept* or hallucination* or pathway* or evoked potentials or feedback or discriminat* or dysfunction* or recogn* or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body adj3 (schema or orientation)))
S9 TI (propriocep* or (kin?esthetic N3 (percept* or discriminat*))) OR AB (propriocep* or (kin?esthetic N3 (percept* or discriminat* or deaf*)))
S10 TI ((odo?r* or smell* or olfact* or scent* or aroma or flavo?r) N3 (memory or acuity or function* or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hedonics or deprivation or hallucinat*)) OR AB ((odo?r* or smell* or olfact* or scent* or aroma or flavo?r) N3 (memory or acuity or function* or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hedonics or deprivation or hallucinat*))
S11 TI (anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia) OR AB (anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia)
S12 TI (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia) OR AB (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia)
S13 TI ((gustat* or tast*) N3 (acuity or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or loss or an?esthesia or absence or phantom)) OR AB ((gustat* or tast*) N3 (acuity or

percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or loss or an?esthesia or absence or phantom))
S14 TI (((speech or speak* or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) N3 (percept* or processing or stimul* or distinguish* or discriminat*)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or "King Kopetsky syndrome") OR AB (((speech or speak* or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) N3 (percept* or processing or stimul* or distinguish* or discriminat*)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or "King Kopetsky syndrome")
S15 TI (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop* or polyop* or metamorphopsia or m?cropsia or ((vision or visual or visual?percept* or visuo?spatial or visuo?construct* or ocular or optokinetic or optic* or oculomotor spatial) N3 (illusion or blurry or overload or double or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or disorientation or allachethesia or deficit* or defect* or disabilit* or disorder* or processing or dysfunction* or recogn* or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia) OR AB (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop* or polyop* or metamorphopsia or m?cropsia or ((vision or visual or visual?percept* or visuo?spatial or visuo?construct* or ocular or optokinetic or optic* or oculomotor spatial) N3 (illusion or blurry or overload or double or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or disorientation or allachethesia or deficit* or defect* or disabilit* or disorder* or processing or dysfunction* or recogn* or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia)
S16 TI (entomopia or palinopsia or asteropsis or strabismus or "Anton syndrome" or "Balint syndrome" or blindsight or achromatopsia or hyperchromatosis or ((facial or face) N3 intermetamorphosis) or (visual N3 anoneria)) OR AB (entomopia or palinopsia or asteropsis or strabismus or "Anton syndrome" or "Balint syndrome" or blindsight or achromatopsia or hyperchromatosis or ((facial or face) N3 intermetamorphosis) or (visual N3 anoneria))
S17 TI ((figure or shape or orientation or form or colo?r or textur* or crowding or contour or object or face or faces) N3 recogn*) OR AB ((figure or shape or orientation or form or colo?r or textur* or crowding or contour or object or face or faces) N3 recogn*)
S18 TI (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic* or touch) N3 (stimul* or memory or acuity or sens* or percept* or processing or stimul* or distinguish* or discriminat* or anisotropy or locali?ation))) OR AB (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic* or touch) N3 (stimul* or memory or acuity or sens* or percept* or processing or stimul* or distinguish* or discriminat* or anisotropy or locali?ation)))
S19 S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 or S14 or S15 or S16 or S17 or S18
S20 S4 and S19
S21 TI (RCT* or random*) OR AB (RCT* or random*) OR SU Randomized Controlled Trials
S22 TI (controlled N5 (trial* or stud*)) OR TI (controlled N5 (trial* or stud*))
S23 TI clinical N5 trial* OR AB clinical N5 trial*
S24 S21 OR S22 OR S23
S25 S20 AND S24

Appendix 5. CINAHL (EBSCO)

S1(MH "Cerebrovascular Disorders") OR (MH "Basal Ganglia Cerebrovascular Disease+") OR (MH "Carotid Artery Diseases") OR (MH "Carotid Artery Dissections") OR (MH "Carotid Artery Thrombosis") OR (MH "Carotid Stenosis") OR (MH "Cerebral Ischemia") OR (MH "Cerebral Ischemia, Transient") OR (MH "Cerebral Small Vessel Diseases") OR (MH "Cerebral Vasospasm") OR (MH "Cerebral Arterial Diseases +") OR (MH "Cerebral Aneurysm") OR (MH "Intracranial Arterial Diseases") OR (MH "Cerebral Arterial Diseases") OR (MH "Intracranial Arteriosclerosis") OR (MH "Intracranial Embolism and Thrombosis") OR (MH "Intracranial Thrombosis+") OR (MH "Intracranial Hemorrhage +") OR (MH "Stroke+") OR (MH "Vertebral Artery Dissections")
S2 TI (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)
S3 TI ((brain or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or middle cerebral arter* or MCA* or anterior circulation or posterior circulation or basilar arter* or vertebral arter* or space-occupying) N5 (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus*)) OR AB ((brain or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or middle cerebral arter* or MCA* or anterior circulation or posterior circulation or basilar arter* or vertebral arter* or space-occupying) N5 (ischemi* or ischaemi* or infarct* or thrombo* or emboli* or occlus*))
S4TI ((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal or putamen or posterior fossa or hemispher* or subarachnoid) N5 (h?emorrhage* or h?ematoma* or bleed*)) OR AB ((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli* or putaminal or putamen or posterior fossa or hemispher* or subarachnoid) N5 (h?emorrhage* or h?ematoma* or bleed*))
S5 S1 or S2 or S3 or S4
S6 (MH "Perceptual Disorders+")
S7 (MH "Visual Perception+") OR (MH "Touch") OR (MH "Sensory Deprivation") OR (MH "Perceptual Masking") OR (MH "Perceptual Distortion") OR (MH "Intuition") OR (MH "Illusions+") OR (MH "Auditory Perception+")

