13 Perceptual Disorders
Evidence Tables

Robert Teasell MD, Katherine Salter PhD (cand.), Andreea Cotoi MSc, Alice Iliescu BSc, Janet Donais OT

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### 13.1 Perceptual Deficits

#### 13.1.1 Treatment of Perceptual Disorders

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<th>Author, Year Country PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
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</thead>
<tbody>
<tr>
<td><strong>Weinberg et al.</strong> (1977) USA 6 (RCT)</td>
<td>57 unilateral right brain damaged (RBD) patients due to stroke at least 4 weeks after onset of stroke were studied. Patients were randomly assigned to the experimental group receiving 20 hours of testing (1 hour/day for 4 weeks in reading, writing and calculation) or to the control group that received no testing between evaluations. In each group, patients were divided into severe and mild visual perceptual deficits. Both groups received occupational therapy as part of general rehabilitation.</td>
<td>RBD severe experimental patients showed significant improvement on WRAT, paragraph, arithmetic, copying, H- cancellation, C- &amp; E- cancellation, picture completion, digit span, DSS (and confront. RBD mild experimental patients significantly improved on WRAT, H-cancellation, C- &amp; E-cancellation, face matching, digit span and impersistence, p=0.05. RBD mild control patients improved on face counting, picture completion and object assembly. RBD severe control patients demonstrated no significant improvement on any of the outcome measures. The experimental group showed more improvement than the control group, especially patients within the experimental group with more severe deficits.</td>
</tr>
<tr>
<td><strong>Weinberg et al.</strong> (1979) USA 6 (RCT)</td>
<td>53 stroke patients, at least 4 weeks post-stroke with right unilateral brain damage were randomly assigned to receive either 1-hour treatment, 5 days a week for 4 weeks of occupational and physical therapy (C) or to receive 15 hours of tracking target practice, searching for lights on board, cancellation of stimuli and practice in reading and 5 hours of training in sensory awareness and training in spatial organisation over 4 weeks (SC).</td>
<td>Those with severe brain damage receiving SC demonstrated significant improvement in 24 of 26 psychological test scores. Those with mild brain damage in the experimental group exceeded those in the control group on 3 of 26 measures and those with severe brain damage in the SC group exceeded those in the control group on 15 of the 26 measures.</td>
</tr>
<tr>
<td><strong>Weinberg et al.</strong> (1982) USA 5 (RCT)</td>
<td>35 right brain-damaged stroke patients at least 4 weeks post-onset of stroke with no clinical neurological signs of bilateral involvement were randomly assigned to an experimental group receiving 20 hours of perceptual retraining or to the control group receiving no perceptual retraining but an extra hour of rehabilitation therapy (usual occupational therapy).</td>
<td>Post-testing revealed that the experimental group significantly improved on visual-cognitive abilities with gains on 10 of 21 tests: embedded figures, visual simultaneity, conditional cancellation, WAI digit symbol, WAIS picture completion, WAIS block design, WAIS object assembly, Knox cubes, WAIS similarities and Goldstein object sort. The control group demonstrated significant improvement on only Conditional Cancellation, WAIS arithmetic and MAT comprehension.</td>
</tr>
<tr>
<td><strong>Carter et al.</strong> (1983) USA 5 (RCT)</td>
<td>33 acute stroke patients were randomly assigned to either a treatment group receiving cognitive skill remediation training administered on a 1-to-1 basis for 30 to 40 minutes 3 times a week on skill areas that needed improvement (visual scanning, visual-spatial, and time judgement skills) for 3 to 4 weeks or patients were randomized to the control group that did not receive any specific training.</td>
<td>Overall mean improvement score was significantly greater for the experimental than for the control group. For each of the specific tasks, improvement was significantly greater for the experimental group than for the control group on scanning, visual-spatial and time-judgement skills.</td>
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receive training but were included in other stroke programs.

<table>
<thead>
<tr>
<th>Study</th>
<th>Location</th>
<th>N (Type)</th>
<th>Intervention</th>
<th>Outcome</th>
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<tbody>
<tr>
<td>Gordon et al. (1985)</td>
<td>USA</td>
<td>No Score</td>
<td>77 stroke patients at least 4 weeks post-onset with right brain damage undergoing active rehabilitation were studied. All patients were right-handed and, exhibited no significant local impairment in visual acuity and demonstrated inattention as determined by neuropsychological testing. Patients were allocated to treatment groups depending on which rehabilitation service the patient was admitted to for treatment. The experimental group received a maximum of 35 hours of perceptual remediation while the control group participated in a leisure or conventional rehabilitation program without the perceptual remediation. At discharge, the experimental group demonstrated a greater improvement in 3 types of perceptual functioning. 4 months post discharge, the control group continued to show perceptual gains while the experimental group reached a plateau. Perceptual performance was equal between the groups at 4 months. The experimental group had a long-term reduction in anxiety but not depression. At discharge the experimental group showed an increase in recreational reading; however, this difference was no longer evident at 4 months.</td>
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</tr>
<tr>
<td>Lincoln et al. (1985)</td>
<td>UK</td>
<td>6 (RCT)</td>
<td>33 head injury and stroke patients with impairments of visual perception demonstrated by a score 2 SD below the mean normal score on Rivermead Perceptual Assessment Battery were randomly assigned to receive either perceptual retraining or to receive conventional therapy for 4 hours a week for 4 weeks. Both groups showed improvements on the Rivermead Perceptual Assessment Battery and the Rivermead Activities of Daily Living scale; however, no significant differences were observed between the perceptual retraining and conventional therapy groups.</td>
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<tr>
<td>Wagenaar et al. (1992)</td>
<td>No Score</td>
<td></td>
<td>5 right-brain-damaged stroke patients with visual inattention were investigated for efficacy of transfer effect of scanning training. Patients were treated according to B-C-B-D design: physical therapy given in all phases; occupational therapy applied during phase B, training of scanning apparatus was given during phase C and training on reading task was given during phase D. 4 out of 5 patients demonstrated a significant positive effect of visual scanning training on visual scanning behaviour. No evidence could be found for any transfer of visual scanning training effects to other domains (ie. gross motor skills).</td>
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<tr>
<td>Lincoln et al. (1997)</td>
<td>UK</td>
<td>6 (RCT)</td>
<td>315 stroke patients who were randomly assigned to receive rehabilitation for neglect on the stroke unit or to remain on conventional ward. Rey Figure Copy score were significantly better for stroke unit patients at 3 months 6 and 12 months compared to those patients on the conventional ward.</td>
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<tr>
<td>Edmans et al. (2000)</td>
<td>UK</td>
<td>6 (RCT)</td>
<td>80 stroke patients with perceptual problems and functional use of one hand were randomized to receive one of two treatment approaches administered for 2.5hr/wk for 6wk: 1) transfer of training approach focusing on a perceptual task, i.e. spatial relations, or 2) to a functional approach group focusing on a specific ADL task. Neither group showed significant improvement on perceptual and functional abilities post treatment. No significant difference between groups on initial demographics, initial scores, or scores at 6 weeks or final scores in outcome, i.e. the Barthel Index, Rivermead Perceptual Assessment and Edmans ADL Index.</td>
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<tr>
<td>Song et al. (2013)</td>
<td>South Korea</td>
<td>Pre-Post</td>
<td>Population: Neglect Group (NG; N=9): Mean age=56.9±9.5yr; Gender: Males=3, Females=6. Sensorimotor Deficit Group (SMG; N=11): Mean age=45.2±6.8yr; Gender: Males=4, Females=7. Intervention: All patients received 60min of physical therapy and 50min of occupational therapy 5x/wk, for a total of 6wk. Both groups also received additional separate somatosensory training for 40min for 3x/wk for 6wk, consisting of practicing functional activities and reach to grasp movements with and without 1. The MFT score on the affected and on the non-affected side of the NG increased significantly from pre to post-treatment (p&lt;0.05; p&lt;0.01). 2. In the NG group, the mean PASS, and K-MBI scores increased significantly from pre to post-treatment (p&lt;0.00; p&lt;0.05). 3. In the SMG, the MFT on the affected size increased significantly from pre to post-treatment (p&lt;0.00), as did the PASS scores.</td>
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visual aid. Participants were assessed at pre and post-training. 

**Outcomes:** Manual Function Test (MFT); Postural Assessment Scale for Stroke (PASS); Functional Reaching Test (FRT); Korean Modified Barthel Index (K-MBI).

4. MFT scores of the affected and unaffected sides were significantly different between groups with higher scores observed in the SMG group (p<0.05 for both).
5. PASS scores were significantly different between groups with higher scores observed in the SMG group (p<0.05).
6. FRT and K-MBI scores were not significantly different between groups.

