Effectiveness of External Cues to Facilitate Task Performance in People with Neurological Disorders: A Systematic Review and Meta-Analysis

Harrison SL[1,2]*, Laver K[1], Ninnis K[1], Rowett C[3], Lannin NA[4,5] and Crotty M[1,2].

[1]Department of Rehabilitation, Aged and Extended Care, Faculty of Medicine, Nursing and Health Sciences, School of Health Sciences, Flinders University, Level 1, C Block, Repatriation General Hospital, Daws Road, Daw Park, SA 5041

[2]NHMRC Cognitive Decline Partnership Centre, University of Sydney, Australia.

[3]Faculty of Medicine, Nursing and Health Science, School of Health Science, Discipline of Occupational Therapy Flinders University, Repatriation General Hospital, Daws Road, Daw Park, SA 5041

[4]School of Allied Health, Department of Community and Clinical Allied Health, College of Science, Health and Engineering, La Trobe University, VIC 3086

[5]Occupational Therapy Department, Alfred Health, 55 Commercial Road, Melbourne VIC 3004

Author email addresses: Stephanie.harrison@sa.gov.au, kate.laver@sa.gov.au, kayla.ninnis@flinders.edu.au, Cherie.rowett@flinders.edu.au, n.lannin@latrobe.edu.au, maria.crotty@sa.gov.au

*Corresponding author: Stephanie.Harrison@sa.gov.au Department of Rehabilitation, Aged and Extended Care, Faculty of Medicine, Nursing and Health Sciences, School of Health Sciences, Flinders University, Level 1, C Block, Repatriation General Hospital, Daws Road, Daw Park, SA 5041. Tel: +61415050971

Abstract

Purpose: To examine in people with neurological disorders, which method/s of providing external cues to improve task performance are most effective.

Methods: Medline, EMBASE and PsycINFO were systematically searched. Two reviewers independently screened, extracted data and assessed the quality of the evidence using GRADE.

Results: 26 studies were included. Studies examined a wide-range of cues including visual, tactile, auditory, verbal and multi-component cues. Cueing (any type) improved walking speed when comparing cues to no cues (Mean difference (95% Confidence Interval): 0.08m/s (0.06 to 0.10), I^2=68%, low quality of evidence). Remaining evidence was analysed narratively; evidence that cueing improves activity-related outcomes was inconsistent and rated as very low quality. It was not possible to determine which form of cueing may be more effective than others.

Conclusions: Providing cues to encourage successful task performance is a core component of rehabilitation, however there is limited evidence on the type of cueing or which tasks benefit most from external cueing. Low-quality evidence suggests there may be a beneficial effect of cueing (any type) on walking speed. Sufficiently powered randomised controlled trials are needed to inform therapists of the most effective cueing strategies to improve activity performance in populations with a neurological disorder.

Introduction

Neurological disorders are among the most common causes of disability worldwide, for instance, there are 46.8 million people living with dementia,[1] while around 15 million people experience a new stroke annually.[2] Other common causes include multiple sclerosis, Parkinson's disease and traumatic brain injury (TBI). While the incidence of the different causes varies, people living with a neurological disorder, regardless of cause, commonly experience impairments of both physical function and cognitive ability. Impairments in cognitive functioning of patients with neurological disorders, including memory, attention and executive function, are common.[3] Such cognitive impairments can reduce a person's ability to perform everyday tasks successfully and reduce their functional performance, including basic activities of daily living (ADLs; such as showering) and instrumental ADLs (such as meal preparation). In the United Kingdom, around 350,000 people require help with the majority of their ADLs and over one million people have some form of disability due to a neurological disorder.[4] Limitations in activities result in the need for increased support, loss of independence and reduced social participation.

Supporting individuals with neurological disorders to improve or maintain their ability to independently participate in meaningful activities is important to improve their quality of life. [5] Therapists use a wide-range of strategies and interventions to assist those with a neurological disorder to be able to complete everyday tasks and participate in activities. Therapists may use a remedial approach, such as repetitive task performance or spaced retrieval, or a compensatory approach such as using cues or modification of the task or environment. Evidence suggests that repetitive task training is an effective approach for regaining motor function after stroke.[6] A recent Cochrane review showed that in comparison with standard physiotherapy or placebo, people who repetitively performed functional tasks showed small improvements in upper-limb function and walking.[6] Similar

positive evidence has been shown for repetitive task training in people with TBI for acquiring and retaining specific skills,[7] and in people with multiple sclerosis repetitive exercise training has been shown to positively influence many outcomes including walking.[8] Providing cues to encourage, guide and praise people undergoing therapy or rehabilitation is considered a key component of therapy and is thought to improve learning.[9] However, as cueing is accepted practice within therapy and rehabilitation settings; there have been relatively few studies which have specifically aimed to identify the efficacy of different type of external cues in improving task performance, even though some forms of external cues (e.g., verbal cues) are being frequently used in therapy.

There are many different methods of delivering external cues in rehabilitation settings. These include auditory cues, tactile cues, visual cues or verbal cues.[10, 11, 12] Providing external cues may involve the therapist-alone or may involve the use of technology to assist the therapist. Technology has widened the scope of potential solutions that therapists can offer patients and a range of devices can be used as part of therapy sessions to help provide cues to patients, such as accelerometers for walking[13] and wearable technology which provides cues via tactile (e.g., vibration) or auditory signals[14]. However, it remains unclear if using technology provides a significant additional benefit to therapist-led cueing[15] and also it remains unclear which type of cues (e.g., tactile, auditory, visual) are most effective for rehabilitation of people with a neurological disorder to improve task performance and activities of daily living.

Several studies and reviews have shown external cues are effective for improving gait in Parkinson's disease, however findings have not been unequivocal.[15, 16, 17] Similarly, several studies have examined the use of cues for walking or upper limb rehabilitation in stroke and have shown cues may also be effective for this population, but the optimal type of cueing remains unclear.[18, 19]

Previous systematic reviews have usually focused on one neurological condition such as Parkinson's disease, one type of cueing and one outcome which is most commonly gait. Although there is some evidence of a beneficial effect of cues, a systematic review has not previously been completed to examine a range of different cues for different tasks and activities of daily living in people with a neurological condition. The aim of this systematic review is to examine the effectiveness of the different methods that may be used to provide external cues in relation to task performance amongst individuals with a neurological disorder. The research questions that will be addressed are:

1. Are cues beneficial for improving everyday task performance or activities of daily living compare to usual care or no intervention in people with neurological disorders?

2. Which type of cues are most beneficial for improving everyday task performance or activities of daily living compared to usual care or no intervention in people with neurological disorders?

Methods

The review protocol was developed and registered on the PROSPERO international prospective register of systematic reviews (http://www.crd.york.ac.uk/PROSPERO; registration number CRD42016046494). The protocol provides full details of the methods used. There were no changes made to the protocol during the review.

Data Sources and Searches

This review was undertaken in accordance with the 2009 PRISMA statement. Medline, EMBASE and PsycINFO databases were systematically searched from the year 2000 to August 2016. The search strategy included search terms related to rehabilitation or occupational therapy, feedback, cues or errorless learning and neurological disorders (dementia, stroke, multiple sclerosis, Parkinson's disease and traumatic brain injury only). These five conditions were included because they are all very common neurological disorders as listed by the World Health Organization and these conditions frequently result in impairments in functional performance and the ability to perform everyday tasks.[20] The full Medline search strategy is provided in the protocol. One author (SLH) completed the electronic search on 17 August 2016. Two authors (SLH and KN) independently assessed the retrieved citations based on the article title and abstracts in line with the inclusion and exclusion criteria for the review. The full-texts were retrieved for studies which were identified as potentially meeting the eligibility criteria. Two authors (SLH and KN) independently assessed all the full-text articles against the eligibility criteria. Any discrepancies between the articles were resolved by consensus or by consulting a third author (KL).