S8 TI (percept* N5 (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*)) OR AB (percept* N5 (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*))
S9 TI (agnosis or agnosia or prosopagnosia or prosophthalmia or somatoparaphrenia or (body N3 (schema or orientation)) or “Alice in Wonderland syndrome” or “Todd syndrome” or all?esthesia* or syn?esthesia* or hypoesthesia or hyperesthesia)OR AB (agnosis or agnosia or prosopagnosia or prosophthalmia or somatoparaphrenia or (body N3 (schema or orientation)) or “Alice in Wonderland syndrome” or “Todd syndrome” or all?esthesia* or syn?esthesia* or hypoesthesia or hyperesthesia)
S10 (MH "Hearing Disorders") OR (MH "Deafness") OR (MH "Hyperacusis") OR (MH "Olfaction Disorders+") OR (MH "Somatosensory Disorders+") OR (MH "Taste Disorders+") OR (MH "Vision Disorders+")
S11 TI (somatosensory* or (sensor* N3 (input* or stimul* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or processing or percept* or hallucination* or pathway* or evoked potentials or feedback or discriminat* or dysfunction* or recogn* or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body adj3 (schema or orientation))) OR AB (somatosensory* or (sensor* N3 (input* or stimul* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or processing or percept* or hallucination* or pathway* or evoked potentials or feedback or discriminat* or dysfunction* or recogn* or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body N3 (schema or orientation)))
S12 (MH "Sensation") OR (MH "Hearing") OR (MH "Pain") OR (MH "Smell") OR (MH "Taste") OR (MH "Touch") OR (MH "Vision") OR (MH "Proprioception+")
S13 TI (propriocep* or (kin?esthetic N3 (percept* or discriminat*))) OR AB (propriocep* or (kin?esthetic N3 (percept* or discriminat*)))
S14 TI ((odo?r* or smell* or olfact* or scent* or aroma or flavo?r) N3 (memory or acuity or function* or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hedonics or deprivation or hallucinat*)) OR AB ((odo?r* or smell* or olfact* or scent* or aroma or flavo?r) N3 (memory or acuity or function* or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hedonics or deprivation or hallucinat*))
S15 TI (anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia) OR AB (anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia)
S16 TI (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia) OR AB (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia)
S17 TI ((gustat* or tast*) N3 (acuity or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or loss or an?esthesia or absence or phantom)) OR AB ((gustat* or tast*) N3 (acuity or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or loss or an?esthesia or absence or phantom))
S18 TI (((speech or speak* or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) N3 (percept* or processing or stimul* or distinguish* or discriminat*)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or “King Kopetsky syndrome”) OR AB (((speech or speak* or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) N3 (percept* or processing or stimul* or distinguish* or discriminat*)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or “King Kopetsky syndrome”)
S19 TI (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop* or polyop* or metamorphopsia or m?cropsia or ((vision or visual or visual?percept* or visuo?spatial or visuo?construct* or ocular or optokinetic or optic* or oculomotor spatial) N3 (illusion or blurry or overload or double or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or disorientation or allachethesia or deficit* or defect* or disabilit* or disorder* or processing or dysfunction* or recogn* or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia) OR AB (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop* or polyop* or metamorphopsia or m?cropsia or ((vision or visual or visual?percept* or visuo?spatial or visuo?construct* or ocular or optokinetic or optic* or oculomotor spatial) N3 (illusion or blurry or overload or double or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or disorientation or allachethesia or deficit* or defect* or disabilit* or disorder* or processing or dysfunction* or recogn* or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia)
S20 TI (entomopia or palinopsia or asteropsis or strabismus or “Anton syndrome” or “Balint syndrome” or blindsight or achromatopsia or hyperchromatosis or ((facial or face) N3 intermetamorphosis) or (visual N3 anoneria)) OR AB (entomopia or palinopsia or asteropsis or strabismus or "Anton syndrome" or "Balint syndrome" or blindsight or achromatopsia or hyperchromatosis or ((facial or face) N3 intermetamorphosis) or (visual N3 anoneria))
S21 TI ((figure or shape or orientation or form or colo?r or textur* or crowding or contour or object or face or faces) N3 recogn*) OR AB ((figure or shape or orientation or form or colo?r or textur* or crowding or contour or object or face or faces) N3 recogn*)
S22 TI (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic* or touch) N3 (stimul* or memory or acuity or sens* or percept* or processing or stimul* or distinguish* or discriminat* or anisotropy or locali?ation))) OR AB (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic* or touch) N3 (stimul* or memory or acuity or sens* or percept* or processing or stimul* or distinguish* or discriminat* or anisotropy or locali?ation)))

S23 S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 or S14 or S15 or S16 or S17 or S18 or S19 or S20 or S21 or S22
S24 S5 and S23
S25 (MH “Randomized Controlled Trials”) OR (MH “Double-blind Studies”) OR (MH “Single-blind Studies”) OR (MH “Random Assignment”) OR (MH “Pretest-Posttest Design”) OR MH “Cluster Sample”)
S26 TI randomised OR randomized
S27 AB random*
S28 TI trial
S29(MH "sample size") AND AB (assigned OR allocated OR control)
S30 (MH "Placebos")
S31 PT randomized controlled trial
S32 AB control W5 group
S33 (MH "Crossover Design") OR (MH "Comparative Studies")
S34 AB cluster W3 RCT
S35 (MH "Animals+")
S36 (MH "Animal Studies")
S37 TI animal model*
S38S35 OR S36 OR S37
S39 (MH "Human")
S40 S39 NOT S38
S41 S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34
S42 S41 NOT S40
S43 S24 AND S42

Appendix 6. AMED search strategy

1. cerebrovascular disorders/ or cerebral hemorrhage/ or cerebral infarction/ or cerebral ischemia/ or cerebrovascular accident/ or stroke/
2. (stroke$ or poststroke or apoplex$ or cerebral vasc$ or brain vasc$ or cerebrovasc$ or cva$ or SAH).ti,ab.
3. ((brain$ or cerebr$ or cerebell$ or vertebrobasil$ or hemispher$ or intracran$ or intracerebral or infratentorial or supratentorial or middle cerebral arter$ or MCA$ or anterior circulation or posterior circulation or basilar arter$ or vertebral arter$ or space-occupying) adj5 (isch? emi$ or infarct$ or thrombo$ or emboli$ or occlus$ or hypoxi$)).ti,ab.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracran$ or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli$ or putaminal or putamen or posterior fossa or hemispher$ or subarachnoid) adj5 (h?emorrhag$ or h? ematoma$ or bleed$)).ti,ab.
5. or/1-4
6. perception/ or exp auditory perception/ or body image/ or discrimination/ or sensory deprivation/ or sensory thresholds/ or exp visual perception/ or sensory integration/
7. perceptual disorders/
8. (percept$ adj3 (impair$ or problem$ or abilit$ or deficit$ or distortion$ or defect$ or disabilit$ or disturbance$ or disorder$ or discriminat $ or deaf$)).ti,ab.
9. (agnosis or agnosia or prosopagnosia or prosophthalmia or Alice in Wonderland syndrome or Todd syndrome or all?esthesia$ or syn? esthesia$ or hypoesthesia or hyperesthesia).ti,ab.
10. sensation/ or hearing/ or smell/ or exp taste/ or touch/ or vision/
11. (somatosensory$ or (sensor$ adj3 (input$ or stimul$ or deficit$ or distortion$ or defect$ or disabilit$ or disturbance$ or disorder$ or discriminat$ or processing or percept$ or hallucination$ or feedback or discriminat$ or dysfunction$ or recogn$ or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body adj3 (schema or orientation))).ti,ab.
12. exp proprioception/
13. (propriocep$ or (kin?esthetic adj3 (percept$ or discriminat$))).ti,ab.
14. ((odo?r$ or smell$ or olfact$ or scent$ or aroma or flavo?r) adj3 (memory or acuity or function$ or percept$ or perceive$ or discriminat $ or distinguish$ or recept$ or sensitiv$ or hedonics or deprivation or hallucinat$)).ti,ab.
15. (anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia).ti,ab.
16. (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia).ti,ab.
17. ((gustat$ or tast$) adj3 (acuity or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hallucination$ or abnormalit$ or distortion$ or disturbance$ or anomal$ or loss or an?esthesia or absence or phantom)).ti,ab.
18. (((speech or speak$ or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) adj3 (percept$ or processing or stimul$ or distinguish$ or discriminat$)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or King Kopetsky syndrome).ti,ab.
19. (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop$ or polyop$ or metamorphopsia or m?cropsia or ((vision or visual or visual?percept$ or visuo?spatial or visuo?construct$ or ocular or optokinetic or optic$ or oculomotor spatial) adj3 (illusion or blurry or overload or double or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hallucination$ or abnormalit$ or

distortion$ or disturbance$ or anomal$ or disorientation or allachethesia or deficit$ or defect$ or disabilit$ or disorder$ or processing or dysfunction$ or recogn$ or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia).ti,ab.
20. (entomopia or palinopsia or asteropsis or strabismus or Anton syndrome or Balint syndrome or blindsight or achromatopsia or hyperchromatosis or ((facial or face) adj3 intermetamorphosis) or (visual adj3 anoneria)).ti,ab.
21. ((figure or shape or orientation or form or colo?r or textur$ or crowding or contour or object or face or faces) adj3 recogn$).ti,ab.
22. (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic$ or touch) adj3 (stimul$ or memory or acuity or sens$ or percept$ or processing or stimul$ or distinguish$ or discriminat$ or anisotropy or locali?ation))).ti,ab.
23. or/6-22
24. 5 and 23