### 13.1.2 Family Participation

#### 13.1.2 Family Participation in Rehabilitation

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<th>Author, Year Country</th>
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<tr>
<td>Osawa &amp; Maeshima (2010) Japan PCT No Score</td>
<td>34 patients with unilateral spatial neglect following right hemisphere stroke received either a) additional structured mobility exercises (2-3 times) in addition to usual therapy with the aid/support of family members OR b) instruction to keep out of bed, stay near the nursing station and to listen to music or talk with others during the day. This intervention was in addition to usual physio and occupational therapy (1 hour per day, 5 days per week). Outcomes were assessed after 3 weeks and included the BIT and laterality index, the MMSE, Raven’s colored progressive matrices, word fluency test, and the Rivermead Mobility Index and the Barthel Index.</td>
<td>There was a significant improvement on BIT scores in the individuals with family participation vs. those without (ANOVA, f=22.55, df=1, p&lt;0.0001, groupXBIT score). Similarly, there were significant improvements noted for line crossing, letter cancellation, star cancellation and line bisection tests for those individuals with family participation, but not for individuals without family participation. There were significant associations found between condition and both RMI and BI scores as well (p&lt;0.0001 and p&lt;0.001, respectively).</td>
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<td>Dai et al. (2013) China 5 (RCT)</td>
<td>48 patients with unilateral neglect were randomized to either a control or experimental group. Both of these groups received conventional rehabilitation however the experimental group also vestibular rehabilitation with a caregiver. The rehabilitation occurred for one month. A registered nurse trained the experimental group in vestibular rehabilitation. The primary caregivers in the experimental group were supervised and guided their patients in vestibular rehabilitation during the third and fourth weeks. Outcome measures were neglect, ADL, balance and falls.</td>
<td>The two groups of patients showed a significant improvement in neglect, ADL and balance over time. However, no statistically significant change was seen between the experimental and control group for outcome measures (p&gt;0.05).</td>
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### 13.3 Treatment of Neglect

#### 13.3.1 Visual Scanning

**Table 13.3.1 Visual Scanning Treatment for Neglect**
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<td>57 unilateral right brain damaged (RBD) patients due to stroke at least 4 weeks after onset of stroke were studied. Patients were randomly assigned to the experimental group receiving 20 hours of testing (1 hour/day for 4 weeks in reading, writing and calculation) or to the control group that received no testing between evaluations. In each group, patients were divided into severe and mild visual perceptual deficits. Both groups received occupational therapy as part of general rehabilitation.</td>
<td>RBD severe experimental patients showed significant improvement on WRAT (Wide Range Achievement Test), paragraph, arithmetic, copying, H- cancellation, C- &amp; E-cancellation, picture completion, digit span, DSS (patient is simultaneously touched in 2 of 4 possible locations (right or left cheek, right or left hand) and confront. RBD mild experimental patients significantly improved on WRAT, H-cancellation, C- &amp; E-cancellation, face matching, impersistence and digit span p=0.05. RBD mild control patients improved on face counting, picture completion and object assembly. RBD severe control patients demonstrated no significant improvement on any of the outcome measures. The experimental group showed more improvement than the control group, especially in more severe cases.</td>
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<td>Those with severe brain damage receiving SC demonstrated significant improvement in 24 of 26 psychological test scores. Those with mild brain damage in the experimental group exceeded those in the control group on 3 of 26 measures and those with severe brain damage in the SC group exceeded those in the control group on 15 of the 26 measures.</td>
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<tr>
<td>Young et al. (1983)</td>
<td>Canada</td>
<td>PCT</td>
<td>27 hemiplegic stroke patients who had significant neglect and/or visual scanning deficits were assigned to one of three groups. Group 1 received routine occupational therapy; Group 2 received 20 minutes of routine occupational therapy, 20 minutes of cancellation training and 20 minutes of visual scanning training; Group 3 received 20 minutes of block design training, 20 minutes of cancellation training and 20 minutes of visual scanning training.</td>
<td>Group 2 and Group 3 improved significantly more on measures of visual scanning, reading and writing compared to Group 1 and Group 3 improved to a significantly greater extent when compared to Group 2.</td>
</tr>
<tr>
<td>Gordon et al. (1985)</td>
<td>USA</td>
<td>PCT</td>
<td>77 stroke patients at least 4 weeks post-onset with right brain damage undergoing active rehabilitation were studied. All patients were right-handed and, exhibited no significant local impairment in visual acuity and demonstrated inattention as determined by neuro-psychological testing. Patients were allocated to treatment groups depending on which rehabilitation service the patient was admitted to for treatment. The experimental group received a maximum of 35 hours of perceptual remediation while the control group participated in a leisure or conventional rehabilitation program without the perceptual remediation.</td>
<td>At discharge, the experimental group demonstrated a greater improvement in 3 types of perceptual functioning. 4 months post discharge, the control group continued to show perceptual gains while the experimental group plateaued. Perceptual performance was equal between the groups at 4 months. The experimental group had a long-term reduction in anxiety but not depression. At discharge the experimental group showed an increase in recreational reading; however, this difference was no longer evident at 4 months.</td>
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13 patients with stabilized hemineglect symptomatology due to right-hemisphere lesions were subjected to rehabilitation training specifically aimed at reducing scanning deficits. The training procedure consisted of visual-spatial scanning, reading and copying training, copying of line drawings on a dot matrix and figure description. At the end of therapy all patients showed significant improvement on several standard test of hemineglect however, patients improved only slightly on standard visual-spatial tests thereby indicating a specificity of training in reducing the scanning defect.

Ladavas et al. (1994) Italy PCT No Score

12 patients with lesions in the right parietal lobes were selected for the study. Stroke onset was at least 6 months prior to study. All patients’ demonstrated visual and tactile neglect as well as visual and tactile extinction and all patients had hemiplegia or hemiparesis. Patients were assigned to either the covert orienting intervention group, the overt orientating group or to the control group (tactile modality). In the covert attention condition, patients were instructed to keep fixating the central point while directing attention to the cued box; in the overt attention condition, patients were instructed to look directly at the cued box and to keep fixating the central point. Eye movement was monitored through 2 mirrors fastened at the two sides of the screen. Treatment was given for 1 hour a day, 5 days a week for 6 weeks. Both overt and covert orienting were equally effective in improving visual extinction and neglect. No improvement was noted for those tests that involved the tactile modality.

Antonucci et al. (1995) Italy 4 (RCT)

20 stroke patients with right unilateral brain damage (RBD) on an MRI and with no hemi-inattention ≥ 2 months post-onset were studied. Patients received either immediate or delayed treatment consisting of 8 weeks training in visual scanning, reading & copying, copying line drawings and figure description. Significant improvement was observed in both the delayed & immediate treatment groups on Barrage Test, Letter cancellation, sentence reading test and Wundt-Jastrow area illusion test. Significant groupxtime interactions were found during the first 8wk for Letter Cancellation (p<0.005), Sentence Reading (p<0.01), Wundt-Jastrow Area Illusion Test (p<0.08) with greater performances observed in the immediate treatment group. No groupxtime interaction was found for the Barrage Test in the first 8wk.

Paolucci et al. (1996) Italy 6 (RCT)

59 right hand dominant, right sided stroke patients, onset 2 to 6 months were studied. Patients received treatment for neglect in 5 X 1 hour sessions per week over 8 weeks (immediate treatment) and then general cognitive treatment 3 X 1 hr sessions per week over 8 weeks (delayed treatment). Patients were randomized to which treatment they would receive first and then were crossed over with the second treatment. Specific training included visual scanning, reading and copying, copying of line drawings, and description of a scene. Subjects were evaluated at baseline, following the first phase of training and following the second phase of training. Improvement was noted in both delayed and immediate treatment groups on Rivermead Mobility Index, Barthel Index, Canadian Neurological Scale, Letter Cancellation Test, Barrage Test, Wundt-Jastrow Area Illusion Test, and Sentence Reading Test.

Wiart et al. (1997) France 4 (RCT)

22 stroke patients with recent stroke of less than 3 months onset who exhibited severe unilateral neglect syndrome with line bisection > 11% of right deviation, line cancellation > 2% of right deviation and line cancellation > 2 left omission (LO) and Bell test of > 6 LO. All 4 test results - line bisection, line cancellation, bell test, and change in Functional Independence Measure improved significantly more in the experimental group relative to the control group at 30 and 60 days.
Patients were randomized to either an experimental or to a control group. Experimental group received 1 hour a day for 20 days of the Bon Saint Come method (use of a device with attached pointer which required trunk rotation to complete scanning tasks) followed by 2 to 3 hours of traditional rehabilitation (1 to 2 hours of PT and 1 hour of OT). Control group received 3 to 4 hours of traditional rehabilitation.

<table>
<thead>
<tr>
<th>Niemeier (1998)</th>
<th>31 stroke patients undergoing comprehensive day rehabilitation were selected in order of their consecutive admissions and on the basis of documented left or right neglect. All subjects received comprehensive multidisciplinary rehabilitation. Treatment group received in addition the &quot;Lighthouse strategy&quot; in which they were instructed to be like horizontal illuminating lighthouses and turn their heads left and right during functional and therapy training tasks. A significant main effect for the treatment procedure was obtained on the Sheltering Arms Functional Autonomy Rating Scale (FARS) in the area of attention. Mesulam Verbal Cancellation test was significantly improved between admission and discharge for experimental group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niemeier et al. (2001)</td>
<td>19 stroke patients with unilateral visual neglect were assigned to receive 3-30 minute sessions of &quot;Lighthouse Strategy&quot; training in addition to usual rehabilitation (n=10) or to the waiting list for treatment. Treatment was associated with significantly better performance on route-finding, walking or wheelchair and problem-solving tasks (all p&lt;0.05). Measures of FIM safety judgement and community reentry and Rancho Los Amigos Cognitive and Behavioural Scale did not demonstrate significant differences associated with treatment.</td>
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<tr>
<td>Piccardi et al. (2006)</td>
<td>7 patients with right-brain damage approx. 2 months following a unilateral stroke, received rehabilitation for neglect using the program of visuo-spatial scanning training (VST) proposed by Pizzamiglio et al. (1992). 45-minute training sessions were conducted around 4 tasks (visual-spatial scanning, reading &amp; copying training, copying line drawings, description of scenes), 5 days a week over a period of 2 months. Assessment for hemineglect (line cancellation, letter cancellation, word/non-word reading test, Bell’s test) and functional ability (serving tea, card dealing, use of common objects) was conducted prior to and shortly after the program of rehabilitation. Screening for attentional disorders was also conducted before, at 2 weeks and after treatment. ANOVA revealed a significant main effect of intervention on the results of assessments of visuo-spatial neglect (F (1,5) = 51.84, p&lt;0.001). Similarly, the rehabilitation program appeared to improved patients’ functional ability (t=3.637, p=0.011). Effectiveness of VST was not affected by the presence of attentional impairments. Performance on attentional assessments was also not affected by VST.</td>
</tr>
<tr>
<td>Ferreira et al. (2011)</td>
<td>10 right-handed patients with hemispatial neglect following right hemisphere ischemic strokes were randomly allocated into study groups; visual scanning (n=5), mental practice (n=5) and control group (n=5). The treatment groups attended 10, 1-hour sessions over 5 weeks. Visual scanning protocol included 4 tasks, each lasting 15-minutes, in which the patient was asked to scan from the left side and instructed participants to touch or mention various figures or objects. The mental practice protocol included 4 tasks; 2 using motor imagery and 2 using visual imagery. All groups received physical therapy, the control group received only physical therapy. Primary outcome measures were BIT score There was a significant difference among the 3 groups in five weeks in Behaviour Inattention Test (BIT) score changes (p=0.047) and in FIM self-care item score changes (p=0.035), the visual scanning protocol being responsible for these differences both in BIT (p=0.008) and in FIM self-care item scores (p=0.016). Therefore visual scanning should probably be considered preferable to mental practice protocols in the treatment of hemispatial neglect patients.</td>
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</table>
(behavioural inattention test) and FIM self-care item score. Assessments were performed in the intervention groups; pre-treatment and three months after that, control patients were evaluated twice with 2 month between evaluations.