Study Selection

Types of Studies

Studies must have included a control group, such as randomised controlled trials (RCTs), crossover trials or any other study design with a control group. Only studies published in English were included.

Population

Studies were included if they included any population of individuals with the following neurological disorders: dementia (all sub-types), stroke, multiple sclerosis, Parkinson's disease or TBI. A range of diagnoses were included in order to (1) maximise the number of relevant studies identified, and (2) because rehabilitation programs typically provide services to people with a range of neurological disorders. Studies were not excluded based on setting as both community and residential care settings were included, nor were there any restrictions placed on the age of the included participants.

Intervention and Comparison

Studies were included if the aim of the study was to examine the efficacy of cueing and if the intervention included cues (visual, auditory, verbal or tactile cues). These cues could either be provided during a therapy session or integrated in to the person's daily routine, but a therapist must have initiated the intervention. The study was included if the aim of the intervention was to improve an individuals' ability to perform an activity (e.g. walking) or complete an everyday task (e.g. meal preparation). Activities had to be listed in the International Classification of Functioning, Disability and Health (ICF) Framework [21] and studies were excluded if they only examined changes in a body function rather than an activity. Interventions that examined cueing in a virtual environment (achieved through virtual reality technology) were excluded as these are not always readily accessible in clinical settings. Studies were included if the comparison was no intervention, usual care or alternative methods of cueing. Any setting was considered for the study if the intervention was conducted as part of a therapy session or if a therapist initiated the intervention.

Outcome

The primary outcome for this review was the ability of an individual to learn or relearn an everyday task (such as activities of daily living), usually measured by time taken to learn the task. A secondary outcome of the review was independence in ADLs. Changes in ADLs could be measured by observation, self-report or proxy report, or tools to assess ADLs or function, for example Fugl-Meyer assessment scores, the Functional Independence Measure, Barthel Index, Alzheimer's Disease Co-operative Study—ADL Inventory, Disability Assessment for Dementia or Cleveland Scale for ADL.

Data Extraction

One author (KN or CR) extracted the data which was checked by a second author (SLH). Disagreements were resolved by discussion or contacting a third author (KL). The data extraction forms were completed for each included study and included study details (authors, publication date, period of study, location and setting, inclusion and exclusion criteria and type of study), study population (baseline characteristics for intervention group, control group and overall: sex, age, type of neurological disorder, known cognitive impairments, sample size, time since onset of disorder), participant flow, details of the intervention and an overview of the results. Results were only extracted for outcomes which were initially defined in the protocol including ADLs, task performance and activities which were defined as "activities and participation" in the ICF framework.[22] We did not contact review authors for further information.

Quality Assessment

The risk of bias for each study was independently assessed by two authors (KN and CR). Risk of bias for each study was determined using the suggested risk of bias criteria for effective practice and organisation of care (EPOC) reviews as recommended by The Cochrane Collaboration.[23] Two authors (SLH and KN) then independently assessed the

quality of the evidence using GRADE.[24] The risk of bias assessments were used in the GRADE assessment and GRADE also considers inconsistency, indirectness, imprecision and possibility of publication bias in the included studies. Any discrepancies between reviewers during quality assessment were resolved by consensus.

Data Synthesis and Analysis

Only RCTs were considered for meta-analysis.[24] When a meta-analysis was possible, the mean and standard deviation for the continuous outcomes post-intervention were extracted for the experimental and control group. In instances when a mean and standard deviation were not reported, the study was not included in the meta-analysis. A fixed effects model was conducted and a sensitivity analysis was completed using a random effects model. A forest plot was generated when meta-analysis was possible and the mean difference and 95% confidence interval was reported. Heterogeneity was considered using the I^2 statistic (50%-90% may represent substantial heterogeneity and 75% to 100% may represent considerable heterogeneity). Review Manager 5.3 was used to complete any meta-analysis. When a meta-analysis was not possible a narrative comparison of the studies by type of cueing was given.

Results

Search Results

There were 7309 articles identified through database searching. After exclusion of duplicates, 5190 titles and abstracts were independently assessed by two authors against the pre-defined inclusion and exclusion criteria. In total, 260 full-text articles were retrieved and assessed for eligibility and 26 articles were included in the review. Figure 1 shows the PRISMA flow chart for the study selection process of the review.

[INSERT FIGURE 1 HERE]

Characteristics of the Included Studies

The interventions examined in the different studies included auditory cues (n=3),[25, 26, 27] verbal cues (n=6),[13, 28, 29, 30, 31, 32] tactile cues (n=1),[33] visual cues (n=6)[34, 35, 36, 37, 38, 39] and multi-component interventions which included more than one type of cueing (n=10) (Table 1).[14, 40, 41, 42, 43, 44, 45, 46, 47, 48] The majority of included studies were RCTs (n=21) and most of the included studies had small sample sizes (≤50 participants, n=19).

[INSERT TABLE 1 HERE]

Methodological Quality of the Included Studies

GRADE quality was determined for the following outcomes: walking speed, Timed Up and Go, cadence, specific task performance and function tests or ADLs. For walking speed a meta-analysis was conducted based on the results of RCTs only therefore two GRADE results were completed for this outcome: 1) examining only the RCTs included in the meta-analysis and 2) examining all studies in the review which had walking speed as an outcome. The evidence for the meta-analysis of walking speed was low and all other GRADE ratings were very low. The GRADE scores were usually downgraded for risk of bias being serious, serious inconsistency in the results and serious imprecision (having <400 participants) (Supplementary material).

Effects of External Cues by Different Method of Cueing

Verbal cues

Six studies examined different verbal cues [13, 28, 29, 30, 31, 32] and four of these were conducted in people with stroke (Table 1).[13, 28, 29, 30] One small randomized cross-over study (n=33) found no significant difference in intervention compared to control groups when examining the effect of verbal cues for a wheelchair preparation task for people with

stroke (median number of days to learn task: 2.5 in intervention group vs. 3 in control group) and similar results were observed for a sock donning task.[30] A further non-randomised self-controlled study of people living with dementia compared verbal cues vs. an implicit method to learn a microwave and coffee machine task and found no difference between the groups as they were both successful in task performance (p=0.16).[32] One RCT examined the effect of verbal cues vs. no cues in participants with Parkinson's disease and found a significant positive effect of verbal cues towards an increase in maintenance of instrumental ADLs (IADLs decreased for the control group, but not the intervention group, p<0.01) and gait speed (p<0.001).[31]

Visual cues

Two studies examined visual cues in people with Parkinson's disease.[37, 38] The visual cues were blue masking tape on the floor providing visual cues for walking in one study[37] and a computerised dancing system providing visual cues for tasks such as reaching in the second study.[38] One RCT (n=28) found a significant improvement in mean Timed Up and Go and in step velocity in the intervention group compared to the control group when the intervention was performed three times a week for 6 weeks.[37] However, the second RCT did not find a significant effect of visual cues on gait velocity in people with Parkinson's disease when the intervention was also performed three times a week, but over 8 weeks.[38]

Four studies examined the use of visual cues in people with stroke[34, 35, 36, 39], however, only three reported a statistical comparison between groups.[35, 36, 39] Of these three studies, two RCTs found a significant improvement in outcomes using visual cues compared to the control group.[36, 39] One RCT found a significant improvement using video cues in everyday task performances including putting clothes on a hanger, folding laundry, washing dishes and carrying out a monetary transaction, however, no significant effect was shown for preparing a cup of tea.[36] A different RCT examined the effect of mirror therapy vs. sham

mirror therapy in people with stroke and found a significant improvement in the FIM self-care score.[39] However, another RCT also examined the effect of mirror therapy vs. sham mirror therapy in people with stroke and found no difference between the intervention and control groups for cadence or velocity.[35]

Auditory cues

Three of the included studies examined types of interventions which were based on auditory cueing methods.[25, 26, 27] In one RCT which examined arm training with auditory cues in people with stroke no significant effect was found for Fugl-Meyer score or a stroke-specific arm score.[27] Furthermore, a non-randomised trial found no significant effect of auditory cues in people with Parkinson's disease in measures including velocity and cadence.[25] One study found a significant effect of auditory cues on any outcome; this was a small RCT which examined the use of gait training with auditory cues from a cane vs. gait training without auditory cues in people with stroke. [26]

Tactile cues

One RCT examined different methods of tactile cues.[33] This RCT examined proprioceptive neuromuscular facilitation and vibratory stimuli compared to no cues in people with Parkinson's disease and found the post-intervention mean walking speed was significantly lower in the control group (0.96 km/hour) compared to those that received tactile cues(1.28 km/hour). Further, a significantly better improvement in mean cadence was also observed in the intervention group.