Appendix 7. PsycINFO search strategy

1. cerebrovascular disorders/ or cerebral arteriosclerosis/ or cerebral hemorrhage/ or exp cerebral ischemia/ or cerebral small vessel disease/ or cerebrovascular accidents/ or subarachnoid hemorrhage/
2. (stroke$ or poststroke or apoplex$ or cerebral vasc$ or brain vasc$ or cerebrovasc$ or cva$ or SAH).ti,ab.
3. ((brain$ or cerebr$ or cerebell$ or vertebrobasil$ or hemispher$ or intracran$ or intracerebral or infratentorial or supratentorial or middle cerebral arter$ or MCA$ or anterior circulation or posterior circulation or basilar arter$ or vertebral arter$ or space-occupying) adj5 (isch? emi$ or infarct$ or thrombo$ or emboli$ or occlus$ or hypoxi$)).ti,ab.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracran$ or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli$ or putaminal or putamen or posterior fossa or hemispher$ or subarachnoid) adj5 (h?emorrhag$ or h? ematoma$ or bleed$)).ti,ab.
5. or/1-4
6. exp perceptual disturbances/
7. perception/ or apperception/ or exp auditory perception/ or exp extrasensory perception/ or "form and shape perception"/ or exp "illusions (perception)"/ or exp intersensory processes/ or numerosity perception/ or exp olfactory perception/ or perceptual closure/ or exp perceptual constancy/ or exp perceptual discrimination/ or exp perceptual distortion/ or exp perceptual learning/ or exp perceptual localization/ or exp perceptual motor processes/ or perceptual organization/ or exp perceptual orientation/ or perceptual style/ or "signal detection (perception)"/ or exp somesthetic perception/ or exp spatial perception/ or subliminal perception/ or taste perception/ or exp visual perception/
8. (percept$ adj3 (impair$ or problem$ or abilit$ or deficit$ or distortion$ or defect$ or disabilit$ or disturbance$ or disorder$ or discriminat $ or deaf$)).ti,ab.
9. (agnosis or agnosia or prosopagnosia or prosophthalmia or Alice in Wonderland syndrome or Todd syndrome or all?esthesia$ or syn? esthesia$ or hypoesthesia or hyperesthesia).ti,ab.
10. sensory system disorders/ or somatosensory disorders/
11. (somatosensory$ or (sensor$ adj3 (input$ or stimul$ or deficit$ or distortion$ or defect$ or disabilit$ or disturbance$ or disorder$ or discriminat$ or processing or percept$ or hallucination$ or feedback or discriminat$ or dysfunction$ or recogn$ or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body adj3 (schema or orientation))).ti,ab.
12. (propriocep$ or (kin?esthetic adj3 (percept$ or discriminat$))).ti,ab.
13. ((odo?r$ or smell$ or olfact$ or scent$ or aroma or flavo?r) adj3 (memory or acuity or function$ or percept$ or perceive$ or discriminat $ or distinguish$ or recept$ or sensitiv$ or hedonics or deprivation or hallucinat$)).ti,ab.
14. (anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia).ti,ab.
15. (ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia).ti,ab.
16. ((gustat$ or tast$) adj3 (acuity or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hallucination$ or abnormalit$ or distortion$ or disturbance$ or anomal$ or loss or an?esthesia or absence or phantom)).ti,ab.
17. (((speech or speak$ or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) adj3 (percept$ or processing or stimul$ or distinguish$ or discriminat$)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or King Kopetsky syndrome).ti,ab.
18. (amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop$ or polyop$ or metamorphopsia or m?cropsia or ((vision or visual or visual?percept$ or visuo?spatial or visuo?construct$ or ocular or optokinetic or optic$ or oculomotor spatial) adj3 (illusion or blurry or overload or double or percept$ or perceive$ or discriminat$ or distinguish$ or recept$ or sensitiv$ or hallucination$ or abnormalit$ or distortion$ or disturbance$ or anomal$ or disorientation or allachethesia or deficit$ or defect$ or disabilit$ or disorder$ or processing or dysfunction$ or recogn$ or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia).ti,ab.
19. (entomopia or palinopsia or asteropsis or strabismus or Anton syndrome or Balint syndrome or blindsight or achromatopsia or hyperchromatosis or ((facial or face) adj3 intermetamorphosis) or (visual adj3 anoneria)).ti,ab.
20. ((figure or shape or orientation or form or colo?r or textur$ or crowding or contour or object or face or faces) adj3 recogn$).ti,ab.
21. (astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic$ or touch) adj3 (stimul$ or memory or acuity or sens$ or percept$ or processing or stimul$ or distinguish$ or discriminat$ or anisotropy or locali?ation))).ti,ab.

22. or/6-21
23. 5 and 22
24. clinical trials/ or treatment effectiveness evaluation/ or placebo/
25. (random$ or RCT or RCTs).tw.
26. (controlled adj5 (trial$ or stud$)).tw.
27. (clinical$ adj5 trial$).tw.
28. ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).tw.
29. (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).tw.
30. ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).tw.
31. ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).tw.
32. (cross-over or cross over or crossover).tw.
33. (placebo$ or sham).tw.
34. trial.ti.
35. (assign$ or allocat$).tw.
36. controls.tw.
37. or/24-36
38. 23 and 37

Appendix 8. Epistemonikos search strategy

(title:((title:(stroke* OR poststroke OR apoplex* OR "cerebral vasc*" OR "brain vasc*" OR cerebrovasc* OR cva* OR SAH) OR abstract:(stroke* OR poststroke OR apoplex* OR "cerebral vasc*" OR "brain vasc*" OR cerebrovasc* OR cva* OR SAH)) AND (title:(perception OR agnosis OR agnosia OR anosognosia OR allesthesia OR hypoesthesia OR hyperesthesia OR somatosensory OR sensory OR sensation OR hearing OR aural OR smell OR olfactory OR taste OR gustatory OR touch OR tactile OR vision OR visual OR optic OR ocular OR proprioception) OR abstract:(perception OR agnosis OR agnosia OR anosognosia OR allesthesia OR hypoesthesia OR hyperesthesia OR somatosensory OR sensory OR sensation OR hearing OR aural OR smell OR olfactory OR taste OR gustatory OR touch OR tactile OR vision OR visual OR optic OR ocular OR proprioception))) OR abstract:((title:(stroke* OR poststroke OR apoplex* OR "cerebral vasc*" OR "brain vasc*" OR cerebrovasc* OR cva* OR SAH) OR abstract:(stroke* OR poststroke OR apoplex* OR "cerebral vasc*" OR "brain vasc*" OR cerebrovasc* OR cva* OR SAH)) AND (title:(perception OR agnosis OR agnosia OR anosognosia OR allesthesia OR hypoesthesia OR hyperesthesia OR somatosensory OR sensory OR sensation OR hearing OR aural OR smell OR olfactory OR taste OR gustatory OR touch OR tactile OR vision OR visual OR optic OR ocular OR proprioception) OR abstract:(perception OR agnosis OR agnosia OR anosognosia OR allesthesia OR hypoesthesia OR hyperesthesia OR somatosensory OR sensory OR sensation OR hearing OR aural OR smell OR olfactory OR taste OR gustatory OR touch OR tactile OR vision OR visual OR optic OR ocular OR proprioception))))