**van Kessel et al.** (2013) Netherlands RCT PEDro=6 TPScon=157.6d TPSexp=140.6d NStart=29 NEnd=29

**Population:** Control Group (CG; N=15): Mean age=59.1±6.1yr; Gender: Males=10, Females=5; Experimental Group (EG; N=14): Mean age=61.9±7.8yr; Gender: Males=7, Females=7.

**Intervention:** Subacute right hemispheric stroke patients were semi-randomly assigned to the EG or CG. All patients received 30 Visual Scanning Training (VST) sessions during 6wk. The EG was administered the same training schedule, but from 4-6wk of the training, a standardized VST digit detection task was combined with lane tracing on the same projection screen, to create a dual task. Participants were assessed twice on two separate days 1 or 2wk prior to the start of the training. Post-training assessments were obtained 1 or 2wk after the end of the training.

**Outcomes:** Behavioral Inattention Test (BIT)
Conventional subtest: Letter Cancellation Test (LtrCT), Line Bisection Test (LBT), Line Crossing Test (LCT); Bell’s Cancellation Test (BCT); Word reading task; Grey Scales Index (GSI); Semi-structured neglect questionnaire: extrapersonal, personal; Subjective neglect questionnaire.

1. The number of omissions in the LCT, LtrCT and BCT significantly decreased after training within both groups (p<0.01; p<0.001; p<0.005) but no significant between group difference was observed.
2. Both groups showed significant within group improvements in reading errors (p<0.005), GSI (p<0.05), extrapersonal section of the semi-structured neglect questionnaire (p<0.001), personal section of the semi-structured neglect questionnaire (p<0.005) and the subjective neglect questionnaire (p<0.005); no significant between group differences were observed.
3. Patients in both groups had significantly improved on lateral positions in the single as well as the dual lane tracking after training (p<0.05) but no difference between the groups was found after training.
4. No significant correlations of any measures were found.

**Priftis et al.** (2013) Italy RCT PEDro=5 TPSLat=81.7d TPSRT=101.6d TPSExp=97.1d NStart=33 NEnd=31

**Population:** Limb Activation Treatment (LAT; N=10): Mean age=64.1±16.4yr; Gender: Males=5, Females=5; Prism Adaptation (PA; N=11): Mean age=68.4±10.4yr; Gender: Males=5, Females=6; Visual Scanning Training (VST; N=10): Mean age=67.6±13.3yr; Gender: Males=6, Females=5.

**Intervention:** Right-hemisphere-damaged patients who showed left neglect (LN) were quasi-randomized to receive either visual scanning training (VST), limb activation treatment (LAT), or prism adaptation (PA). Each program lasted 2wk and consisted of 20 sessions, with 1 session in the morning and 1 session in the evening, and each session lasting roughly 20min. Assessments were conducted at baseline (A1 and A2), post-intervention (A3) and at a 2wk follow-up (A4).

**Outcomes:** Fluff Test (FT); Comb and Razor Test (CRT); Picture Scanning subtest (PS); Menu Reading subtest (MR); Coin Sorting subtest (CR); Semi-structured ecological scale (Subtest A – serving tea, Subtest C – card dealing); Room description; Catherine Bergego Scale (CBS).

1. There was no significant main effect of intervention type observed for any of the outcomes (FT, CRT, PS, MR, CS, semi-structured ecological scale (both subtests), room description and CBS).
2. A significant difference between A1 and A2 was observed on the FT (p<0.05).
3. Significant differences between A2 and A3 were observed on the PS (p<0.05), MR (p<0.05), semi-structured ecological scale subtest C (p<0.05) and CBS (p<0.05).
4. Significant differences between A3 and A4 were observed on the semi-structured ecological scale subtest C (p<0.05) and A (p<0.05).
5. No significant effects of intervention type by assessment point were observed for any outcome and no other significant effects were observed.

**Chan & Man** (2013) China

**Population:** Experimental Group (EG; N=20): Mean age=59.7±13.8yr; Gender: Males=16, Females=4. Control

1. The improvement in CBS scores was significantly greater in the EG compared to
RCT
PEDro=6
TPSov=20.1±15.8d
TPSCon=11.9±6.4d
NStart=40
NEnd=40

Group (CG; N=20): Mean age=60.2±11.6yr; Gender: Males=20, Females=0.

**Intervention:** The EG received visual scanning training along with conventional rehabilitation whilst the CG received conventional rehabilitation only. The visual scanning program was provided 3/wk for 4wks with each session lasting 45mins. Assessments were conducted at baseline and at post-treatment.

**Outcomes:** Behavioural Inattention Test-Conventional Subtest (BIT-CT); Catherine Bergego Scale (CBS); Mini Mental State Examination (MMSE); Modified Barthel Index (MBI).

4.

The CG demonstrated significant increase from baseline to post-treatment on the MMSE (p=0.010), BIT-CT (p<0.001) and CBS (p<0.001) but not on the MMSE (p=0.065).

5.

There were no other statistically significant differences between the two groups on other assessments.

6.

The between group difference for BIT-CT scores approached significance with the EG showing a greater change compared to the CG (EG: ΔM=26.03±8.23; CG: ΔM=23.23±7.34; p=0.052).

---

**van Wyk et al. (2014)**

South Africa

RCT

PEDro=8

TPSoverall=1-3wk

NStart=24

NEnd=24

**Population:** Experimental Group (EG; N=12); Control Group (CG; N=12)

**Intervention:** Participants were randomized to either the EG and received saccadic eye movement training with visual scanning exercises integrated with task-specific activities, or to the CG and received only task-specific activities. The training lasted 4wk. Participants were assessed before and after the training.

**Outcomes:** King-Devick Test (KDT): subtests 1, 2 and 3; Star Cancellation Test (SCT); Barthel Index (BI).

1.

The KDT subtest 3 score at 4wk was significantly better in EG compared to CG (p=0.02).

2.

The difference in the SCT was not significantly different between the two groups at 4wk (p=0.06). However, when comparing the difference in ranks of stars "cancelled" after adjusting for matching and baseline values, participants from the EG were significantly better than participants in the CG (p=0.02).

3.

EG showed higher level of functional performance on the BI compared to CG after the intervention (p=0.004).

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### 13.3.2 Computer Based Rehabilitation