Multi-component cues

Ten studies examined interventions which combined more than one type of cueing. Combining different methods of cueing had mixed results, but there was wide variation in the methods used and the types of cueing which were combined.

The multi-component interventions which did not show any improvement compared to the control group for the any of the outcomes extracted included a vibration and auditory cueing wristwatch vs. a sham device in people with stroke,[14] visual cues vs. verbal and tactile cues vs. no intervention in people with Parkinson's disease[44] and a motor learning walking program with cues vs. a treadmill training program.[40] One study compared verbal cues and videotaped replay vs. verbal cues alone and found improvements in a meal preparation task in both groups of people with TBI, but no additional significant benefit of the additional visual cues was observed, although this was with a very small number of participants (n=10).[46] A different study which compared verbal cues with verbal cues plus additional visual cues in people with stroke did not find any additional benefit of adding the visual cues for the sock and shoes subset of the Klein-Bell ADL.[42] Similarly, no significant effect on ADLs was found when using computer assisted errorless learning or therapist-led errorless learning compared to no intervention in people with Alzheimer's disease.[43]

The Effect of Cues on Walking Speed

Due to the number of different outcomes reported in studies and the different study designs it was only possible to conduct a meta-analysis for one outcome: walking speed. For studies which did not report walking speed in m/s, the author team converted published data to m/s. The meta-analysis included five studies.[26, 28, 33, 35, 38] These studies examined a range of different types of cues including verbal, tactile, visual and auditory cues. Three of the studies examined people with stroke and two of the studies examined people with Parkinson's disease. The results suggested cues compared to no cues for walking speed had an estimated significant improvement of 0.08m/s (Mean difference (95%CI): 0.08 (0.06 to 0.10)). There was substantial heterogeneity in this estimate (I^2=68%) and the estimate slightly reduced when random effects were used to produce the estimate rather than fixed effects (0.06 (0.00 to 0.13)). The GRADE quality of evidence for this estimate was rated as low.

Figure 2 shows the forest plot for the meta-analysis for the effect of cues vs. no cues for walking speed.

[INSERT FIGURE 2 HERE]

Discussion

This review synthesised the effect of different types of cueing in a therapy setting for people with a neurological disorder on successful task performance. The review included studies where the interventions used visual, verbal, auditory, tactile and multi-component methods to cue performance. We found mixed results regarding the efficacy of cueing with some studies reporting significant effects of cueing on activities of daily living or everyday task performance and some studies reporting no significant effect. Meta-analysis of five studies revealed a significant effect of cueing vs. no cueing in relation to improvement of walking speed; however, it was not possible to determine which method of cueing may be most beneficial based on the current available evidence. Because there was a wide variation in types of cues given in the interventions, differences in the neurological disorders of the populations and outcomes assessed in the studies, comparison between the studies was difficult. Furthermore, the majority of the included studies had small sample sizes and the overall GRADE quality of evidence was assessed to be 'low' or 'very low'. A number of these were pilot studies with larger studies planned in the future. Furthermore, there are a number of trials examining the efficacy of cueing published as protocols or registered on clinical trial registries suggesting that this is a growing area of research.[49, 50, 51, 52, 53]

Many of the included studies only conducted the cueing interventions for a small amount of time (usually a small number of sessions over one to two months). Longer treatment durations involving a consistent therapy approach may be required for certain conditions in order to see a beneficial effect. For instance, it has been suggested that auditory cues to improve walking for people with Parkinson's disease should be given for at least six months,[54] however, none of the included studies provided cueing over that length of time for this population. Future studies should therefore examine the long-term benefits of cueing and if the improvements seen in people with a neurological disorder are sustained over time.

Such research is needed to determine the amount of therapy sessions with external cueing required to see a sustained beneficial effect. This may not only have potential positive effects towards task performance and activities in people with a neurological disorder, but may positively impact on their quality of life and reduce caregiver burden.[55]

The studies included in this review tended to have small sample sizes and there is a need for larger robust studies which report evidence on a wide-range of clinically important outcomes. Even in these underpowered studies, some trialists reported a significant beneficial effect of some methods of cueing for different activities and performance of different tasks which gives an indication that cueing may be beneficial for these populations. Some forms of cueing, such as verbal cues, are likely to be performed frequently as part of therapy sessions; however, few studies have specifically examined the effect of this method towards task performance in people with a neurological disorder. Further research is needed to determine if certain types of cues are more useful depending on the underlying neurological disorder and on what the activity/outcome of interest is. Frequency of cues provided may also be an important factor related to efficacy. It is important to consider the stage of the neurological disorder, for instance many forms of stroke rehabilitation may be more effective if performed in the early stages after a stroke (within three months).[56] Furthermore, there was significantly more research studies performed in people with stroke and very few studies in people with dementia. With the ageing population there will be a large increase in the numbers of people with dementia and therefore studies investigating the effects of cues should also be conducted in this population; the potential benefit of maintaining independence in patients with dementia is great.

Strengths and Limitations

This review comprised of a comprehensive literature search of multiple databases, and screening for relevant studies was conducted in duplicate by two different authors to help to

ensure no relevant studies were missed. This review was wide in scope and included an examination of multiple types of cues in people with different neurological disorders, to be as inclusive as able with respect to this area of research. There are, however, some limitations. Only studies published in English were included and thus it is plausible that trials of cueing have been excluded. It was also difficult to synthesise the available evidence on cues in relation to any of the outcomes included in this review due to the large variability in the study design, outcomes tested, comparison used and data reported in the studies. As such a meta-analysis was only possible for cues vs. no cues for walking speed and no meta-analyses were possible based on a single type of cueing. If more studies were available which met the inclusion criteria the synthesis of results would have been separated by type of cue, outcome and neurological condition, however, due to the limited number of studies available the results were narratively combined by type of cue. In order to compare studies, more studies comparing cueing in relation to task performance or activities are needed with better consistency of methodological approaches and adequate reporting of data. If more studies are conducted, future reviews should aim to examine external cues by neurological condition as the cues may have different effects depending on the underlying condition. However, in this review we aimed to show a range of studies which have examined external cues, but there were insufficient studies to separate results by type of condition due to the broad range of outcomes. The mechanisms of the condition and thus presenting symptoms and their response to cues are different between conditions and clinicians should consider the applicability of the results in relation to other conditions. Furthermore, we included studies with a control group, but not all studies were RCTs and therefore the quality of the studies was frequently low. Further high quality RCTs of cues for ADLs and everyday task performance are needed in order to determine which methods of cueing are most effective for people with neurological disorders.