Appendix 9. Web of Science - Core Collection Search strategy

Web of Science – Core Collection (Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=All years) (Indexes= Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI),Arts & Humanities Citation Index (A&HCI), Conference Proceedings Citation Index- Science (CPCI-S), Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH), Book Citation Index– Science (BKCI-S), Book Citation Index– Social Sciences & Humanities (BKCI-SSH), Emerging Sources Citation Index (ESCI) (Timespan=All years)
#1 TS=(stroke* or poststroke or apoplex* or “cerebral vasc*” or “brain vasc*” or cerebrovasc* or cva* or SAH)
#2 TS=((brain* or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or “middle cerebral arter*” or MCA* or “anterior circulation” or “posterior circulation” or “basilar arter*” or “vertebral arter*” or “space-occupying”) NEAR/5 (isch?emi* or infarct* or thrombo* or emboli* or occlus* or hypoxi*))
#3 TS= ((brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or “basal gangli*” or putaminal or putamen or “posterior fossa” or hemispher* or subarachnoid) NEAR/5 (h?emorrhag* or h?ematoma* or bleed*))
#4 #1 or #2 or #3
#5 TS=(percept* NEAR/3 (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*))
#6 TS=(agnosis or agnosia or prosopagnosia or prosophthalmia or “Alice in Wonderland syndrome” or “Todd syndrome” or all?esthesia* or syn?esthesia$ or hypoesthesia or hyperesthesia)
#7 TS=(somatosensory* or (sensor* NEAR/3 (input* or stimul* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or processing or percept* or hallucination* or pathway* or “evoked potentials” or feedback or discriminat* or dysfunction* or recogn* or interpretation)) or somatosognosia or asomatognosia or somatoparaphrenia or (body NEAR/3 (schema or orientation)))
#8 TS=(propriocep* or (kin?esthetic NEAR/3 (percept* or discriminat*)))
#9 TS=((odo?r* or smell* or olfact* or scent* or aroma or flavo?r) NEAR/3 (memory or acuity or function* or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hedonics or deprivation or hallucinat*))
#10 TS=(anosmia or anodmia or anosmy or Kallmann syndrome or dysosmia or hyposmia or hyposphresia or phantosmia or par?osmia or ageusia or hypogeusia or dysgeusia or troposmia or euosmia or cacosmia or malodour or superosmia)

#11 TS=(ageusia or dysgeusia or parageusia or phantogeusia or hypogeusia or amblygeustia or hypogeusesthesia or hyp?esthesia or superosmia or phantosmia or parosmia or troposmia or euosmia or cacosmia or dysosmia or hypergeusia or phantogeusia or hyperosmia or hyposmia)
#12 TS=((gustat* or tast*) NEAR/3 (acuity or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or loss or an?esthesia or absence or phantom))
#13 TS=(((speech or speak* or voice or spoken or acoustic or audio or auditory or sound or pitch or prosody or binaural or phoneme) NEAR/3 (percept* or processing or stimul* or distinguish* or discriminat*)) or hyperacusis or misophonia or phonophobia or sonophobia or amusia or “King Kopetsky syndrome”)
#14 TS=(amblyop? or aniseikonia or oscillopsia or xanthopsia or d?plop* or polyop* or metamorphopsia or m?cropsia or ((vision or visual or visual?percept* or visuo?spatial or visuo?construct* or ocular or optokinetic or optic* or “oculomotor spatial”) NEAR/3 (illusion or blurry or overload or double or percept* or perceive* or discriminat* or distinguish* or recept* or sensitiv* or hallucination* or abnormalit* or distortion* or disturbance* or anomal* or disorientation or allachethesia or deficit* or defect* or disabilit* or disorder* or processing or dysfunction* or recogn* or interpretation or analysis or comprehension)) or stereoillusion or kakopsia or kalopsia or pelopsia or archromatopsia or akinetopsia or telopsia or stereopsis or palinopsia or teleopsia or simultanagnosia)
#15 TS=(entomopia or palinopsia or asteropsis or strabismus or “Anton syndrome” or “Balint syndrome” or blindsight or achromatopsia or hyperchromatosis or ((facial or face) NEAR/3 intermetamorphosis) or (visual NEAR/3 anoneria))
#16 TS=((figure or shape or orientation or form or colo?r or textur* or crowding or contour or object or face or faces) NEAR/3 recogn*)
#17 TS=(astereognosia or stereognosis or astereognosis or paraesthesia or hypersensitivity or ((tactile or haptic* or touch) NEAR/3 (stimul* or memory or acuity or sens* or percept* or processing or stimul* or distinguish* or discriminat* or anisotropy or locali?ation)))
#18 #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17
#19 #4 and #18
#20 TS=random*
#21 TS=RCT*
#22 TS=(controlled NEAR/5 (trial* or stud*))
#23 TS=(clinical NEAR/5 trial*)
#24 TS=((control or treatment or experiment* or intervention) NEAR/5 (group* or subject* or patient*))
#25 TI=trial*
#26 #25 OR #24 OR #23 OR #22 OR #21 OR #20
#27 #26 AND #19

Appendix 10. DARE, NHS EE and HTA search strategies

#1 MeSH DESCRIPTOR Cerebrovascular Disorders EXPLODE ALL TREES IN DARE,NHSEED,HTA
#2 (stroke* or poststroke or apoplex* or cerebral vasc* or brain vasc* or cerebrovasc* or cva* or SAH):TI IN DARE, NHSEED, HTA
#3 #1 OR #2
#4 MeSH DESCRIPTOR Perceptual Disorders EXPLODE ALL TREES IN DARE,NHSEED,HTA
#5 MeSH DESCRIPTOR Perception EXPLODE ALL TREES IN DARE,NHSEED,HTA
#6 (percept* AND (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*)):TI IN DARE, NHSEED, HTA
#7 (agnosis or agnosia or anosognosia or prosopagnosia or prosophthalmia or Alice in Wonderland syndrome or Todd syndrome or all?esthesia* or syn?esthesia* or hypoesthesia or hyperesthesia):TI IN DARE, NHSEED, HTA
#8 MeSH DESCRIPTOR Sensation EXPLODE ALL TREES IN DARE,NHSEED,HTA
#9 (somatosensory* or (sensor* AND (input* or stimul* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or processing or percept* or hallucination* or pathway* or evoked potentials or feedback or discriminat* or dysfunction* or recogn* or interpretation))):TI IN DARE, NHSEED, HTA
#10 #4 OR #5 OR #6 OR #7 OR #8 OR #9
#11 #3 AND #10

Appendix 11. PROQUEST Dissertation and thesis

S1 ti(stroke* or poststroke or apoplex* or cerebral vasc* or brain vasc* or cerebrovasc* or cva* or SAH) OR ab(stroke* or poststroke or apoplex* or "cerebral vasc*" or "brain vasc*" or cerebrovasc* or cva* or SAH)
S2 ti(percept* NEAR/3 (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*)) OR ab(percept* NEAR/3 (impair* or problem* or abilit* or deficit* or distortion* or defect* or disabilit* or disturbance* or disorder* or discriminat* or deaf*))
S3 ti(agnosis or agnosia or anosognosia or prosopagnosia or prosophthalmia or “Alice in Wonderland syndrome” or “Todd syndrome” or all?esthesia* or syn?esthesia* or hypoesthesia or hyperesthesia) OR ab(agnosis or agnosia or anosognosia or prosopagnosia or prosophthalmia or “Alice in Wonderland syndrome” or “Todd syndrome” or all?esthesia* or syn?esthesia* or hypoesthesia or hyperesthesia)

S4 ti(somatosensory* OR (sensor* NEAR/3 (input* OR stimul* OR deficit* OR distortion* OR defect* OR disabilit* OR disturbance* OR disorder* OR discriminat* OR processing OR percept* OR hallucination* OR pathway* OR "evoked potentials" OR feedback OR discriminat* OR dysfunction* OR recogn* OR interpretation))) OR ab(somatosensory* OR (sensor* NEAR/3 (input* OR stimul* OR deficit* OR distortion* OR defect* OR disabilit* OR disturbance* OR disorder* OR discriminat* OR processing OR percept* OR hallucination* OR pathway* OR "evoked potentials" OR feedback OR discriminat* OR dysfunction* OR recogn* OR interpretation)))
S5 S2 OR S3 OR S4
S6 S1 AND S5
S7 ti(random* OR RCT*) OR ab(random* OR RCT*)
S8 ti(controlled NEAR/5 (trial* or stud*)) OR ab(controlled NEAR/5 (trial* or stud*))
S9 ti(clinical NEAR/5 trial*) OR ab(clinical NEAR/5 trial*)
S10 ti((control or treatment or experiment* or intervention) NEAR/5 (group* or subject* or patient*)) OR ab((control or treatment or experiment* or intervention) NEAR/5 (group* or subject* or patient*))
S11 S7 OR S8 OR S9 OR S10
S12 S6 AND S11