**Table 13.3.2 Computer-Based Rehabilitation in Neglect**

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robertson et al. (1990)</td>
<td>Scotland</td>
<td>6 (RCT)</td>
<td>36 stroke patients with unilateral left visual field neglect were randomized to one of 2 groups: Computer scanning and attention training (Group 1) or recreational computing (Group 2). Group 1 received an average of 15.5 hours of training and the control group received on average 11.4 hours of control computer use.</td>
<td>No significant differences were noted between the groups on any outcome measure: Behavioural Inattention Test, WAIS-R, Neale Reading test, letter cancellation test, or Rey-Osterreith Test, an observers’ report of neglect.</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Score</td>
<td>Participants</td>
<td>Intervention Details</td>
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</tr>
<tr>
<td>Fanthome et al.  (1995)</td>
<td>UK</td>
<td>No Score</td>
<td>14 patients</td>
<td>Visual neglect, computer games</td>
</tr>
<tr>
<td>Webster et al.   (2001)</td>
<td>USA</td>
<td>No Score</td>
<td>40 patients</td>
<td>Computer assisted training (CAT)</td>
</tr>
<tr>
<td>Kim et al.       (2011)</td>
<td>Korea</td>
<td>No Score</td>
<td>12 patients</td>
<td>Virtual reality</td>
</tr>
<tr>
<td>Castiello et al. (2004)</td>
<td>UK</td>
<td>No Score</td>
<td>6 patients</td>
<td>Virtual reality</td>
</tr>
<tr>
<td>Location</td>
<td>Study Design</td>
<td>Participants</td>
<td>Intervention</td>
<td>Outcomes</td>
</tr>
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<tr>
<td>13. Perceptual Disorders</td>
<td><a href="http://www.ebrsr.com">www.ebrsr.com</a></td>
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</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Geographical Location</th>
<th>Sample Size</th>
<th>Intervention Details</th>
<th>Outcomes Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katz et al. (2005)</td>
<td>Israel</td>
<td>19 patients</td>
<td>Right hemispheric stroke and USN</td>
<td>Patients in both conditions experienced improvement over the course of the sessions. Significant within group improvements were demonstrated on the Mesulam symbol cancellation test in the control group, and on the ADL checklist for both groups (p&lt;0.05). ADL performance was significantly worse among patients in the treatment condition than in the control condition at both assessment times. For VR street crossing performance, the treatment group demonstrated significant improvement in looking to the left and number of accidents. Change in “looking left” did not differ between groups, while the treatment group showed a greater decrease in the number of accidents when compared to controls (p&lt;0.05), although the number of accidents in the treatment group at baseline was &gt;2x that of the controls. In real street crossing performance, there were no significant between group differences reported, although the authors note that the direction of the results suggests greater improvement was experienced by those patients in the treatment condition. A moderate association between decision times in real life street crossing and the number of times looking left in the VR scenario (r=0.47; NS) and the ADL checklist score (r=0.49, p&lt;0.05) was reported.</td>
</tr>
<tr>
<td>Thimm et al. (2006)</td>
<td>Germany</td>
<td>Population: Mean age=65yr; Gender: Males=5, Females=2.</td>
<td>Patients with right hemisphere brain damage and neglect due to stroke underwent 14 sessions of computer-based alertness training over 3wk with each session lasting for 45min. Assessments were conducted at baseline, 3wk following the first measurement, post-intervention and 4wk post-intervention.</td>
<td>1. The number of improved neglect test results was significantly greater post-intervention compared to the baseline phase (p=0.026). 2. Group analysis of the fMRI neglect task post-intervention revealed significantly increased number of detected stimuli for the left (p=0.04) but not the right side (p=0.16). These improvements did not persist at 4wk post-intervention. 3. 5 patients showed a significant improvement on at least 1 neglect task post-intervention and 3 patients showed significant improvement on at least one test 4wk post-intervention. 4. Group analysis of the fMRI alertness task revealed no significant improvements; 1 patient showed significantly faster reaction times compared to baseline and 4 patients</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Score</td>
<td>Methodology</td>
<td>Results</td>
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<tr>
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</tr>
<tr>
<td>Ansuini et al. (2006)</td>
<td>Italy</td>
<td>No Score</td>
<td>6 patients with left neglect following right hemisphere stroke participated in a training intervention involving grasping either a real or virtual object presented with a midline, 30 deg left or 30 deg right presentation. A data glove on the reaching hand allowed the patient to see his/her hand movement in a virtual environment. Following 120 training trials (baseline session), participants were required to reach for real objects located at 1 of the 3 locations while viewing the real-time virtual representation of their hand (training session). While moving toward the real object, a virtual hand could be seen moving toward a virtual object. The virtual and real objects could be either spatially congruent or incongruent. In total, 240 trials were conducted with rest period provided every 60 trials. Following the training session, patients were asked to perform a “sensory” task – reporting verbally the location in which the object appeared. All sessions were conducted in the same day.</td>
<td>For analysis, patients were separated into 2 groups based on lesion location; 1) fronto-parietal (FP) vs 2) temporo-parietal (TP). At baseline, patients in both groups were unable to respond to leftward targets (when compared to “control” subjects – p&lt;0.01). Performance of all groups was similar re: central and rightward targets (p&gt;0.5). Only patients in the FP group demonstrated significant improvement in responses to targets on the left following training (p&lt;0.01) – patients in the TP group did not show improvement. Similarly, on the sensory task, FP patients demonstrated significant improvement (p&lt;0.001) while TP patients did not.</td>
</tr>
<tr>
<td>Kim et al. (2007)</td>
<td>Korea</td>
<td>No Score</td>
<td>10 subjects with left visual neglect following right hemisphere stroke took part in virtual environment training sessions. Wearing a head-mounted display, the participant attempts to keep his avatar safe while crossing the road by detecting cars approaching from either the left or right. Visual and auditory cues were provided as the car approached as necessary. Level and difficulty were controlled by increasing the speed of the cars or decreasing the distance from the cars to the avatar. 60 trials were completed.</td>
<td>Patients with neglect performed significantly worse than normal controls in terms of reaction time, need for visual and auditory cues and task failure rates. To assess the effectiveness of the training system in improving neglect, left/right ratio scores and deviation angles were calculated. The authors reported that asymmetry for neglect decreased following training and this effect remained at the 3 month follow-up.</td>
</tr>
<tr>
<td>DeGutis and Van Vleet (2010)</td>
<td>USA</td>
<td>No Score</td>
<td>Population: Experimental Group (EG; N=12): Mean age=57.0±18.5yr; Gender: Males=9, Females=3; Control Group (CG; N=12): Mean age=66.0±9.0yr; Gender: Males=8, Females=4. Intervention: Experiment 1 (N=24): Patients with hemispatial neglect due to stroke were assigned to the EG and received the Tonic and Phasic Alertness Training (TAPAT) computer-based visual discrimination training or to the CG and were wait listed for treatment. The EG received training for 9 consecutive days with each session lasting approximately 42min. Experiment 2 (N=3): 3mo post-TAPAT, 3 patients received 9d of visual searching training. Outcomes: Visual Conjunction Search task (CS); Alternative CS; Subjective Midpoint Estimation task (LM); Spatial and Non-Spatial Selective Attention task (AB).</td>
<td>Experiment 1. 1. EG showed no significant improvements on commission accuracy, correct commission reaction time, or omission accuracy following TAPAT. 2. A three factor ANOVA comparing side of display (left/right), group and time (pre/post) for the CS task revealed no significant main effects but a significant three-way interaction between factors (p&lt;0.05); a greater improvement in searching the left side was observed in the EG compared to CG. 14d post-intervention, the difference between detecting left and right targets was not significantly different from baseline. 3. A two factor ANOVA comparing side of display and time for the alternative CS task in the EG revealed a significant effect of time (p&lt;0.05) and a significant interaction of side x time (p&lt;0.05); no difference was observed in the detection of left vs. right</td>
</tr>
</tbody>
</table>
13. Perceptual Disorders

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| Kim et al. (2011) | 24 stroke patients who had unilateral spatial neglect as a result of right hemisphere stroke were recruited. Patients were randomly assigned to virtual reality (n=12) or control (n=12). The virtual reality group wore gloves that read responses of patients to a virtual reality program intervention administered for 30 minutes a day, once a day, five times a week. The virtual reality program had three conditions; i) a program that required the participant to touch a flying ball, ii) the participant had to catch a coconut and iii) the patients moved a box carried in a container from one side of the simulation to the other. The primary outcome measures were the star cancellation test, line bisection test, the Catherine Bergego Scale (CBS) and the Korean version of modified Barthel Index (K-MBI). These measurements were taken before and after treatment. All patients performed the other tests accurately. The two groups did not show any significant differences in performance on the star cancellation test, line bisection test, CBS before treatment and K-MBI. After treatment, both groups showed significant improvement in the star cancellation test, line bisection test, CBS and K-MBI (p<0.05). The VR group showed a greater increase in the star cancellation test and CBS score after treatment than the control group (p<0.05), there were no between differences after treatment on the line bisection and K-MBI assessments. | targets post-intervention however, patients took significantly longer to detect left targets 14d post-intervention (p<0.05).

4. A two factor ANOVA comparing time and group for the LM task revealed no significant main effects but a significant interaction between factors (p<0.05); a greater leftward shift was observed in the EG compared to the CG post-intervention. At 14d and 28d post-intervention, the EG had shifted their estimation significantly rightward compared to post-intervention (p<0.05).

5. A two factor ANOVA comparing time and group for the AB task revealed a significant effect of time (p<0.005) and a significant interaction between factors (p<0.05); a greater improvement was observed in the EG compared to the CG post-intervention however, by 14d and 28d post-intervention, there was no significant difference between baseline.

Experiment 2

1. Following TAPAT training, all patients demonstrated a significant reduction in the search bias score on the CS task (left display time/right display time) (p<0.05 for all), while no patients showed a significant reduction in the search bias score post-searching training.

2. Following TAPAT training, 2 patients significantly shifted their midpoint to the left on the LM task (p<0.05) and 1 showed a trend towards significance (p=0.058). Following searching training, no patients showed a significant leftward shift.

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<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Sample Size</th>
<th>Design</th>
<th>Intervention</th>
<th>Outcome Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modden et al. (2012)</td>
<td>Germany</td>
<td>45</td>
<td>RCT</td>
<td>Compensatory Therapy (CT), Restorative Computerized Training (RT), standard inpatient rehabilitation therapy</td>
<td>Visual scanning abilities, attention, perimeter test</td>
<td>CT resulted in better visual search performance when compared with OT. RT did not result in a larger expansion of the visual field. Intra group comparisons (pre-post) showed that CT improved significantly in all outcome parameters, RT improved significantly in visual field enlargement, cancelation tasks of the BIT, attention, and Extended Barthel Index. OT improved on the Extended Barthel Index only.</td>
</tr>
<tr>
<td>Jo et al. (2012)</td>
<td>Korea</td>
<td>29</td>
<td>RCT</td>
<td>Virtual Reality (VR) training or no intervention control group</td>
<td>WMFT, MVPT</td>
<td>Both groups improved on the WMFT, yet, no differences were observed between the 2 groups on this measure. The MVPT total score, response time, visual difference, and figure ground subtests showed significant differences between the two groups in favour of VR training (p&lt;0.05)</td>
</tr>
<tr>
<td>Funk et al. (2013)</td>
<td>Germany</td>
<td>13</td>
<td>No Score</td>
<td>Computer training of visual line orientation</td>
<td>Visual line orientation discrimination and visuospatial and visuoconstructive tasks</td>
<td>Rapid improvements in both trained and untrained spatial orientation tests were observed in all 13 participants. Furthermore, improvements were maintained at 8 week follow up. A transfer of improvements related to spatial tasks was also observed, however, no transfers to unrelated measures of visual performance were observed.</td>
</tr>
<tr>
<td>Van Vleet and DeGutis (2014)</td>
<td>USA</td>
<td>41.8±13.2mo</td>
<td>No Score</td>
<td>Tonic and Phasic Alertness Training (TAPAT) computer-based auditory discrimination training</td>
<td></td>
<td>1. A three factor ANOVA comparing time (pre/post), side of the display (left/right) and group (EG/CG) for the CS task revealed a significant main effect of side of the display (p&lt;0.01), time (p&lt;0.05) and a significant interaction of side of display x time x group (p&lt;0.05); greater improvements was found in searching the left side of the display in</td>
</tr>
</tbody>
</table>
N\textsubscript{EG}=16 were wait listed for treatment. The EG received training for 9 consecutive days with each session lasting approximately 42min. **Outcomes:** Visual Conjunction Search task (CS); Subjective Midpoint Estimation task (LM); Spatial and Non-Spatial Selective Attention task (AB).