Conclusion

In conclusion, there is limited available evidence from controlled trials examining cueing in a therapeutic setting in relation to task performance or activities in populations with a neurological disorder. Studies vary in regards to what type of cueing has been examined with studies reporting effects of visual, tactile, auditory, verbal and multi-component cueing interventions with mixed results in relation to different activity-related outcomes. Evidence suggests there may be a beneficial effect of cueing (any type) compared to no cueing on walking speed, but the quality of evidence was low and insufficient to determine which method of cueing may be more preferable compared to other methods. Further research should focus on RCTs with larger sample sizes to compare different types of cueing with no cueing in relation to different activity-related outcome measures in order for effective comparisons of cueing interventions to be made.

Acknowledgments

Declarations of Interest

NL: no financial interest in this intervention, but has authored one trial reported in this review.

Other authors: The authors report no conflicts of interest.

References

1.   Alzheimer'sDiseaseInternational. World Alzheimer Report 2015. Available from: https://www.alz.co.uk/research/WorldAlzheimerReport2015.pdf.
2.   World Heart Foundation. The global burden of stroke 2017 [08/03/2017]. Available from: http://www.world-heart-federation.org/cardiovascular-health/stroke/.
3.   Kolakowsky-Hayner S, Kreutzer J. Cognitive Rehabilitation 2002.
4.   Neurological Alliance. Neuro Numbers: a Brief Review of the Numbers of People in the UK with a Neurological Condition. 2008. Available from: www.neural.org.uk/store /assets/files/20/original/NeuroNumbers.pdf.
5.   Andersen CK, Wittrup-Jensen KU, Lolk A, Andersen K, Kragh-Sorensen P. Ability to perform activities of daily living is the main factor affecting quality of life in patients with dementia. Health Qual Life Outcomes. 2004;2:52.
6.   French B, Thomas LH, Coupe J, McMahon NE, Connell L, Harrison J, Sutton CJ, Tishkovskaya S, Watkins CL. Repetitive task training for improving functional ability after stroke. Cochrane Database Syst Rev. 2016;11:CD006073.
7.   Skidmore ER. Training to Optimize Learning after Traumatic Brain Injury. Curr Phys Med Rehabil Rep. 2015;3:99-105.
8.   Motl RW, Pilutti LA. The benefits of exercise training in multiple sclerosis. Nature reviews Neurology. 2012;8:487-97.
9.   Schmidt RA, Lee TD. Motor Learning and Performance. 5th Edition ed. Champaign, IL.: Human Kinetics; 2014.
10.   Schaefer RS. Auditory rhythmic cueing in movement rehabilitation: findings and possible mechanisms. Philos Trans R Soc Lond B Biol Sci. 2014;369:20130402.
11.   Dobkin BH. Strategies for stroke rehabilitation. Lancet neurol. 2004;3:528-36.
12.   Shen X, Mak MKY. Effects of strategy-focused balance training on balance and gait performance in patients with parkinson's disease. Physiotherapy (United Kingdom). 2011;97:eS1129.
13.   Mansfield A, Wong JS, Bryce J, Brunton K, Inness EL, Knorr S, Jones S, Taati B, McIlroy WE. Use of Accelerometer-Based Feedback of Walking Activity for Appraising Progress With Walking-Related Goals in Inpatient Stroke Rehabilitation: A Randomized Controlled Trial. Neurorehabil Neural Repair. 2015;29:847-57.
14.   Fong KN, Yang NY, Chan MK, Chan DY, Lau AF, Chan DY, Cheung JT, Cheung HK, Chung RC, Chan CC. Combined effects of sensory cueing and limb activation on unilateral neglect in subacute left hemiplegic stroke patients: A randomized controlled pilot study. Clinical Rehabilitation. 2013;27:628-37.
15.   Ginis P, Nackaerts E, Nieuwboer A, Heremans E. Cueing for people with Parkinson's disease with freezing of gait: A narrative review of the state-of-the-art and novel perspectives. Ann Phys Rehabil Med. 2017.
16.   Rocha P, Porfirio G, Aguiar L, Ferraz H, Trevisani V. Effects of external cues on gait parameters of Parkinson's disease patients: A systematic review. Mov Disord. 2014;29:S14.
17.   Munoz-Hellin E, Cano-de-la-Cuerda R, Miangolarra-Page JC. Visual cues as a therapeutic tool in Parkinson's disease. A systematic review. Revista Espanola de Geriatria y Gerontologia. 2013;48:190-7.
18.   Subramanian SK, Massie CL, Malcolm MP, Levin MF. Does provision of extrinsic feedback result in improved motor learning in the upper limb poststroke? A systematic review of the evidence. Neurorehabil Neural Repair. 2010;24:113-24.
19.   Hollands KL, Pelton TA, Tyson SF, Hollands MA, van Vliet PM. Interventions for coordination of walking following stroke: systematic review. Gait Posture. 2012;35:349-59.
20.   World Health Organization. Neurological Disorders: Public Health Challenges 2006 [cited 2017 09/11/2017]. Available from: http://www.who.int/mental_health/neurology/neurological_disorders_report_web.pdf.

21.   World Health Organisation. International Classification of Functioning, Disability and Health (ICF) 2016 [November 2016]. Available from: http://apps.who.int/classifications/icfbrowser/.

22.   Stier-Jarmer M, Grill E, Ewert T, Bartholomeyczik S, Finger M, Mokrusch T, Kostanjsek N, Stucki G. ICF Core Set for patients with neurological conditions in early post-acute rehabilitation facilities. Disabil Rehabil. 2005;27:389-95. Epub 2005/07/26.

23.   Effective Practice and Organisation of Care (EPOC). Suggested risk of bias criteria for EPOC reviews. Oslo: Norwegian Knowledge Centre for the Health Services2016. Available from: http://epoc.cochrane.org/epoc-specific-resources-review-authors.

24.   The Cochrane Collaboration. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 2011. Available from: http://handbook.cochrane.org/.

25.   del Olmo MF, Cudeiro J. Temporal variability of gait in Parkinson disease: Effects of a rehabilitation programme based on rhythmic sound cues. Parkinsonism & Related Disorders. 2005;11:25-33.

26.   Jung K, Kim Y, Cha Y, In TS, Hur YG, Chung Y. Effects of gait training with a cane and an augmented pressure sensor for enhancement of weight bearing over the affected lower limb in patients with stroke: a randomized controlled pilot study. Clinical Rehabilitation. 2015;29:135-42.

27.   Luft AR, McCombe-Waller S, Whitall J, Forrester LW, Macko R, Sorkin JD, Schulz JB, Goldberg AP, Hanley DF. Repetitive Bilateral Arm Training and Motor Cortex Activation in Chronic Stroke: A Randomized Controlled Trial. JAMA: Journal of the American Medical Association. 2004;292:1853-61.

28.   Dobkin BH, Plummer-D'Amato P, Elashoff R, Lee J. International randomized clinical trial, stroke inpatient rehabilitation with reinforcement of walking speed (SIRROWS), improves outcomes. Neurorehabilitation and Neural Repair. 2010;24:235-42.

29.   Dorsch A, Thomas S, Xu C, Kaiser W, Dobkin B. Implementation of a multicenter, international, randomized clinical trial in subacute stroke patients using wireless health technology. Neurorehabilitation and Neural Repair. 2014;28 (4):NP17.

30.   Mount J, Pierce SR, Parker J, DiEgidio R, Woessner R, Spiegel L. Trial and error versus errorless learning of functional skills in patients with acute stroke. Neurorehabilitation. 2007;22:123-32.

31.   Piemonte MEP, Mendes FAS, Pikel M, Lopes A, Maciel L. Improvement of the gait stability after cognitive strategy patients with Parkinson's disease: A single-blind, randomised clinical trial. Mov Disord. 2015;30:S111-S2.