Appendix 12. Clinical trials register searches

US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (www.clinicaltrials.gov)
(perception OR agnosis OR agnosia OR anosognosia OR allesthesia OR hypoesthesia OR hyperesthesia OR somatosensory OR sensory OR sensation OR hearing OR aural OR smell OR olfactory OR taste OR gustatory OR touch OR tactile OR vision OR visual OR optic OR ocular OR proprioception) AND AREA[StudyType] EXPAND[Term] COVER[FullMatch] "Interventional" AND AREA[ConditionSearch] (Vertebral Artery OR Brain Infarction OR Intracranial Hemorrhages OR Carotid Artery Diseases OR Brain Ischemia OR Cerebral Hemorrhage OR Cerebrovascular Disorders OR Stroke) AND AREA[StdAge] EXPAND[Term] COVER[FullMatch] ("Adult" OR "Older Adult")

World Health Organization International Clinical Trials Registry Platform (apps.who.int/trialsearch)
1. Phases are: ALL;
Basic search: perception AND CEREBROVASCULAR OR agnosis AND CEREBROVASCULAR OR agnosia AND CEREBROVASCULAR OR anosognosia AND CEREBROVASCULAR OR allesthesia AND CEREBROVASCULAR OR hypoesthesia AND CEREBROVASCULAR OR hyperesthesia AND CEREBROVASCULAR OR somatosensory AND CEREBROVASCULAR OR sensory AND CEREBROVASCULAR OR sensation AND CEREBROVASCULAR OR hearing AND CEREBROVASCULAR OR aural AND CEREBROVASCULAR OR smell AND CEREBROVASCULAR OR olfactory AND CEREBROVASCULAR OR taste AND CEREBROVASCULAR OR gustatory AND CEREBROVASCULAR OR touch AND CEREBROVASCULAR OR tactile AND CEREBROVASCULAR OR vision AND CEREBROVASCULAR OR visual AND CEREBROVASCULAR OR optic AND CEREBROVASCULAR OR ocular AND CEREBROVASCULAR OR proprioception AND CEREBROVASCULAR
2. Phases are: ALL;
Basic search: perception AND STROKE OR agnosis AND STROKE OR agnosia AND STROKE OR anosognosia AND STROKE OR allesthesia AND STROKE OR hypoesthesia AND STROKE OR hyperesthesia AND STROKE OR somatosensory AND STROKE OR sensory AND STROKE OR sensation AND STROKE OR hearing AND STROKE OR aural AND STROKE OR smell AND STROKE OR olfactory AND STROKE OR taste AND STROKE OR gustatory AND STROKE OR touch AND STROKE OR tactile AND STROKE OR vision AND STROKE OR visual AND STROKE OR optic AND STROKE OR ocular AND STROKE OR proprioception AND STROKE
2. Phases are: ALL;
Basic search: perception AND CEREBRAL OR agnosis AND CEREBRAL OR agnosia AND CEREBRAL OR anosognosia AND CEREBRAL OR allesthesia AND CEREBRAL OR hypoesthesia AND CEREBRAL OR hyperesthesia AND CEREBRAL OR somatosensory AND CEREBRAL OR sensory AND CEREBRAL OR sensation AND CEREBRAL OR hearing AND CEREBRAL OR aural AND CEREBRAL OR smell AND CEREBRAL OR olfactory AND CEREBRAL OR taste AND CEREBRAL OR gustatory AND CEREBRAL OR touch AND CEREBRAL OR tactile AND CEREBRAL OR vision AND CEREBRAL OR visual AND CEREBRAL OR optic AND CEREBRAL OR ocular AND CEREBRAL OR proprioception AND CEREBRAL

Appendix 13. Previous searches

For the previous version of this review (Issue 4, 2011), the review authors conducted the following searches.

- Trials registers of the Cochrane Stroke Group and the Cochrane Infectious Diseases Group (last searched May 2009),
- the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2009, Issue 3),
- MEDLINE (1950 to August 2009)
- EMBASE (1980 to August 2009)
- CINAHL (1982 to August 2009)
- PsycINFO (1974 to August 2009)
- REHABDATA (http://www.naric.com/research)
- PsycBITE (Psychological Database for Brain Impairment Treatment Efficacy: http://www.psycbite.com/) (May to June 2009).

The previous search strategy for **MEDLINE (Ovid)** is given below and we adapted this for the other databases.

1. cerebrovascular disorders/ or exp basal ganglia cerebrovascular disease/ or exp brain ischemia/ or exp carotid artery diseases/ or cerebrovascular accident/ or exp brain infarction/ or exp cerebrovascular trauma/ or exp hypoxia-ischemia, brain/ or exp intracranial arterial diseases/ or exp "intracranial embolism and thrombosis"/ or exp intracranial haemorrhages/ or exp vertebral artery dissection/
2. (stroke$ or post stroke$ or post-stroke$ or cerebral vascular or cerebrovascular or cva$).tw.
3. (cerebral or brain$ or vertebrobasilar) adj5 (infarct$ or isch?emi$ or thrombo$ or apoplexy or emboli$).tw.
4. (cerebral or brain or subarachnoid) adj5 (haemorrhage or haemorrhage or haematoma or hematoma or bleed).tw.
5. (trauma$ or acquired) adj5 brain injur$).tw.
6. exp brain damage, chronic/ or brain injuries/ or exp brain concussion/ or exp brain haemorrhage, traumatic/ or brain injury, chronic/ or diffuse axonal injury/
7. craniocerebral trauma/ or exp head injuries, closed/ or exp intracranial haemorrhage, traumatic/
8. exp brain abscess/ or exp central nervous system infections/ or exp encephalitis/ or exp meningitis, viral/
9. (encephalitis or meningitis).tw.
10. exp brain neoplasms/
11. (brain or cerebr$) adj5 (neoplasm$ or lesion$ or tumor$ or tumour$)).tw.
12. or/1-11
13. exp perceptual disorders/ or exp perception/
14. (perception or visuo?perception or visual?perception or agnosia or prosopagnosia or stereognosis).tw.
15. (percept$ or visuo?percept$ or visual?percept$ or visuo?spatial or visual?spatial or visuo?construct$ or visual?construct$) adj5 (disorder$ or impairment$ or problem$ or abilit$ or difficult$ or deficit$ or training or re?training or remediation or rehabilitation or intervention or therapy)).tw.
16. or/13-15
17. Randomized Controlled Trials/
18. random allocation/
19. Controlled Clinical Trials/
20. control groups/
21. clinical trials/
22. double-blind method/
23. single-blind method/
24. Placebos/
25. placebo effect/
26. cross-over studies/
27. Multicenter Studies/
28. Therapies, Investigational/
29. Research Design/
30. Program Evaluation/
31. evaluation studies/
32. randomized controlled trial.pt.
33. controlled clinical trial.pt.
34. clinical trial.pt.
35. multicenter study.pt.
36. evaluation studies.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$).tw.
42. (multicenter or multicentre or therapeutic) adj5 (trial$ 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. latin square.tw.
47. versus.tw.
48. (cross-over or cross over or crossover).tw.
49. placebo$.tw.
50. sham.tw.
51. (assign$ or alternate or allocat$ or counterbalance$ or multiple baseline).tw.
52. controls.tw.
53. or/17-52
54. 12 and 16 and 53
55. limit 54 to humans

EMBASE (Ovid)