2. A two factor ANOVA comparing time and group for deviation from the centre on the LM task revealed an interaction between factors approaching significance (p<0.18) but no significant main effects; a more leftward shift was observed in the EG compared to the CG.

3. A two factor ANOVA comparing time and group for each lag (2 and 6) for the AB task revealed a significant main effect of time for lag 2 (p<0.01), a significant time x group interaction for lag 2 (p<0.01) and a significant time x group interaction for lag 6 (p<0.01) although no main effects were found for lag 6; greater improvement at lag 2 and lag 6 was seen in the EG compared to the CG.

### 13.3.4. Limb Activation

**Table 13.3.4 Limb Activation Interventions for Neglect**

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robertson et al. (1994)</td>
<td>UK</td>
<td>No Score</td>
<td>6 patients with unilateral neglect and 6 control subjects were instructed to walk a short distance to a doorway. The position of the top of their head in relation to a scale positioned above the door was measured. This was repeated 10 times for each subject. In one-half of these tests, the subjects were instructed to clench and unclench their left hand while walking.</td>
<td>All participants with neglect deviated to the right of centre as measured by their position in the doorway. Analysis of variance demonstrated deviation to the right was greater in the neglect (no hand movement) condition than in other conditions. Hand movement resulted in significantly less deviation toward the right in neglect patients when compared to no hand movements (p=0.03). The neglect hand movement condition did not differ significantly from control conditions.</td>
</tr>
<tr>
<td>Kalra et al. (1997)</td>
<td>UK</td>
<td>7 (RCT)</td>
<td>50 stroke patients with partial anterior circulation infarctions and visual neglect identified by a comprehensive assessment were randomly assigned to receive either therapy aimed to restoring normal tone, movement patterns and motor activity or to receive therapy aimed at integrating attentional and motor functions using the limb activation approach.</td>
<td>Significant improvement was noted on body image and cancellation subtest of the (RPAB) Rivermead Perceptual Assessment Battery at 12 weeks in favour of the treatment group receiving spatial cuing via limb activation.</td>
</tr>
<tr>
<td>Cubellia et al. (1999)</td>
<td>Italy</td>
<td>4 (RCT)</td>
<td>10 patients with clinical evidence of left neglect after stroke and had the preserved ability to move the left hand participated in the study. All patients participated in three different experiments given to them in randomized order: two reading conditions and one target cancellation condition. Experiment 1: Reading task under conditions of normal reading no movement, movement of affected</td>
<td>In only one patient did they find that on reading and cancellation the total number of omissions was significantly decreased when irrelevant movements were performed with the left hand in the left space.</td>
</tr>
<tr>
<td>Study</td>
<td>Participants/Methods</td>
<td>Findings</td>
<td></td>
<td></td>
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<tr>
<td>Frassinetti et al. (2001)</td>
<td>8 patients with left visual neglect following right-sided stroke performed object naming, object pointing, object reaching, and line bisection tasks in both near and far space under conditions of passive left limb movements with and without active right limb movements.</td>
<td>Passive left limb movements were associated with significant reductions of neglect on all tasks in both near and far space. Neglect was more severe in far space than close space on pointing tasks (pointing using a laser pointer). Difference in performance in near and far space was not demonstrated on reaching tasks (i.e. reaching an object with a stick). Active movement of the right arm alone did not reduce neglect. Effect of passive left limb movement was not increased by the addition of active right limb movement.</td>
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<tr>
<td>Robertson et al. (2002)</td>
<td>40 patients with right hemisphere strokes were randomly allocated to perceptual training group (PT) or limb activation treatment (LAT) with PT (LAT+PT). The PT group received perceptual training on visuoperceptual puzzles that required scanning to the left. The LAT+PT: same training as PT but also had a timer that emitted a tone when movement was not performed by left wrist, leg or shoulder within a set time period. Both groups received 12 45-minute sessions over a 12-week period. Patients were assessed at intake, post-training and 3, 6 and 18 to 24 months post-training.</td>
<td>Time by treatment condition interaction significant for Motricity Index. Improvement up to 24 months in LAT+PT group with little change in PT group over time.</td>
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<tr>
<td>Eskes et al. (2003)</td>
<td>Assessment of visual scanning performance was performed in 9 individuals with left-sided neglect subjected to 2 treatment conditions and a control condition in 10 trials each over a 1 – 2 day period. Order of conditions was counterbalanced between assessment/trials. Treatment conditions consisted of passive movement via FES stimulation and active movement of the left hand (clicking a mouse button to terminate an auditory signal).</td>
<td>Eight patients completed the passive movement condition. FES stimulation was associated with overall improvement of 17% in left visual scanning; a significant improvement over the no movement condition (p&lt;0.05). 3 subjects completed the active movement condition; 2 of 3 demonstrated improvement. The active movement condition was associated with a 17% improvement in visual scanning. However, the difference between active movement and no movement reached significance in only 1 patient.</td>
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<tr>
<td>Eskes &amp; Butler (2006)</td>
<td>24 individuals (7 with neglect, 7 with right-sided lesions but no neglect, 10 healthy controls) participated in a total of 5 trials for each movement/space combination. Movement conditions consisted of FES stimulation or active movement (as in Eskes et al. 2003). Space conditions were defined by the distance from the participant to target detection sheets (assessment of scanning performance). Detection sheets were presented either 30 cm from the participant (near space) or</td>
<td>No between group comparisons were conducted. Within the neglect group, participants demonstrated a gradient of decreasing target detection from right space to left. Following FES stimulation, group analysis demonstrated no significant effect in either near or far space. Individually, 4/7 participants demonstrated improvement. Only one could participate in the active limb stimulation.</td>
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</table>
projected on a wall, 250 cm from the participant (far space).

Luukkainen-Markkula et al. (2009) 7 (RCT)
12 individuals with left-sided neglect following right stroke were randomly assigned to receive either 20 – 30 hours of left arm activation therapy or 10 hours of traditional visual scanning training. Both interventions were offered as part of a comprehensive program of post-stroke rehabilitation. Outcomes were assessed at baseline, end of intervention (3 weeks) and 6 months post-intervention. Visual neglect was assessed using the BIT & behavioural neglect using the Catherine Bergego Scale. Other assessments included FIM, Motor Assessment Scale, WMFT in addition to a neuropsychological assessment battery.

In the arm activation condition, visual neglect improved significantly over the course of the intervention (p=0.031) and from baseline to 6 months (p=0.031). Patients in the visual scanning condition demonstrated non-significant improvement at the end of intervention; however, improvement was significant at 6 months when compared to baseline (p=0.031). Arm activation was associated with a trend toward improvement in both groups at both post intervention (p=0.063) and at the 6 month assessment for the arm activation condition only (p=0.063). Both groups demonstrated significant improvement in FIM scores over the course of the 3 week rehabilitation program.

Keller et al. (2009) Germany Pre-Post No Score TPS mean=3.2mo NStart=10 NEnd=10
Population: Mean age=58.8yr; Gender: Males=5, Females=5.
Intervention: Right hemisphere damaged patients with unilateral spatial neglect due to stroke received a single session of 4 different treatments lasting for 30min each in a span of 4d. The treatments were optokinetic stimulation with pursuit eye movements (OKSP), visual scanning treatment (VST), OSKSP with prism adaptation (OKSP + P) and OKSP with arm movements (OKSP + A).
Outcomes: Line Bisection Test (LBT); Tactile Search Test; Text Reading; Cancellation Task.

1. Compared to VST, patients improved following OKSP to a significantly greater degree on all measures: LBT (p=0.024), Cancellation task (p=0.012), Text reading (p=0.014) and Tactile search task (p=0.024).
2. Compared to VST, patients improved to a significantly greater degree following OKSP + P only on the Cancellation task (p=0.045).
3. No significant differences were observed on any outcome measures following OKSP + A compared to VST.
4. Following treatment, patients improved on every measure except for Tactile Search Test following VST and all measures for OKSP + A.

Reinhart et al. (2012) No Score
8 patients with right hemisphere stroke and left spatial neglect participated in the study. Patients were presented with a test in which they were shown a visual stimulus, and asked to determine if the drawing depicted a right or left human hand. Participants underwent either a passive limb activation intervention where the lower left arm was covered and was continuously stretched and flexed by an examiner, or an alertness cueing intervention in which an auditory alertness cue was presented 1000ms before each visual stimulus. Experimental conditions were presented in a random order. Participants completed two, one hours sessions over a one week period.

A significant effect of treatment was seen ($F_{(2,14)}=3.95$, $p=0.044$), however, no treatment x hand side interaction was observed. There was a significant reduction in errors for the limb activation treatment ($p=0.032$), but not for alertness cueing, when compared to baseline for left hand depiction recognition only.