32.   van Tilborg IA, Kessels RP, Hulstijn W. How should we teach everyday skills in dementia? A controlled study comparing implicit and explicit training methods. Clin Rehabil. 2011;25:638-48. Epub 2011/03/24.

33.   El-Tamawy MS, Darwish MH, Khallaf ME. Effects of augmented proprioceptive cues on the parameters of gait of individuals with Parkinson's disease. Annals of Indian Academy of Neurology. 2012;15:267-72.

34.   Hollands KL, Pelton TA, Wimperis A, Whitham D, Tan W, Jowett S, Sackley CM, Wing AM, Tyson SF, Mathias J, Hensman M, Van Vliet PM. Feasibility and preliminary efficacy of visual cue training to improve adaptability of walking after stroke: Multi-centre, single-blind randomised control pilot trial. PLoS ONE. 2015;10 (10) (no pagination).

35.   Ji SG, Kim MK. The effects of mirror therapy on the gait of subacute stroke patients: a randomized controlled trial. Clinical Rehabilitation. 2015;29:348-54.

36.   Liu KP, Chan CC. Pilot randomized controlled trial of self-regulation in promoting function in acute poststroke patients. Arch Phys Med Rehabil. 2014;95:1262-7.

37.   Sayed HM, Fayez ES, Abd El Rahman SM, Yamany AA. Visual cues training on parkinsonian gait: A randomized controlled study. Egyptian Journal of Neurology, Psychiatry and Neurosurgery. 2013;50:331-7.

38.   Shen X, Mak MK. Balance and gait training with augmented feedback improves balance confidence in people with Parkinson's disease: A randomized controlled trial. Neurorehabilitation and Neural Repair. 2014;28:524-35.

39.   Yavuzer G, Selles R, Sezer N, Sutbeyaz S, Bussmann JB, Koseoglu F, Atay MB, Stam HJ. Mirror Therapy Improves Hand Function in Subacute Stroke: A Randomized Controlled Trial. Archives of Physical Medicine and Rehabilitation. 2008;89:393-8.

40.   De Paul VG, Meier J, Laylor M, Parokaran Varghese J, McIlroy W. Cortical activation during learning of a novel locomotor movement pattern: A pilot study. Int j. 2015;10:79-80.

41.   Frazzitta G, Maestri R, Uccellini D, Bertotti G, Abelli P. Rehabilitation treatment of gait in patients with Parkinson's disease with freezing: a comparison between two physical therapy protocols using visual and auditory cues with or without treadmill training. Mov Disord. 2009;24:1139-43.

42.   Gilmore PE, Spaulding SJ. Motor learning and the use of videotape feedback after stroke. Topics in Stroke Rehabilitation. 2007;14:28-36.

43.   Lee GY, Yip CC, Yu EC, Man DW. Evaluation of a computer-assisted errorless learning-based memory training program for patients with early Alzheimer's disease in Hong Kong: a pilot study. Clin Interv Aging. 2013;8:623-33.

44.   Marchese R, Diverio M, Zucchi F, Lentino C, Abbruzzese G. The role of sensory cues in the rehabilitation of parkinsonian patients: a comparison of two physical therapy protocols. Mov Disord. 2000;15:879-83.

45.   Nieuwboer A, Kwakkel G, Rochester L, Jones D, Van Wegen E, Willems A, Chavret F, Hetherington V, Baker K, Lim I. Cueing training in the home improves gait-related mobility in Parkinson's disease: The RESCUE trial. Journal of Neurology, Neurosurgery & Psychiatry. 2007;78:134-40.

46.   Schmidt J, Fleming J, Ownsworth T, Lannin NA. Video feedback on functional task performance improves self-awareness after traumatic brain injury: a randomized controlled trial. Neurorehabil Neural Repair. 2013;27:316-24.

47.   Walker C, Brouwer BJ, Culham EG. Use of visual feedback in retraining balance following acute stroke. Phys Ther. 2000;80:886-95.

48.   Sungkarat S, Fisher BE, Kovindha A. Efficacy of an insole shoe wedge and augmented pressure sensor for gait training in individuals with stroke: a randomized controlled trial. Clinical Rehabilitation. 2011;25:360-9.

49.   Capato TTC, Tornai J, Avila P, Barbosa ER, Piemonte MEP. Randomized controlled trial protocol: Balance training with rhythmical cues to improve and maintain balance control in Parkinson's disease. BMC Neurol. 2015;15 (1) (no pagination).

50.   Moore SA, Da Silva R, Balaam M, Brkic L, Jackson D, Jamieson D, Ploetz T, Rodgers H, Shaw L, van Wijck F, Price C. Wristband Accelerometers to motiVate arm Exercise after Stroke (WAVES): study protocol for a pilot randomized controlled trial. Trials. 2016;17:508.

51.   Van Der Loos M. Reaching in Stroke 3rd Phase (RISP3) 2016. Available from: https://clinicaltrials.gov/ct2/show/NCT02912923?term=stroke+cues&rank=5.

52.   Frazzitta G. Handwriting Rehabilitation in Parkinson Disease (HRPD) 2016. Available from: https://clinicaltrials.gov/ct2/show/NCT02718560?term=parkinson%27s+disease+cues&rank=18.

53.   Frazzitta G. Effectiveness of Different Approaches for the Rehabilitation of Gait in Patients With Parkinson's Disease (Tr-T-VR) 2017. Available from: https://clinicaltrials.gov/ct2/show/NCT03021408?term=parkinson%27s+disease+cues&rank=25.

54.   Ashoori A, Eagleman DM, Jankovic J. Effects of Auditory Rhythm and Music on Gait Disturbances in Parkinson's Disease. Front Neurol. 2015;6:234.

55.   Foster ER, Bedekar M, Tickle-Degnen L. Systematic review of the effectiveness of occupational therapy-related interventions for people with Parkinson's disease. American Journal of Occupational Therapy. 2014;68:39-49.

56.   Stinear C, Ackerley S, Byblow W. Rehabilitation is initiated early after stroke, but most motor rehabilitation trials are not: a systematic review. Stroke. 2013;44:2039-45. Epub 2013/05/30.

57.   DePaul VG, Wishart LR, Richardson J, Thabane L, Ma J, Lee TD. Varied overground walking training versus body-weight-supported treadmill training in adults within 1 year of stroke: a randomized controlled trial. Neurorehabil Neural Repair. 2015;29:329-40.

58.   Schmidt J, Fleming J, Ownsworth T, Lannin N, Khan A. Feedback interventions for improving self-awareness after brain injury: a protocol for a pragmatic randomised controlled trial. Australian Occupational Therapy Journal. 2012;59:138-46.

Table 1. Characteristics of included studies and effects of the interventions.