1 Cerebrovascular Disorders/ (16422)
2 exp basal ganglia cerebrovascular disease/ (113)
3 exp brain ischemia/ (45292)
4 exp carotid artery diseases/ (21630)
5 Stroke/ (68071)
6 exp brain infarction/ (26669)
7 exp cerebrovascular trauma/ (24594)
8 exp hypoxia-ischemia, brain/ (45292)
9 exp intracranial arterial diseases/ (874)
10 exp "intracranial embolism"/ and "thrombosis "/ (80)
11 exp intracranial hemorrhages/ (38079)
12 exp vertebral artery dissection/ (3817)
13 (stroke$ or poststroke$ or post-stroke$ or cerebral vascular or cerebrovascular or cva$).tw. (109262)
14 ((cerebral or brain$ or vertebrobasilar) adj5 (infarct$ or isch?emi$ or thrombo$ or apoplexy or emboli$)).tw. (43959)
15 ((cerebral or brain$ or subarachnoid) adj5 (haemorrhage or hemorrhage or haematoma or hematoma or bleed)).tw. (16392)
16 ((trauma$ or acquired) adj5 brain injur$).tw. (10356)
17 exp brain damage, chronic/ (261)
18 Brain Injuries/ (45966)
19 exp brain concussion/ (898)
20 exp brain hemorrhage, traumatic/ (38079)
21 Brain Injury, Chronic/ (45966)
22 Diffuse Axonal Injury/ (331)
23 Craniocerebral Trauma/ (19791)
24 exp head injuries, closed/ (101463)
25 exp intracranial hemorrhage, traumatic/ (38079)
26 exp brain abscess/ (4216)
27 exp central nervous system infections/ (65815)
28 exp encephalitis/ (32942)
29 exp meningitis, viral/ (1423)
30 (encephalitis or meningitis).tw. (34571)
31 exp brain neoplasms/ (56761)
32 ((brain or cerebr$) adj5 (neoplasm$ or lesion$ or tumor$ or tumour$)).tw. (36761)
33 exp perceptual disorders/ (8058)
34 exp perception/ (94573)
35 33 or 34 (100645)
36 (perception or visuo?perception or visual?perception or agnosia or prosopagnosia or stereognosis).tw. (47235)
37 ((percept$ or visuo?percept$ or visual?percept$ or visuo?spatial or visual?spatial or visuo?construct$ or visual?construct$) adj5 (disorder$ or impairment$ or problem$ or abilit$ or difficult$ or deficit$ or training or re?training or remediation or rehabilitation or intervention therapy)).tw. (6904)
38 35 or 37 or 36 (130920)
39 Randomized Controlled Trial/ (171725)
40 Random Allocation/ (26967)
41 Controlled Clinical Trial/ (64098)
42 Control Groups/ (4194)
43 Clinical Trial/ (549766)
44 Double-Blind Method/ (73417)
45 Single-Blind Method/ (8388)
46 Placebos/ (129417)
47 Placebo Effect/ (271)
48 Cross-Over Studies/ (21585)
49 Multicenter Study/ (46769)
50 Therapies, Investigational/ (382)
51 Research Design/ (414056)
52 Program Evaluation/ (55867)
53 Evaluation Studies/ (54946)
54 random.tw. (88168)
55 (controlled adj5 (trial$ or stud$)).tw. (130272)
56 (clinical adj5 trial).tw. (46741)
57 ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).tw. (607058)
58 (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).tw. (1024)
59 ((multicenter or multicentre or therapeutic) adj5 (trial$ or stud$)).tw. (58882)
60 ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).tw. (85295)

61 ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).tw. (95822)
62 (coin adj5 (flip or flipped or toss)).tw. (56)
63 latin square.tw. (1124)
64 versus.tw. (245008)
65 (cross-over or cross over or crossover).tw. (39465)
66 placebo$.tw. (112155)
67 sham.tw. (37685)
68 (assign$ or alternate or allocat$ or counterbalance$ or multiple baseline).tw. (167922)
69 contols.tw. (45)
70 62 or 58 or 48 or 66 or 65 or 63 or 43 or 67 or 41 or 60 or 39 or 50 or 69 or 45 or 59 or 52 or 56 or 46 or 53 or 42 or 64 or 47 or 54 or 55 or 44 or 51 or 68 or 61 or 40 or 57 or 49 (2069902)
71 32 or 21 or 7 or 26 or 17 or 2 or 1 or 18 or 30 or 16 or 27 or 25 or 28 or 20 or 14 or 24 or 10 or 31 or 11 or 22 or 13 or 23 or 29 or 6 or 3 or 9 or 12 or 15 or 8 or 4 or 19 or 5 (465477)
72 38 and 71 and 70 (2021)
73 limit 72 to human (1692)
74 limit 72 to yr="2007-current" (355)
75 from 74 keep 1-355 (355)
76 from 75 keep 1-355 (355)

PsycINFO

1 exp Cerebrovascular Disorders/ (9239)
2 exp basal ganglia/ (12036)
3 exp cerebral ischemia/ (1219)
4 exp carotid arteries/ (361)
5 Stroke/ (6947)
6 exp vertebral artery dissection/ (0)
7 (stroke$ or poststroke$ or post-stroke$ or cerebral vascular or cerebrovascular or cva$).tw. (13149)
8 ((cerebral or brain$ or vertebrobasilar) adj5 (infarct$ or isch?emi$ or thrombo$ or apoplexy or emboli$)).tw. (2480)
9 ((cerebral or brain$ or subarachnoid) adj5 (haemorrhage or hemorrhage or haematoma or hematoma or bleed)).tw. (687)
10 ((trauma$ or acquired) adj5 brain injur$).tw. (6499)
11 exp brain damage/ (20526)
12 Traumatic Brain Injury/ (5669)
13 exp brain concussion/ (427)
14 exp head injuries/ (3939)
15 exp encephalitis/ (1000)
16 exp meningitis/ (252)
17 (encephalitis or meningitis).tw. (2401)
18 exp brain neoplasms/ (899)
19 ((brain or cerebr$) adj5 (neoplasm$ or lesion$ or tumor$ or tumour$)).tw. (8314)
20 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 (57647)
21 exp perceptual distubances/ (0)
22 exp perception/ (222011)
23 (perception or visuo?perception or visual?perception or agnosia or prosopagnosia or stereognosis).tw. (110968)
24 ((percept$ or visuo?percept$ or visual?percept$ or visuo?spatial or visual?spatial or visuo?construct$ or visual?construct$) adj5 (disorder$ or impairment$ or problem$ or abilit$ or difficult$ or deficit$ or training or re?training or remediation or rehabilitation or intervention therapy)).tw. (15629)
25 21 or 22 or 23 or 24 (286572)
26 exp sampling/ (1968)
27 best practices/ (244)
28 treatment effectiveness evaluation/ (10973)
29 Control Groups/ (586)
30 Clinical Trial/ (3120)
31 clinical trials/ (3120)
32 exp Placebo/ (2384)
33 cultural differences/ (29215)
34 Research Design/ (7427)
35 program evaluation/ (8022)
36 evaluation/ (11057)
37 random.tw. (28273)

38 (controlled adj5 (trial$ or stud$)).tw. (22707)
39 (clinical adj5 trial).tw. (5224)
40 ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).tw. (133153)
41 (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).tw. (271)
42 ((multicenter or multicentre or therapeutic) adj5 (trial$ or stud$)).tw. (5558)
43 ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).tw. (16996)
44 ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).tw. (14175)
45 (coin adj5 (flip or flipped or toss)).tw. (65)
46 latin square.tw. (384)
47 versus.tw. (42047)
48 (cross-over or cross over or crossover).tw. (4655)
49 placebo$.tw. (22867)
50 sham.tw. (5390)
51 (assign$ or alternate or allocat$ or counterbalance$ or multiple baseline).tw. (74075)
52 contols.tw. (4)
53 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 (354273)
54 53 and 20 and 25 (1090)
55 limit 54 to yr="2007-current" (165)
56 limit 55 to human (147)
57 from 56 keep 1-147 (147)
58 from 57 keep 1-147 (147)