Priftis et al. (2013) Italy RCT PEDro=5
Population: Limb Activation Treatment (LAT; N=10): Mean age=64.1±16.4yr; Gender: Males=5, Females=5; Prism Adaptation (PA; N=11): Mean age=68.4±10.4yr; Gender: Males=5, Females=6; Visual Scanning Training (VST; N=10): Mean age=67.6±13.3yr; Gender: Males=6,

1. There was no significant main effect of intervention type observed for any of the outcomes (FT, CRT, PS, MR, CS, semi-structured ecological scale (both subtests), room description and CBS).
### Sensory Stimulation Interventions

#### Table 13.3.5 Activation Interventions using External Stimuli

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Population</th>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wu et al. (2013)</td>
<td>Constraint-Induced Therapy with Eye Patching Group (CIT+EP; N=7): Mean age=56.1±14.5yr; Gender: Males=5, Females=2; Constraint-Induced Therapy Group (CIT; N=8): Mean age=65.5±9.8yr; Gender: Males=5, Females=3; Control Group (CG; N=9): Mean age=61.3±11.2yr; Gender: Males=7, Females=2.</td>
<td>Participants with right side cerebral stroke were randomized to CIT+EP, CIT alone, or to the CG and received conventional rehabilitation treatment matched in intensity and duration with the other groups. The therapy was administered for 2hr, 5d/wk, for 3wk. Participants were assessed pre-treatment and at post-treatment.</td>
<td>Catherine Bergego Scale (CBS); Eye movement variables: fixation amplitude, left fixation points, left fixation time; Arm-trunk movement variables: reaction time, movement time, total distance, percentage of movement time that peak velocity occurs (PPV); Trunk lateral shift.</td>
</tr>
</tbody>
</table>

1. Functional performance on the CBS was significantly different post-intervention (p=0.006) with greater improvements in CIT+EP and in CIT compared to the CG (p<0.001; p=0.02).
2. For eye movement variables, only the number of left fixation points was significantly different between groups (p=0.036) with CIT and CG showing a greater total number of left fixation points than the CIT+EP group (p=0.03; p=0.02).
3. The reaction time of arm-trunk movement was significantly different between groups (p=0.029); only CIT improved on the reaction time of arm-trunk movements compared to the CG (p=0.01).
4. PPV was significantly different between groups (p=0.013) with CIT+EP showing more preplanned control of the reaching movement than CIT alone and CG (p=0.02; p=0.01).
5. No significant between group differences were observed for the arm-trunk movement variables of movement time and total distance.
6. Trunk lateral shift was significantly different between groups (p=0.034) with CIT+EP showing greater trunk lateral shift to the left than CIT alone (p=0.01); no difference was observed between CIT and CG.

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**Table 13.3.5 Activation Interventions using External Stimuli**

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wu et al. (2013)</td>
<td>Taiwan RCT PEDro=7</td>
</tr>
<tr>
<td>Country</td>
<td>PEDro Score</td>
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<tr>
<td>---------------</td>
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</tr>
<tr>
<td>Hommel et al.</td>
<td>4 (RCT)</td>
</tr>
<tr>
<td>Butter et al.</td>
<td>No Score</td>
</tr>
<tr>
<td>Prada &amp; Tallis</td>
<td>No Score</td>
</tr>
<tr>
<td>Yates et al.</td>
<td>No Score</td>
</tr>
<tr>
<td>Polanowska et al.</td>
<td>7 (RCT)</td>
</tr>
</tbody>
</table>
13.3.6 Feedback Strategies

Table 13.3.6 Studies Assessing the Use of Feedback

<table>
<thead>
<tr>
<th>Author, Year Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soderback et al. (1992) Sweden No Score</td>
<td>4 patients with right hemisphere stroke and hemineglect were studied. The study included four phases (A1, B, A2, A3). Phases A1 and A2 included 4 observation times and phase A3 three observation times over 12 weeks for each patient. Three household tasks were assessed (finding the pastry in the refrigerator, cutting the pastry, arranging the cakes on an oven tray) and the patients’ neglect behaviour while performing; the tasks were video recorded. A modified Albert’s test was used but not filmed. In the intervention program, the patients</td>
<td>All the patients exhibited an improvement in their neglect behaviour in the task of finding the pastry in the refrigerator and in the Albert test. On the task of cutting the dough and arranging the cake on the tray, 3 patients showed improvement and the results were maintained in the follow-up measurement for finding the pastry and arranging the cakes on the tray for all 4 patients.</td>
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</tbody>
</table>

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current) stimulation in the control group. Severity of neglect was assessed at baseline and post-treatment via line crossing and star cancellation tests from the BIT and a task of reading letters aloud. Impact of treatment on functional status was assessed using the BI. Pre and post treatment BI scores revealed that all participants had significant improvements over time; however, there were no significant between group differences (p=0.46), main effects for group (p=0.55) or group X time interactions (p=0.11).
watched the film that was stopped by the occupational therapist where the neglect behaviour was significant. Through dialogue the patients were led to perceive and interpret their neglect behaviour and strategies for relearning and remediation were recommended.

<table>
<thead>
<tr>
<th>Study (Reference)</th>
<th>Country</th>
<th>Design</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robertson et al. (1995)</td>
<td>UK</td>
<td>No Score</td>
<td>8 right-hemisphere damaged CAV patients suffering from unilateral neglect for ≥3 months were trained to sustain attention using self-alarming techniques based on learned auditory feedback strategies. Study design was multiple baseline-by-function and multiple-baseline-by-subject.</td>
<td>Pre-post assessment demonstrated significant improvements on the Baking Tray Test (p&lt;0.005) and vertical letter cancellation test (p&lt;0.002). Improvement was also demonstrated on letter cancellation, but this did not reach significance (p&lt;0.097). Improvements were demonstrated on measures of visual neglect as well as sustained attention.</td>
</tr>
<tr>
<td>Fanthome et al. (1995)</td>
<td>UK</td>
<td>5 (RCT)</td>
<td>18 stroke inpatients with a score &lt; 130 on Behavioural Inattention Test were randomly assigned to wear treatment glasses or no glasses. Treatment patients wore glasses that beeped if patient failed to move eyes to the left in 15 seconds. Eye movements recorded while looking at slides.</td>
<td>No significant differences were noted between the treatment and control group on the Behaviour Inattention Test.</td>
</tr>
<tr>
<td>Tham &amp; Tegner (1997)</td>
<td>Sweden</td>
<td>PCT</td>
<td>14 patients with moderate to severe USN were assigned to group A or B (seven patients in each condition). Subjects in group A viewed their performance of the Baking Tray Task (BTT) immediately (viewing their left side performance on the right side of a TV monitor). Group B subjects were given verbal and visual guidance to see their BTT results.</td>
<td>In testing 3 hours after training, the video feedback group demonstrated significant improvement on BTT performance (p&lt;0.02). The improvement on BTT, associated with video feedback of BTT performance, did not generalize to performance on other tests of neglect. Group B demonstrated no improvement on BTT or on other measures of neglect.</td>
</tr>
<tr>
<td>Ramachandran et al. (1999)</td>
<td>USA</td>
<td>No Score</td>
<td>12 patients with visual neglect caused by a right stroke. All patients sat at a table and had mirror propped vertically on their right side in the parasagittal plane. When the patient rotated his head rightward and looked into the mirror, he could see the neglected side of the environment reflected in the mirror. The investigator stood on the left side and held an object within the patient’s reach in their neglected visual field. He asked the patient what the object was and requested that the patient reach out to grab the object. Control patients had mirror placed in the coronal position.</td>
<td>For some patients, the presence of the mirror seemed to help them overcome the neglect. For other patients, they kept reaching for the mirror reflection of the object (mirror agnosia or looking-glass syndrome). This was not observed in the control patients.</td>
</tr>
<tr>
<td>Harvey et al. (2003)</td>
<td>UK</td>
<td>4 (RCT)</td>
<td>14 patients with hemispatial neglect were allocated to either a control group or intervention group “pseudorandomly”. Intervention consisted of reaching and lifting rods of varying lengths and attempting to balance them by grasping them at their central point. This activity is thought to provide both visual and proprioceptive feedback on task performance. Control subjects lifted only the right-hand side of the rod. Rod lifting was administered as an experimenter led activity for 3 days, followed by 2 weeks of self-led practice. Assessments occurred following 3 days, at the end of self-practice and at one month following the end of intervention.</td>
<td>At the end of 3 days, improvements were demonstrated in the intervention group relative to controls on the landmark test (p=0.047) but not on line bisection or real objects testing. BIT conventional scores improved significantly between the end of home training and one month follow-up in the intervention group only. Generalization of this improvement to ADL performance as assessed by the Barthel Index was not demonstrated.</td>
</tr>
</tbody>
</table>
Population: Mirror Therapy Group (MTG; N=26): Mean age=63±11yr; Gender: Males=14, Females=13; Control Group (CG; N=21): Mean age=64±12yr; Gender: Males=14, Females=7.

Intervention: Participants with thalamic and parietal lobe lesions were randomized to the MTG or to the CG (sham MT). MTG performed flexion and extension movements of the non-paretic wrist and fingers while looking into the mirror and were asked to do the same with the paretic hand. The sham MT group did the same exercises but used the non-reflecting side of the mirror, hence the paretic hand was hidden from their sight. Patients received therapy for 1-2hr/d, 5 d/wk, for 4wk. Participants were assessed at baseline and 1, 3, and 6mo after.

Outcomes: Behavioral Inattention Test (BIT) Conventional subtest: Star Cancellation Test (SCT), Line Bisection Test (LBT); Picture Identification Task (PIT); Functional Independence Measure (FIM); Modified Rankin Scale (mRS).

1. MTG demonstrated a significant improvement from baseline to follow-up (at 1, 3, 6mo, and overall) compared to the CG on the SCT test (all p<0.0001), on the LBT (M1mo: p=0.002; M3mo: p=0.005; M6mo: p=0.006; Moverall: p=0.001), and on the picture identification task (all p<0.0001).

2. Analysis of FIM results revealed that MTG patients were more likely to be independent compared to the CG at 3mo (p=0.03) and at 6mo (p=0.004) but not at 1mo (p=0.99).

3. Analysis of mRS results revealed that CG patients were more likely to have a poor outcome compared to the EG at 3mo (p=0.04) and 6mo (p=0.01) but not at 1mo (p=0.99).