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
Del Olmo 2005[25]	Non-randomised case-control study	Not reported/ 5 sessions a week for a period of 4 consecutive weeks	Not reported	Rhythmic sound cues vs. no intervention	Idiopathic Parkinson's disease Female: 46.7% Age, mean (SD): 61.7 (5.2) MMSE: not reported N=15	No known neurological disorder Female: 26.7% Age, mean (SD): 63.1 (4.3) MMSE: not reported N=15	Velocity (m/min) Cadence (steps/min) Step length (combined in a coefficient of variability)	Intervention group data only reported. Coefficient of variability improved significantly for preferred gait, but there was no significant difference in coefficient of variability between intervention and control group.
Jung 2015[26]	RCT	Not reported/5 times per week for 4 weeks	Inpatient rehabilitation center, Korea	Gait training with auditory cues from cane	Stroke Female: 36% Age, mean (SD): 56.4 (11.1) MMSE: 26.7 (2.0) N= 11	Stroke Female: 30% Age, mean (SD): 56.3 (17.1) MMSE: 27.3 (2.4) N= 10	Velocity(cm/s)	Mean difference (95% CI) Intervention: 13.5 (7.1 to 19.9) Control: 3.7 (2.3 to 9.7) Difference between groups: P=0.022
Luft 2004[27]	RCT	2001 – 2004/ 1 hour 3 times per week for 6 weeks	Ambulatory rehabilitation program, US	Bilateral arm training with rhythmic auditory cueing	Stroke Female: 22% Age, mean (SD): 63.3 (15.3) MMSE: not reported N= 9	Stroke Female: 58% Age, mean (SD): 59.6 (10.5) MMSE: not reported N= 12	Fugl-Meyer Score

UMAQS | Mean difference between groups (95% CI) 2.22 (-1.63 to 6.07) P=0.24

Mean difference between groups (95% CI) 0.30 (-5.18 to 5.78) P=0.91 |
| Dobkin 2010[28] | RCT | July 2007 – Feb 2009/Cues once a day. | Inpatient rehabilitation, USA | Verbal cues - daily with encouragement | Stroke Sex not reported Age, mean (SD): | Stroke Sex not reported Age, mean (SD): | Walking speed (m/s) | Mean difference (SD), 95% CI Intervention: 0.91 (0.57) – |

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
				concerning walking speed, in addition to conventional inpatient rehabilitation	62.9 (12.6) MMSE: not reported N=88	65.1 (11.9) MMSE: not reported N=91	FAC ≥4	0.21 to 2.03 Control: 0.72 (0.44), -0.14 to 1.58 P=0.01 Intervention: 36% Control: 24% P=0.12
Dorsch 2014[29]	RCT (parallel-group)	March 2011 – October 2012/ Three times a week.	Inpatient rehabilitation centers, USA	Encouragement and review of walking performance summary graphs in addition to verbal cues about walking speed after activity	Stroke Female: 39.7% Age, mean (SD): 61.8 (15.7) MMSE: not reported N=78	Stroke Female: 39.4% Age, mean (SD): 65.0 (13.2) MMSE: not reported N=73	15 meter walking speed (m/s) FAC ≥4 SIS-16 score	Mean (SD) at discharge Intervention: 0.91 (0.53) Control: 0.93 (0.47) P=0.96 Intervention: 41 (61.2) Control: 34 (58.6) P=0.39 Intervention: 71.4 (18.9) Control: 72.9 (21.5) P=0.68
Mansfield 2015[13]	RCT	October 2012 - January 2014/Daily	Inpatient rehabilitation, Canada	Accelerometer-based daily cues about walking activity via physiotherapists	Stroke Female: 31% Age, mean (SD): 64.0 (19) MMSE: not reported N= 29	Stroke Female: 43% Age, mean (SD): 61.5 (13) MMSE: not reported N= 28	Cadence (steps/min)	Mean difference (95% CI) Intervention: 81.1 (77.9 to 84.4) Control: 77.0 (73.7 to 80.3) P=0.013
Mount 2007[30]	Randomized crossover design	Not reported/7 days of training	Rehabilitation hospital USA	Errorless learning of wheelchair transfer and use of sock donner	Stroke Female: Not reported Age, mean (SD): Not reported	Stroke Female: Not reported Age, mean (SD): Not reported	Wheelchair preparation task number of days to learn	Median number of days to learn task Intervention: 2.5 Control: 3

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
					MMSE: Not reported N= 16	MMSE: Not reported N= 17	Successful carry-over of wheelchair task to a similar task	Odds of carryover with trial and error learning OR=0.86, p=0.89, 95% CI 0.12 to 5.98
							Sock donning task number of days to learn	Median number of days to learn task Intervention: 3 Control: 2
							Successful carry-over of sock donning task to a similar task	Odds of carryover with trial and error learning OR=19.92, p=0.03,95% CI 1.34 to 2.96
Piemonte 2015[31]	RCT	Not reported/ 8 sessions twice a week	Parkinson Disease Associations, Brazil	Declarative memory cues during gait training	Parkinson's disease Female: 41% Age, mean (SD): 70.5 (6.4) MMSE: not reported N= 25	Parkinson's disease Female: 41% Age, mean (SD): 70.3 (4.1) MMSE: not reported N= 25	Gait speed (m/s) IADL	RM-ANOVA results: Interaction for training and assessment F(2,116)= 113.29, p<0.001, ES=0.95 (Gait speed increased for intervention group, but not the control group) Interaction for training and assessment F (2,116) =118.35, p<0.01, ES=0.85 (IADL decreased for control group, but not the intervention group)
Van Tilborg 2011[32]	Counterbalanced self-controlled study	Not reported/ 5 15 minute sessions	Group treatment facility in a local residential care	1) Implicit learning method	Dementia Female: Not reported	Healthy participants Female: Not	Microwave and coffee machine task	F(1,24)=2.09,p=0.16 (Both methods successful, but no difference between

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
			home, Netherlands	(modelling) 2) Explicit learning method (providing verbal cues).	Age, mean (SD): 79.8 (4.4) MMSE: 20.4 (3.5) N= 10	reported Age, mean (SD): 76.3 (7.1) MMSE: 27.7 (1.7) N= 16	performance	training methods)
El-Tamawy 2012[33]	RCT	Not reported/3 sessions a week for 8 weeks.	Outpatient, Egypt	Proprioceptive neuromuscular facilitation and vibratory stimuli during treadmill training in addition to routine physiotherapy program	Parkinson's disease Sex not reported Age, mean (SD): 61.4 (7.3) MMSE: not reported N=15	Parkinson's disease Sex not reported Age, mean (SD): 63.2 (5.6) MMSE: not reported N=15	Cadence (step/min) Walking speed (km/hr)	Mean (SD) Intervention: 105.87 (4.26) Control: 97.47 (3.68) P=0.001 Mean (SD) Intervention: 1.28 (0.1) Control: 0.96 (0.09) P value=0.001
Hollands 2015*[34]	RCT	(June 2012-October 2013) and follow-up periods (October 2013- January 2014)/ Twice weekly for 8 weeks	Outpatient neurorehabilitation services, UK	1) Treadmill walking training using visual cues 2) Overground walking training using visual cues	1) Stroke Female: 39% Age, mean (SD): 59.0 (18.0) MMSE: 24.9 (5.6) N= 18 2) Stroke Female: 26% Age, mean (SD): 56.1 (12.2) MMSE: 24.5 (6.3) N=19	Stroke Female: 58% Age, mean (SD): 60.0 (13.6) MMSE: 26.3 (3.0) N=19	Gait speed (m/s)	Median (IQR) change from baseline *Post-treatment* Treadmill based visual cue training: 0.14 (0.06, 0.32) Overground visual cue training: 0.18 (0.05, 0.34) Control: 0.09 (0, 0.15) *Follow-up* Treadmill based visual cue training: 0.12 (0.01, 0.26) Overground visual cue training: 0.18 (0.06, 0.45) Control: 0.20 (0.03, 0.28)