CINAHL EBSCO Search strategy

S109.S107 and S108
S108. Limiters - Published Date from: 200701-200912
S107.S29 and S61 and S106
S106.S62 or S63 or S64 or S65 or S66 or S67 or S68 or S69 or S70 or S71 or S72 or S73 or S74 or S75 or S76 or S77 or S78 or S79 or S80 or S81 or S82 or S83 or S84 or S85 or S86 or S87 or S88 or S89 or S90 or S91 or S92 or S93 or S94 or S95 or S96 or S97 or S98 or S99 or S100 or S101 or S102 or S103 or S104 or S105
S105.controls
S104.assign* or alternate or allocat* or counterbalance* or multiple baseline
S103.sham
S102.placebo*
S101.cross-over or cross over or crossover
S100.versus
S99.latin square
S98.coin N5 toss
S97.coin N5 flipped
S96.coin N5 flip
S95.trebl* N5 blind*
S94.trebl* N5 mask*
S93.tripl* N5 mask*
S92.tripl* N5 blind*
S91.doubl* N5 blind*
S90.doubl* N5 mask*
S89.singl* N5 mask*
S88.singl* N5 blind*
S87.control N5 manage* or experiment* N5 manage* or conservative N5 manage*
S86.control N5 procedure or experiment* N5 procedure or conservative N5 procedure
S85.control N5 treatment or experiment* N5 treatment or conservative N5 treatment
S84.control N5 therapy or experiment* N5 therapy or conservative N5 therapy
S83.multicenter N5 stud* or multicentre N5 stud* or therapeutic N5 stud*
S82.multicenter N5 trial* or multicentre N5 trial* or therapeutic N5 trial*
S81.quasi-random* or quasi random or pseudo-random* or pseudo random
S80.intervention N5 group* or intervention N5 subject* or intervention N5 patient*
S79.experiment* N5 group* or experiment* N5 subject* or experiment N5 patient*
S78.control N5 group* or control N5 subject* or control N5 patient*
S77.treatment N5 group* or treatment N5 subject* or treatment N5 patient*

S76.(ZT "clinical trial") or (ZT "research") or (ZT "systematic review")
S75.controlled n5 stud*
S74.controlled n5 trial*
S73.clinical n5 trial
S72.random
S71.(MH "Formative Evaluation Research") or (MH "Evaluation Research") or (MH "Summative Evaluation Research") or (MH "Concurrent Prospective Studies")
S70.(MH "Program Evaluation")
S69.(MH "Study Design") or (MH "Cross Sectional Studies")
S68.(MH "Multicenter Studies")
S67.(MH "Crossover Design")
S66.(MH "Placebos") or (MH "Placebo Effect")
S65.(MH "Double-Blind Studies") or (MH "Single-Blind Studies") or (MH "Triple-Blind Studies")
S64.(MH "Control Group")
S63.(MH "Resource Allocation") or (MH "Random Sample")
S62.(MH "Clinical Trials")
S61.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 or S45 or S46 or S47 or S48 or S49 or S50 or S51 or S52 or S53 or S54 or S55 or S56 or S57 or S58 or S59 or S60
S60.abilit* N5 Visual?percept* or difficult* N5 visual?percept* and deficit* N5 visual?percept*
S59.rehabilitation N5 percept* or intervention therapy N5 percept*
S58.rehabilitation N5 visuo?percept* or intervention therapy N5 visuo?percept*
S57.rehabilitation N5 visual?percept* or intervention therapy N5 visual?percept*
S56.rehabilitation N5 visual?spatial or intervention therapy N5 visual?spatial
S55.rehabilitation N5 visuo?spatial or intervention therapy N5 visuo?spatial
S54.rehabilitation N5 visuo?construct* or intervention therapy N5 visuo?construct*
S53.rehabilitation N5 visual?construct* or intervention therapy N5 visual?construct*
S52.training N5 visual?construct* or re?training N5 visual?construct* or remediation N5 visual?construct*
S51.training N5 visuo?construct* or re?training N5 visuo?construct* or remediation N5 visuo?construct*
S50.training N5 visuo?spatial or re?training N5 visuo?spatial or remediation N5 visuo?spatial
S49.training N5 visual?spatial or re?training N5 visual?spatial or remediation N5 visual?spatial
S48.training N5 visual?percept* or re?training N5 visual?percept* or remediation N5 visual?percept*
S47.training N5 visuo?percept* or re?training N5 visuo?percept* or remediation N5 visuo?percept*
S46.training N5 percept* or re?training N5 percept* or remediation N5 percept*
S45.abilit* N5 percept* or difficult* N5 percept* or deficit* N5 percept*
S44.abilit* N5 visual?construct* or difficult* N5 visual?construct* or deficit* N5 Visual?construct*
S43.abilit* N5 visuo?construct* or difficult* N5 visuo?construct* or deficit* N5 Visuo?construct*
S42.abilit* N5 visuo?percept* or difficult* N5 visuo?percept* or deficit* N5 Visuo?percept*
S41.abilit* N5 visual?spatial or difficult* N5 visual?spatial or deficit* N5 Visual?spatial
S40.abilit* N5 visuo?spatial or difficult* N5 visuo?spatial or deficit* N5 Visuo?spatial
S39.disorder* N5 visuo?spatial or impairment* N5 visuo?spatial or problem* N5 Visuo?spatial
S38.disorder* N5 visual?construct* or impairment* N5 visual?construct* or problem* N5 Visual?construct*
S37.disorder* N5 visuo?construct* or impairment* N5 visuo?construct* or problem* N5 Visuo?construct*
S36.disorder* N5 visual?spatial or impairment* N5 visual?spatial or problem* N5 Visual?spatial
S35.disorder* N5 visual?percept* or impairment* N5 visual?percept* or problem* N5 Visual?percept*
S34.disorder* N5 visuo?percept* or impairment* N5 visuo?percept* or problem* N5 Visuo?percept*
S33.disorder* N5 percept* or impairment* N5 percept* or problem* N5 percept*
S32.perception or visuo?perception or visual?perception or agnosia or prosopagnosia or stereognosis
S31.(MH "Perception+")
S30.(MH "Perceptual Disorders+")
S29.S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 or S14 or S15 or S16 or S17 or S18 or S19 or S20 or S21 or S22 or S23 or S24 or S25 or S26 or S27 or S28
S28.brain N5 tumour* or cerebr* N5 tumour*
S27.brain N5 tumor* or cerebr* N5 tumor*
S26.brain N5 lesion* or cerebr* N5 lesion*
S25.brain N5 neoplasm* or cerebr* N5 neoplasm*
S24.cerebral N5 bleed or brain* N5 bleed or subarachnoid N5 bleed
S23.cerebral N5 haematoma or brain* N5 haematoma or subarachnoid N5 haematoma
S22.cerebral N5 hematoma or brain* N5 hematoma or subarachnoid N5 hematoma
S21.cerebral N5 hemorrhage or brain* N5 hemorrhage or subarachnoid N5 hemorrhage
S20.cerebral N5 haemorrhage or brain* N5 haemorrhage or subarachnoid N5 haemorrhage
S19.(MH "Brain Neoplasms+")
S18.encephalitis or meningitis

S17.(MH "Meningitis, Viral")
S16.(MH "Encephalitis+")
S15.(MH "Central Nervous System Infections+")
S14.acquired n5 brain injur*
S13.trauma* n5 brain injur*
S12.stroke* or poststroke* or post-stroke* or cerebral vascular or cerebrovascular or cva*
S11.(MH "Head Injuries+")
S10.(MH "Brain Damage, Chronic")
S9.(MH "Vertebral Artery Dissections")
S8.(MH "Intracranial Hemorrhage+")
S7.(MH "Cerebral Embolism and Thrombosis")
S6.(MH "Intracranial Arterial Diseases+")
S5.(MH "Anoxia")
S4.(MH "Stroke")
S3.(MH "Carotid Artery Diseases+")
S2.(MH "Cerebral Ischemia+") or (MH "Brain Abscess+") or (MH "Brain Concussion+") or (MH "Brain Injuries") or (MH "Brain Damage, Chronic")
S1.(MH "Cerebrovascular Disorders") or (MH "Basal Ganglia Cerebrovascular Disease+")

Searching other additional resources:

1. The review authors (2011) searched the following trials and research registers in May and June 2009:

- UK National Research Register Archive (http://www.nrr.nhs.uk/search.htm) (records up to September 2007)
- UK Clinical Research Network Study Portfolio (http://public.ukcrn.org.uk/search/)
- Current Controlled Trials Register (http://www.controlled-trials.com)2.