Table 13.3.7 Studies Assessing Prism Adaptation Treatment

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rossi et al. (1990)</td>
<td>USA</td>
<td>4 (RCT)</td>
<td>39 stroke patients with homonymous hemianopsia (HHA) or unilateral visual neglect (UVN) in an inpatient stroke rehabilitation unit were studied. Patients demonstrated best corrected visual acuity &gt; 20/200 and were able to comprehend and cooperate with visual field assessment. Patients were randomly assigned to a treatment (prism) or to a non-treatment group. Treatment patients received special glasses with 15 diopter plastic press on Fresnel prisms. Visual perception and ADL were assessed at baseline (similar results) and at 2 and 4 weeks.</td>
<td>At 4 weeks, the prism group had significant improvement in Motor-free Visual Perceptual Test scores, line bisection, line cancellation and the Tangent Screen Exam relative to baseline and control. At 4 weeks, the prism treated group had significant improvement in the Harrington Flocks Visual Screen relative to baseline compared to the control group. No significant difference between the two groups in Barthel ADL index was evident. Treatment with Fresnel prisms improved visual perception test scores but not ADL function in stroke patients with HHA and UVN.</td>
</tr>
<tr>
<td>Rossetti et al. (1998)</td>
<td></td>
<td></td>
<td>Patients with left hemispatial neglect participated in a 2 part study. In part 1, 8 patients and 5 control</td>
<td>In the first experiment, patients demonstrated adaptation to the 10° rightward shifts in visual</td>
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</tbody>
</table>

13. Perceptual Disorders

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<table>
<thead>
<tr>
<th>Country</th>
<th>Study Design</th>
<th>Score</th>
<th>Study Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>5 (RCT)</td>
<td></td>
<td>5 (RCT) subjects were randomly assigned to short-term exposure to right and leftward adjusting wedge prisms. Adaptation was assessed by pre and post treatment target-pointing tasks. In part 2, 12 subjects were randomly assigned to treatment vs. control conditions. Testing occurred before and after exposure to prisms and 2 hours following exposure. Control subjects wore neutral goggles. Testing (part 2) consisted of a standard neuropsychological battery; line cancellation, line bisection, copying a drawing, drawing from memory and reading simple text. Field such that the post-treatment performance on the target-pointing task was close to normal. Patients did not adapt to a leftward shift. In the second experiment, all patients in the treatment group demonstrated significant improvements immediately following prism exposure (p&lt;0.01). These were maintained at the 2-hour assessment (p&lt;0.05). No difference was observed in the control subjects between assessments.</td>
</tr>
<tr>
<td>Frassinetti et al. (2002)</td>
<td>Italy</td>
<td>No Score</td>
<td>7 patients with chronic left spatial neglect performed a simple pointing task while wearing prismatic goggles. Patients also completed the pointing task before and after prism exposure. Treatment continued for 2 20-minute sessions each day for 2 weeks (20 sessions in total). 6 patients were assigned to a control condition and were tested at the same intervals as experimental subjects. Assessment included the Behavioural Inattention Test (BIT), Bell cancellation test, reading test, fluff test, room description test, object reaching test and the Motricity Index. Assessments were conducted at baseline, and at 2 days, 1 week and 5 weeks following treatment. Improvement in BIT scores was demonstrated at each testing session. The improvements demonstrated at 1 and 5 weeks following treatment were greater than those seen 2 days after treatment (p&lt;0.01 &amp; p&lt;0.003). Similar improvements were seen on cancellation tests, reading tests and room description and object reaching tests for the experimental condition only. Improvement in performance appeared to be durable to 5 weeks post treatment. No improvement associated with PA was found in motor function as assessed by the Motricity Index.</td>
</tr>
<tr>
<td>Farne et al. (2002)</td>
<td>Italy</td>
<td>Case Series</td>
<td>Population: Mean age=58.7yr; Gender: Males=2, Females=1. Intervention: Patients with visual neglect due to stroke underwent 1 session of prism adaptation (PA) using rightward shifted lenses. A subgroup of patients (N=4) also underwent a second PA procedure 1wk following the first session. Assessments were conducted at baseline, post-PA, 1d post-PA, 1wk post-PA, post-second PA and 6hr post-second PA. Outcomes: Open-loop pointing task; Letter Cancellation Test (LetterCT); Line Cancellation Test (LineCT); Bell’s Cancellation Test (BCT); Line Bisection Test (LBT); Object description; Object naming; Single-word reading. 1. A two factor ANOVA comparing position (left, centre and right) and session (baseline, immediate, 1d post and 1wk post) for the mean error of the final finger position revealed significant effects of position (p&lt;0.02) and session (p&lt;0.0001) but no interaction of position x session. Patients made larger leftward deviations when pointing towards the center and right side compared to the left side (p&lt;0.04 for both) and a significant leftward deviation was present post-PA and 1d post-PA (p&lt;0.0002 for both). 2. The degree of leftward deviation in final finger position was significantly larger post-PA compared to 1d post-PA (p&lt;0.05) and 1wk post PA (p&lt;0.0002). 3. A three factor ANOVA comparing type of test (visuo-verbal and visuo-manual) session and test (LineCT, LBT, LetterCT, BCT, Object description, Object naming, Reading, Open-loop pointing) for the mean number of correct performances on the various tests revealed a significant effect of session (p&lt;0.0001) but no other significant effects or</td>
</tr>
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</table>
4. The mean number of correct performances on the various tests was significantly increased post-PA and 1d post-PA compared to baseline (p<0.0002 for both); the number of correct performances was significantly reduced 1wk post-PA compared to post-PA and 1d post-PA (p<0.0002 for both).
5. In the subgroup that received a second session of PA, a four factor ANOVA comparing group (post-2nd PA, 6hr post-2nd PA), type of test, test and session for the mean number of correct performances on the various tests revealed a significant effect of session (p<0.0001) but no effect of group; significant improvement was observed following the second PA compared to baseline and 1wk post-first PA (p<0.001 for both).

| Maravita et al. (2003) | Population: Mean age=60yr; Gender: Males=19, Females=14. | 1. The average open-loop pointing direction post-intervention was significantly more leftward compared to pre-intervention (p=0.05). |
| UK Pre-Post No Score TPSOverall=4-24mo NStart=4 NEnd=4 | **Intervention:** Right hemisphere damaged patients with neglect due to stroke received one session of prism adaptation (PA) with a 20° rightward shift for 10min. **Outcomes:** Letter Cancellation Test (LCT); Line Bisection Test (LBT); Star Cancellation Test (SCT); Open-loop pointing direction; Detection of contralesional stimuli. | 2. All patients showed improvement on the LCT, LBT, or SCT following PA. |
| Berberovic et al. (2004) | Population: Mean age=68.8yr; Gender: Males=3, Females=2. | 3. All patients significantly improved their detection of contralesional stimuli during bilateral stimulation post-intervention (p<0.01). |
| Australia Pre-Post No Score TPSOverall=NA NStart=5 NEnd=5 | **Intervention:** Patients with unilateral right hemisphere brain damage and neglect due to stroke underwent 1 session of prism adaptation (PA) using 15° rightward shifted lenses. **Outcomes:** Open-loop pointing task; Temporal order judgement task. | |
| Angeli et al. (2004) | Population: Experimental Group (EG; N=8): Mean age=70.1yr; Gender: Males=5, Females=3; Control Group (CG; N=5): Mean age=66.4yr; Gender: Males=3, Females=2. **Intervention:** Patients with left hemispatial neglect and neglect dyslexia due to stroke were assigned to the EG and received prism adaptation (PA) with a 10° rightward optical shift (EG) or to the CG and received PA with neutral sham goggles. Each group received only one session of PA. **Outcomes:** Visual pointing accuracy: Visible, Invisible, Reading task: Words, Non-words; Endpoint | 1. A two factor ANOVA comparing session (pre and post) and target position (left, right and centre) for displacement in visible pointing revealed no significant main effect and no interaction between the factors for the EG; data was not analyzed for the CG. |
| France PCT No Score TPSOverall=12mo NStart=13 NEnd=13 | | 2. A two factor ANOVA comparing session (pre and post) and target position (left, right and centre) for displacement in invisible pointing in the EG revealed only a significant main effect of session (p<0.0004); a significant leftward displacement was found post-PA. |
of first saccade; Mean fixation time.

3. A three factor ANOVA comparing group (EG and CG), lexicality (word and non-word) and session (pre and post) for the number of correct responses on the reading task revealed only a significant main effect of lexicality ($p<0.0002$) and a significant group x condition interaction; the EG made significantly more correct responses following PA ($p<0.001$) while the CG showed no significant difference post-PA.

4. A three factor ANOVA comparing group (EG and CG), session (pre and post) and lexicality (words and non-words) for endpoint of the first saccade revealed only a significant interaction of group x session ($p<0.03$); EG’s endpoint was initially closer to the middle and was displaced to the left post-PA ($p<0.03$) while the CG showed no significant difference post-PA.

5. A four factor ANOVA comparing group, lexicality, space (left, right and centre) and session for the mean fixation time revealed a significant effect of space and a significant group x session x space interaction ($p<0.001$); fixation time decreased from left to centre ($p<0.06$) to right space ($p<0.04$) and the EG spent more time inspecting the left space following PA ($p<0.004$). There was also a reduction in fixation time on the right side in the EG following PA ($p<0.04$).

Serino et al. (2006)
Italy
No Score

24 patients with right brain damage and left hemispatial neglect following stroke were assigned to either prism adaptation treatment ($n=16$) or control ($n=8$) conditions. Patients in the control group received general cognitive stimulation and motor treatments for 2 weeks. Patients in the treatment condition received 10 daily sessions (20 minutes per session over a period of 2 weeks) of prism adaptation (pointing task while wearing prismatic goggles). Assessments included the conventional and behavioural scales of the BIT administered at baseline (before treatment), and at one week, 1 month and 3 months following the end of treatment. Pointing performance and eye movements were also assessed.

Group X session analysis was significant ($p<0.003$) – post hoc comparisons demonstrated that over time, conventional BIT scores improved for patients in the treatment condition, while for control patients, scores in the 2nd, 3rd & 4th sessions were not significantly different than the first. Similar results were reported for the BIT behavioural scores (groupXsession interaction, $p<0.002$). For both BIT subscales, the treatment group did not differ from the control group at baseline, but at each assessment treatment group scores were significantly higher ($p<0.05$ for all). Similarly, reading accuracy increased in the treatment group ($p<0.02$), but not in the control group. Patients with greater leftward deviation of gaze demonstrated greater improvements as did patients who were able to correct pointing errors within the first week of prism adaptation sessions. Improvements in visuo-spatial tasks appeared stable at 1 and 3 months post-treatment.