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
							Timed Up and Go (s)	Median (IQR) *Post-treatment* Treadmill based visual cue training: 29.7 (20.7, 50.2) Overground visual cue training: 34.4 (17.3, 55.4) Control: 31.2 (21.4, 55.2) *Follow-up* Treadmill based visual cue training: 28.3 (18.9, 59.7) Overground visual cue training: 35.2 (15.5, 45) Control: 26.8 (21.9, 38.7)
Ji 2015[35]	RCT	February 2013 - July 2013/Therapy 5 days per week for 4 weeks	Outpatient rehabilitation hospital, Korea	Mirror therapy for paretic limb	Stroke Female: 47% Age, mean (SD): 55.2 (7.5) MMSE: 26.9 (1.7) N= 17	Stroke Female: 41% Age, mean (SD): 54.3 (8.7) MMSE: 26.8 (1.6) N= 17	Cadence (step/min) Velocity, (cm/s)	Mean difference (SD) Intervention: –6.6 (−10.8 to −2.3) Control: –3.7 (−6.5 to −0.8) $p > 0.05$ Intervention: -16.8 (−27.9 to −5.6) Control: –9.5 (−16.0 to −3.0) $p > 0.05$
Liu 2014[36]	RCT	Not reported/ 5 one-hour sessions in one week	Hospital rehabilitation unit, Hong Kong	Self-reflection on performance of daily living tasks using video playback	Stroke Female: 54% Age, mean (SD): 69.7 (6.0) MMSE: not reported N= 24	Stroke Female: 45% Age, mean (SD): 72.3 (9.9) MMSE: not reported N= 20	Task performance (put clothes on hanger, fold the laundry, prepare a cup of tea, wash	$p < 0.01$ or $p < 0.001$ for 4 of 5 tasks in intervention not control group (not preparing a cup of tea)

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
							the dishes and carry out a monetary transaction)	
							FIM motor	Median before, after intervention Intervention:45.0, 68.0 Control: 43.0, 57.0 P=0.002
							FIM cognitive	Intervention: 32.0, 32.0 Control: 31.0, 31.0 P=0.052
							FMA UE	Intervention: 40.0, 50.0 Control: 51.0, 53.0 P=0.211
							FMA LE	Intervention:24.0, 28.0 Control:25.0, 26.0 P=0.657
Sayed 2013[37]	RCT/3 times per week for 6 consecutive weeks	Not reported	Outpatient clinic, Cairo	Visually cued 10 meter walking task in combination with physical therapy	Parkinson's Disease Female: not reported Age, mean (SD): 63.5 (4.9) MMSE: not reported N= 14	Parkinson's Disease Female: not reported Age, mean (SD): 61.6 (5.1) MMSE: not reported N= 14	Timed Up and Go

Step velocity | Mean (SD) Intervention: 13.65 (2.42) Control: 16.15 (3.98) Mean difference: 2.50 p=0.005

Mean (SD) Intervention: 0.81 (0.12) Control: 0.76 (0.18) Mean difference: 0.05 P=0.001 |

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
Shen 2014[38]	RCT	Not reported/ 8 weeks, 3 sessions per week	Parkinson's Disease Association and Outpatient Clinics, Hong Kong	Visually cued gait training with augmented cues	Parkinson's Disease Female: 40% Age, mean (SD): 63.5 (4.9) MMSE: 29.0 (1.7) N= 22	Parkinson's Disease Female: 48% Age, mean (SD): 63.5 (4.9) MMSE: 28.1 (2.5) N= 23	Gait velocity (cm/s)	Mean change (95% CI) Intervention: 9.6 (1.1 to 18.0) Control: 10.2 (5.6 to 14.8)
Yavuzer 2008[39]	RCT	February 2006 - April 2006/ 5 days a week, 2 to 5 hours a day, for 4 weeks	Rehabilitation education and research hospital, Turkey	Mirror therapy in addition to conventional rehabilitation program	Stroke Female: 47% Age, mean (SD): 63.2 (9.2) MMSE: not reported N= 17	Stroke Female: 47% Age, mean (SD): 63.3 (9.5) MMSE: not reported N= 19	FIM self-care score	Between group difference, Mean (SD) Intervention:5.20 (3.90) Control: 1.10 (2.60) Mean difference 4.10 P<0.01
De Paul 2015[57]	RCT (parallel-group)	January 1 2007 - August 31 2010/ 15 sessions over 5 weeks.	Outpatient clinic - Hamilton and Burlington, Ontario	Motor-learning-science–based overground walking training program with delayed, intermittent and summary cues	Stroke Female: 40.0% Age, mean (SD): 66.4 (11.0) MMSE: 28.0 (2.0) N=35	Stroke Female: 38.9% Age, mean (SD): 69.0 (12.3) MMSE: 27.4 (2.1) N=36	Comfortable gait speed (m/s) Fast gait speed (m/s) SIS ADL	Differential effect MLWP over BWSTT (95% CI) -0.00 (−0.11 to 0.11) p=0.98 0.02 (−0.10 to 0.14) p=0.79 1.68 (−0.72 to 4.09) p=0.17
Fong 2013[14]	RCT	Not reported/Intervention for 3 hours a day, 5 days per week for 3 weeks	Subacute inpatients Rehabilitation hospital Hong Kong	Conventional training and cueing wristwatch (vibration and auditory	Stroke Female: 15.8% Age, mean (SD): 66.2 (14.8) MMSE: 21.7 (4.2) N=19	Stroke Female: 43.8% Age, mean (SD): 68.6 (10.6) MMSE: 22.0 (4.5)	FIM	Between group difference, mean gain from baseline *Post-training* Intervention: 67.2 Control: 69.1 *Follow-up*

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
				signals)		N=16		Intervention: 107.8 Control: 96.1 p=0.843
							FTHUE	*Post-training* Intervention: 53.3 Control: 40.0 *Follow-up* Intervention: 93.3 Control: 60.0 p=0.340
							FMA UE	*Post-training* Intervention: 96.7 Control: 60.6 *Follow-up* Intervention: 152.5 Control: 75.8 p=0.301
Frazzitta 2009[41]	RCT	February 2013 – July 2013/Both groups received 20 minutes every day for 4 weeks	Inpatient rehabilitation hospital, Italy	Rehabilitation program based on treadmill training with auditory and visual cues	Idiopathic Parkinson's disease Female: 60% Age, mean (SD): 71 (8) MMSE: not reported N= 20	Idiopathic Parkinson's disease Female: 55% Age, mean (SD): 71 (8) MMSE: not reported N= 20	6MWT (m) Gait speed (m/s)	Mean increase Intervention: 130 Control: 57 P=0.0004 Intervention: 0.4 Control: 0.3 P=0.0126
Gilmore 2007[42]	RCT	Not reported/10 treatment sessions	Inpatient rehabilitation Ontario, Canada	Verbal cues after each practice performance augmented with	Stroke Female: not reported Age, mean (SD): 65.8 (7.8)	Stroke Female: not reported Age, mean (SD): 72.0 (14.1)	Socks and shoes subset of the KB-ADL	Mean (SD) *Sock subtest* Intervention: session 1: 3.0 (1.58), session 3: 6.2 (2.17)

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
				cues from the videotape replay.	MMSE: 28.0 (1.2) N= 5	MMSE: 27.25 (2.1) N= 5		Control: session 1: 3.2 (1.92), session 3: 5.4 (3.78) *Shoe subtest* Intervention: session 1: 2.0 (0.0), session 4: 4.2 (1.10) Control: session 1: 2.4 (1.67), session 4: 4.6 (1.34)
Lee 2013*[43]	RCT	Not reported/12 30 minute training sessions approximately twice a week	Psychogeriatric day hospitals, psychogeriatric outpatients and an elderly daycare center, China	1) Computer-assisted errorless learning program (CELP) 2) Therapist-led training program (TELP)	1) Alzheimer's disease Female: 85.7% Age: not reported MMSE: 15.3 (2.7) N=7 2) Alzheimer's disease Female: 50% Age: not reported MMSE: 17.0 (3.5) N=6	Alzheimer's disease Female: 66.7% Age: not reported MMSE: 17.6 (4.7) N=6	MBI HKLIADL	Between group difference. Mean (SD) Intervention 1: 2.83 (2.32) Intervention 2: 2.5 (3.33) Control: 0.71 (1.60) p=0.2 Intervention 1:2.17 (5.85) Intervention 2: 2.5 (3.27) Control: -2.14 (4.30) p=0.14
Marchese 2000[44]	RCT	Not reported/3 times per week for 6 consecutive weeks	Outpatient rehabilitation, Italy	Performed physical exercises with the visual (mirror, tracking lines), auditory (metronome), or tactile cues	Idiopathic Parkinson's Disease Female: not reported Age, mean (SD): 66.9 (6.3) MMSE: not reported N= 10	Idiopathic Parkinson's Disease Female: not reported Age, mean (SD): 65.0 (5.8) MMSE: not reported N= 10	ADL section UPDRS	Mean difference (SD) *Post-treatment* Intervention: -2.7 (2.54) Control: -2.8 (2.53) *Follow-up* Intervention: -2.7 (2.06) Control: -0.8 (4.66)