2. The review authors (2011) handsearched the *Journal of Clinical and Experimental Neuropsychology* (1979 to June 2009) and *Psychology and Aging* (1986 to June 2009). To avoid duplication of effort, we searched only relevant journals that had not been handsearched by The Cochrane Collaboration (*see* Master List of Journals at http://apps1.jhsph.edu/cochrane/masterlist.asp). At the time of publishing our protocol we had planned to handsearch five journals but, when it came to carrying out the review, expansion of the Master List reduced our workload;

3. The review authors (2011) searched reference lists of included articles

4. The review authors (2011) contacted authors of included articles and other researchers in the field.

The review authors (2011) contacted the Cochrane Injuries Group to request a search of their trials register but they confirmed there was no need to search their register as all trials were sent regularly to CENTRAL. We searched for trials in all languages and planned to arrange translation of trial reports published in languages other than English: we found no relevant non-English language trials.

WHAT'S NEW

Date	Event	Description
20 December 2021	New citation required and conclusions have changed	Conclusions changed.
20 December 2021	New search has been performed	The previous 2011 version of this systematic review included participants who experienced perceptual disorders as a result of stroke or other non-progressive brain injuries. It included six trials (339 participants). This 2022 review focuses more specifically on stroke survivors while expanding the inclusion criteria to potentially include all interventions to address perceptual disorders (see Differences between protocol and review for full details of changes). The review now includes 18 trials and 541 participants, of whom 535 (98.9%) were stroke survivors. We excluded four trials from the 2011 review as a consequence of the narrower participant inclusion criteria.

HISTORY

Protocol first published: Issue 2, 2008
Review first published: Issue 4, 2011

Date	Event	Description
9 May 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

Authors: CH: Christine Hazelton; KT: Katie Thomson; ATB: Alex Todhunter-Brown; PC: Pauline Campbell; CC: Charlie SY Chung; LD: Liam Dorris; DG: David C Gillespie; SH: Sue M Hunter; KMc: Kris McGill; DN: Donald J Nicholson; LW: Linda J Williams; MB: Marian C Brady

All authors have contributed to the following International Committee of Medical Journal Editors (ICMJE) criteria.

- Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND
- Drafting the work or revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Using the CRediT Taxonomy (CASRAI 2021), authors have participated in the following roles.

- Conceptualisation: CH, ATB, PC, CC, LD, DG, SH, KMc, DN, LW, MB
- Data curation: CH, KT, PC, KMc
- Formal analysis: CH, KT, ATB, PC, LW, MB
- Project administration: CH, KT, MB
- Resources: CH, KT, PC
- Supervision: CH, ATB, LW, MB
- Funding acquisition: CH, ATB, PC, CC, LD, DG, SH, DN, LW, MB
- Investigation: CH, KT, ATB, PC, CC, DG, LD, LW, SH, DN, KMc
- Methodology: CH, KT, ATB, PC, CC, DG, LD, SH, KMc, DN, LW, MB
- Validation: CH, KT, ATB, PC, CC, DG, LD, SH, DN, KMc, LW, MB
- Visualisation: CH, KT, ATB, PC
- Writing original draft: CH, KT, MB
- Writing: reviewing and editing: all authors

DECLARATIONS OF INTEREST

Dr Christine Hazelton. Grants and contracts: funding for this project was received from the National Institute for Health Research (NIHR); a personal fellowship from the Stroke Association. Work as a health professional: clinical work as an optometrist at Glasgow Caledonian University (GCU).

Dr Katie Thomson. Grants and contracts: time on this review was covered by a project grant from the National Institute for Health Research. Work as a health professional: an occupational therapy lecturer at GCU. Other: an honorarium and travel expenses for the Occupational Therapy Show.

Dr Alex Todhunter-Brown. Grants and contracts: Dr Todhunter-Brown is (joint) Co-ordinating Editor for Cochrane Stroke. Funding to support this role is provided by the Scottish Government's Chief Scientist Office; contribution to this review was funded by a grant from the National Institute for Health Research.

Pauline Campbell. Grants and contracts: time on this review was covered by a project grant from the National Institute for Health Research (co-applicant).

Dr Charlie Chung. Work as a health professional: occupational therapist in the National Health Service (NHS) providing stroke rehabilitation, including some adaptive interventions for perceptual disorders. Affiliation: Royal College of Occupational Therapists Specialist Section Neurological Practice.

Liam Dorris. Work as a health professional: consultant paediatric neuropsychologist, Royal Hospital for Children, Glasgow, NHS Greater Glasgow & Clyde, Glasgow, UK.

David Gillespie. Work as a health professional: consultant clinical neuropsychologist, NHS Lothian.

Susan M Hunter. Grants and contracts: time on this review was covered by a project grant from the National Institute for Health Research (co-applicant). Work as a health professional: reader in physiotherapy at Keele University, and worked as a clinical physiotherapist up to 2000.

Kris McGill. None known.

Dr Donald J Nicolson. Grants and contracts/employed: from Metix Medical. In this role, I won an Innovate UK award for £75k for Metix Medical for the Business-led innovation in response to global disruption (de minimis) funding application stream. This evaluated the utility of a prototype high acuity monitoring device. I was the grant holder and the project lead. I drew a salary from this project, acting as Medical Science Liaison. Travel/other: flights and hotel expenses to present a keynote at the Association for Borderland Studies Conference (University of Vienna).

Linda Williams. None known.

Prof. Marian Brady. Grants and contracts: funding from the NIHR. Employment: professor, Nursing, Midwifery and Allied Health Professions Research Unit, Glasgow Caledonian University, funded by the Chief Scientist's Office. Travel: Speech Pathology Australia (SPA) and the New Zealand Speech-language Therapists' Association (NZSTA). Publications: World Health Organization Package of Interventions for Rehabilitation - Parkinson's Disease. Work as a health professional: speech and language therapist, Fellow of the Royal College of Speech and Language Therapists; an Editorial board member for the Cochrane Stroke Group.

SOURCES OF SUPPORT

Internal sources

- Glasgow Caledonian University, UK

  We acknowledge the support of the Department of Occupational Therapy, Human Nutrition and Dietetics at Glasgow Caledonian University which enabled in part Dr Katie Thomson's contribution to the review.

External sources

- National Institute for Health Research (NIHR), UK

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- Stroke Association, UK

  Christine Hazelton is funded by the Stroke Association (TSA), UK (SA L-NC 20\100003)
- Chief Scientist Office, Scottish Government, Health and Social Care Directorate, Scotland, UK

  The Nursing, Midwifery and Allied Health Professions Research Unit and Marian Brady are funded by the Chief Scientist Office, Health and Social Care Directorates, UK

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

For this update of the 2011 review, we made a number of changes. Key changes were:

- making the review stroke specific – the previous version focused on "stroke and other adult-acquired, non-progressive brain injury"; we included only stroke populations;
- including all interventions - the previous version was limited to non-pharmacological interventions; we included ANY intervention for perception;
- clarifying the primary outcome and extend the secondary outcomes;
- using TIDieR categories to describe interventions (Hoffmann 2014), using the GRADE approach to assess the quality of evidence (Guyatt 2008), and summarising findings in summary of findings tables, in line with current practice;
- amending the title to "Interventions for perceptual disorders following stroke" to reflect the other changes made.

All changes were reviewed and agreed by the Cochrane Stroke Group; a protocol was published (Hazelton 2019b).

INDEX TERMS

Medical Subject Headings (MeSH)

Activities of Daily Living; *Perceptual Disorders [etiology] [rehabilitation]; Randomized Controlled Trials as Topic; *Stroke [complications]; *Stroke Rehabilitation; Vision Disorders [rehabilitation]

MeSH check words

Adult; Humans