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
Nieuwboer 2007[45]	Single-blind randomised crossover trial	Not reported/3 weeks of training and 3 weeks without training	University Medical Centers in UK, Belgium and The Netherlands	3-week home cueing programme using a device delivering auditory, visual and somatosensory cues followed by 3 weeks without training	Parkinson's disease Female: 37% Age, median (IQR): 67.5 (61.5–72) MMSE, median (IQR): 28.5 (27–30) N=76	Parkinson's disease Female: 48% Age, median (IQR): 69 (62.5–73) MMSE, median (IQR): 29 (27–30) N=77	Gait speed (m/s) NEADL (0–66) TGUG (s)	Intervention change estimate (SE) Intervention: 0.05 (0.02) Intervention: 1.71 (0.94) Intervention: 20.0 (0.73)
Schmidt 2012*[58]	RCT	November 2009 - March 2012/ 4 sessions	Inpatient and community rehabilitation, Australia	1) Video cues following meal preparation task 2) Verbal cues following meal preparation task	1) TBI Female: 22% Age, mean (SD): 42.7 (11.7) MMSE: not reported N= 18 2) TBI Female: 22% Age, mean (SD): 41.6 (14.1) MMSE: not reported N= 18	TBI Female: 0% Age, mean (SD): 37.5 (13.0) MMSE: not reported N= 18	Number of errors	Mean difference between groups (95% CI) Video plus verbal: 19.7 (9.2 to 30.1) Verbal: 12.4 (1.8 to 23.0) Experiential: 7.3(-3.4 to 17.9)
Sungkarat 2011[48]	RCT	Not reported/ 15 sessions	Rehabilitation unit and physical therapy department, Thailand	Somatosensory and auditory cues during standing and gait training.	Stroke Female: 29% Age, mean (SD): 52.1 (7.2) MMSE: not reported N= 17	Stroke Female: 33% Age, mean (SD): 53.8 (11.2) MMSE: not reported N= 18	Gait speed (cm/s) Timed Up and Go (s)	Mean difference (SD) Intervention: 12.24 (11.7) Control: 4.06 (6.0) p=0.02 Intervention: 9.88 (9.2) Control: 4.41 (6.4)

Study	Type of study	Period of study/ length of intervention	Location and setting	Intervention and control	Intervention group (Type of neurological disorder, sex, age, MMSE, sample size)	Control group (Type of neurological disorder, sex, age, MMSE, sample size)	Outcomes	Results
								p=0.04
Walker 2000[47]	Controlled study	Not reported/regular therapy for 2 hours a day and an extra 30 minutes for the intervention groups until discharge	Inpatient rehabilitation unit, Canada	1) Regular therapy with visual cues from balance training 2) Regular therapy with verbal and tactile cues for balance training	1) Stroke Female: 25% Age, mean (SD): 65.4 (13.8) MMSE: not reported N= 16 2) Stroke Female: 50% Age, mean (SD): 62.4 (13.3) MMSE: not reported N= 16	Stroke Female: 36% Age, mean (SD): 62.4 (13.3) MMSE: not reported N= 14	Gait speed (m/s) Timed Up and Go (s)	Mean (SD) *Discharge* Intervention (VF): 0.57 (0.34) Intervention (CT): 0.89 (0.65) Control: 0.74 (0.53) *Follow-up* Intervention (VF): 0.63 (0.36) Intervention (CT): 0.93 (0.58) Control: 0.82 (0.60) *Discharge* Intervention (VF): 33.4 (20.3) Intervention (CT): 21.3 (12.8) Control: 29.3 (21.6) *Follow-up* Intervention (VF): 28.2 (20.2) Intervention (CT): 17.8 (9.8) Control: 28.8 (25.2)

*These studies had more than two study arms

Abbreviations: RCT, Randomised Controlled Trial; FAC, Functional Ambulatory Category; SD, Standard Deviation; CI, Confidence Interval; SIS-16, Stroke Impact Scale 16; P, P-value; RM-ANOVA, Repeated Measures ANOVA; F, ; IQR, Inter Quartile Range; FIM, Functional Independence Measure; FMA UE/LE, Fugl-Meyer Assessment Upper Extremity/Lower Extremity; ADL, Activities of Daily Living; FTHUE, Functional Test for the Hemiplegic Upper Extremity; 6MWT, 6 Meter Walk Test; KB-ADL, Klein-Bell Activities of Daily Living Scale; MBI, Modified Barthel Index; HKIADL, Hong Kong Instrumental Activities of Daily Living Scale; UMAQS, University of Maryland Arm Questionnaire for Stroke; UPDRS, Unified Parkinson's Disease Rating Scale; NEADL, Nottingham Extended Activities of Daily Living; TGUG, Timed Get Up and Go; , Mini Mental State Exam;

1 **Figure legends**

2 Figure 1. PRISMA flow diagram of the study selection process.

3 Figure 2. Forest plot of the results of randomised controlled trials to show the effect of cues
4 vs. no cues for walking speed (m/s) in therapeutic settings.

Supplementary material. GRADE profile to compare cues for different outcomes.

No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Cues	Control	Relative (95% CI)	Absolute	Quality
Walking speed (measured with: RCTs; Better indicated by higher values)											
5	randomised trials	serious[1]	no serious inconsistency	no serious indirectness	serious[2]	none	142	147	-	MD 0.08 higher (0.06 to 0.10 higher)	⊕⊕OO LOW
Walking speed (all studies)											
11	observational studies	serious[3]	very serious[4]	no serious indirectness	no serious imprecision	none	-	-	-	-	⊕OOO VERY LOW
								0%		-	
TUG											
5	observational studies	serious[5]	very serious[4]	no serious indirectness	serious[2]	none	-	-	-	-	⊕OOO VERY LOW
								0%		-	
Cadence											
4	observational studies	Serious[6]	Serious	no serious indirectness	serious[2]	none	-	-	-	-	⊕OOO VERY LOW
								0%		-	
Specific task performance											
4	observational	very	very serious[4]	no serious	serious[8]	none	-	-	-	-	⊕OOO

	studies	serious[7]		indirectness							VERY LOW
								0%		-	
Function test/ADLs											
10	observational studies	serious[9]	no serious inconsistency	no serious indirectness	serious[2]	none	-	-	-	-	$\oplus\bigcirc\bigcirc\bigcirc$ VERY LOW
								0%		-	

[1] 3/5 studies rated as serious risk of bias and 2/5 studies rated as No risk of bias therefore serious risk of bias overall

[2] <400 participants

[3] Majority of studies (9/11) rated as serious

[4] >2 studies disagree on the result

[5] 4/5 studies had a risk of bias rating as serious and 1/5 studies had no risk of bias.

[6] 3/4 studies rated as serious, 1/4 studies rated as no risk of bias and 1/5 studies rated as very serious risk of bias so overall judged to be serious risk of bias.

[7] 3/4 studies rated to be very serious risk of bias

[8] No explanation was provided

[9] 7/10 studies rated as serious risk of bias, 1/10 studies rated as very serious risk of bias and 2/10 studies rated as no risk of bias