Rousseaux et al.

Population: Mean age=55.5yr; Gender: Males=5,

1. Spatial neglect participants performed
<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Study Design</th>
<th>Participants</th>
<th>Intervention</th>
<th>Outcomes</th>
<th>Significant Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>France</td>
<td>Pre-Post</td>
<td>Females=5</td>
<td>Participants completed treatment sessions with deviating prisms (10 deg toward the right) or neutral prisms. Patients participated in six sessions of approximately 35 minutes each. Participants were also compared to a healthy control group (CG; N=8). <strong>Intervention</strong>: Treatment sessions with deviating prisms (10 deg toward the right) or neutral prisms. <strong>Outcomes</strong>: Bell’s Cancellation Test (BCT); Line Bisection Test (LBT); Ogden scene drawing and reading tests (lists and text).</td>
<td>Significantly worse compared to the CG on the BCT (p=0.0001), LBT (p=0.0007) and the Ogden scene drawing task (p=0.006). 2. Analysis of results for Reading single words revealed a significant main effect of time (p=0.001) and a significant interaction between group and time (p=0.002); the main effect of group approached significance (p=0.052) and no main effect for prism type was observed. 3. Analysis of results for Reading single non-words revealed significant effects of group (p=0.009) and time (p=0.009) but no main effect of prism type and no significant interaction between group, time and prism type. 4. Analysis of results for Reading a text revealed a significant effect of group (p=0.0001); no other effects were significant and no interaction was observed between factors.</td>
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<tr>
<td>2008</td>
<td>Netherlands</td>
<td>6 (RCT)</td>
<td>16 patients with visual neglect, within 4 weeks of a stroke event, were randomly assigned to receive either prism treatment (1 session per day for 4 consecutive days, n=10) or placebo/fake prism treatment (1 session/day for 4 days, n=6). Immediate effects of training were assessed using line bisection, scene copying (visuoconstruction task) and letter cancellation tests. Effect of treatment at one month was assessed via the Behavioural Inattention Test and modified Barthel Index.</td>
<td>Both groups in the control group &amp; active treatment group demonstrated significant improvements over time. Patients receiving active prism treatment demonstrated faster gains than the control group on line bisection and cancellation tests (p=0.04 &amp; 0.045 respectively). On the visuoconstruction task, the control group demonstrated a different pattern of improvement and, in the middle sessions, showed more benefit than prism treatment. At one month, there were no significant between group differences for gains on the figure copying, representational drawing, line bisection or star cancellation tests of the BIT. For the full BIT, there were no differences between groups on scores at one month. Differences in the modified Barthel Index were not reported.</td>
<td></td>
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<tr>
<td>2009</td>
<td>Italy</td>
<td>20 patients were allocated to 2 matched groups. One group received a pointing intervention while wearing prismatic goggles (shifting the visual field 10 deg. to the right) while the other group completed the same training while wearing neutral goggles. Both groups received 10 daily sessions of 30 minutes (5 sessions per week for 2 weeks). At the end of 2 weeks, patients in the neutral condition received an additional 2-week treatment with prism goggles. Neglect was assessed using the BIT battery (conventional and behavioural) &amp; the Bell Cancellation Test. Testing was performed at admission, baseline, and post-treatment. Neutral</td>
<td>Both groups demonstrated significant improvement on BIT scores over the course of the intervention (p&lt;0.0002 &amp; p&lt;0.02 for the prism and neutral conditions, respectively); however, patients in the prism group demonstrated significantly more improvement than those in the neutral condition (p=0.0006). On the cancellation tasks, both groups demonstrated significant improvement, but the prism group improved more than the neutral group (p&lt;0.03). Reading accuracy improved over time in the prism group (p&lt;0.0003), but not in the neutral group (p=0.08). The additional prism treatment provided to the</td>
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</table>
condition patients were assessed following the 2-weeks additional prism training and all patients were assessed one month following the end of all prism treatment.

neutral group resulted in significant improvements on all assessments. At one month follow-up, BIT scores remained significantly greater than at baseline (p<0.0002) and were not significantly different from scores obtained at the end of treatment. Similar results were recorded for cancellation tests and for reading accuracy.

<table>
<thead>
<tr>
<th>Population: Mean age=59.2yr; Gender: Males=5, Females=3.</th>
<th>Experiment 1:</th>
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<tbody>
<tr>
<td>Intervention: Patients with hemispatial neglect due to stroke performed a time restricted visual search task (Experiment 1; N=4) or a visual search task without a time limit (Experiment 2; N=4). Both tasks were performed using a 10° rightward shifted prism lenses.</td>
<td>1. Significant visuomotor adaptation was observed on the open-loop tests for all patients following prism adaptation (p&lt;0.05).</td>
</tr>
<tr>
<td>Outcomes: Visual search task: Number of correct responses, Response time; Open-loop pointing task; Paper and pencil neglect tests: Albert’s test, Line bisection test, Number cancellation, Copy drawing, Free hand drawing.</td>
<td>2. No significant difference was observed between pre and post-intervention for the average percent correct or the response time on the seven paper and pencil tests.</td>
</tr>
<tr>
<td></td>
<td>3. No significant difference was observed between pre and post-intervention for the three visual search conditions (left target, right target, absent target).</td>
</tr>
<tr>
<td></td>
<td>4. Significant differences in response time were observed between pre and post-intervention for all three visual search conditions (left target: p&lt;0.001; right target: p&lt;0.001; absent target: p&lt;0.001).</td>
</tr>
<tr>
<td>Padula et al. (2009)</td>
<td>Experiment 2:</td>
</tr>
<tr>
<td>USA</td>
<td>1. Significant visuomotor adaptation was observed on the open-loop tests for all patients following prism adaptation (p&lt;0.05).</td>
</tr>
<tr>
<td>No Score</td>
<td>2. Significant differences were observed between pre and post-intervention for the average percent correct on the seven paper and pencil tests (p=0.018) and the response time (p=0.004).</td>
</tr>
<tr>
<td></td>
<td>3. All patients detected significantly more targets on the left (p&lt;0.001) and right (p=0.008) sides following prism adaptation; no significant difference was found for the target absent condition.</td>
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<tr>
<td></td>
<td>4. Significant reductions in response time were observed between pre and post-intervention for all three visual search conditions (left target: p&lt;0.001; right target: p&lt;0.001; absent target: p&lt;0.001).</td>
</tr>
</tbody>
</table>

Participants included 30 individuals with previous CVA and visual midline shift and 30 controls with no known neurological impairment. Participants were provided with 12 dioptres of base-left and base-right yoked prisms. Visual midline shift and postural orientation were assessed qualitatively using a set of conditions established a priori.

For patients with right CVA, use of base-left yoked prisms was associated with 85% decrease in positive visual midline shift (away from the hemiparetic side) vs. 26% with base right prisms (p=0.001). In addition, 82% of right CVA participants demonstrated improvement in weight-bearing with appropriate base-left prisms. For patients with left CVA (right hemiparesis), there was a 77% decrease in positive midline shift.
<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Design</th>
<th>PEDro</th>
<th>TPS EG</th>
<th>TPS CG</th>
<th>N Start</th>
<th>N End</th>
<th>Population</th>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keller et al. (2009)</td>
<td>Germany</td>
<td>Pre-Post</td>
<td>3.2mo</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
<td>Population: Mean age=58.8yr; Gender: Males=5, Females=5. Intervention: Right hemisphere damaged patients with unilateral spatial neglect due to stroke received a single session of 4 different treatments lasting for 30min each in a span of 4d. The treatments were optokinetic stimulation with pursuit eye movements (OKSP), visual scanning treatment (VST), OSKSP with prism adaptation (OKSP + P) and OKSP with arm movements (OKSP + A). Outcomes: Line Bisection Test (LBT); Tactile Search Test; Text Reading; Cancellation Task.</td>
<td>Compared to VST, patients improved following OKSP to a significantly greater degree on all measures: LBT (p=0.024), Cancellation task (p=0.012), Text reading (p=0.014) and Tactile search task (p=0.024). Compared to VST, patients improved to a significantly greater degree following OKSP + P only on the Cancellation task (p=0.045). No significant differences were observed on any outcome measures following OKSP + A compared to VST. Following treatment, patients improved on every measure except for Tactile Search Test following VST and all measures for OKSP + A.</td>
<td></td>
</tr>
<tr>
<td>Turton et al. (2010)</td>
<td>UK</td>
<td>6 (RCT)</td>
<td></td>
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<td>36 patients with right hemisphere stroke and visual neglect were assigned to either treatment or sham conditions. Treatment procedure was based on repeated pointing tasks similar to those reported in Franssini et al. (2002), while wearing prisms (shifting the visual field 6 degrees to the right). Patients in the sham condition followed the same pointing procedures, but wore glasses with plain, flat glass rather than prisms. The pointing intervention was delivered once per day, each working day, for 2 weeks, in addition to usual rehabilitation. Assessments were conducted 4 days post-treatment and at 8 weeks and included the Catherine Bergego Scale (CBS – to assess self-care performance), the pencil and paper tests from the BIT and the Barthel Index.</td>
<td>Performance on both the CBS and BIT improved within groups over time (p&lt;0.001), but there were no significant between group differences reported. Mean change in CBS scores were similar for both groups.</td>
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</table>
| Jacquin-Courtois et al. (2010) | France | RCT | 6 | 236±96.8d | 69±19.4d | 12 | 12 | Population: Experimental Group (EG; N=6): Mean age=59.7±6.5yr; Gender: Males=3, Females=3; Control Group (CG; N=6): Mean age=56.7±4.7yr; Gender: Males=3, Females=3. Intervention: Right hemisphere damaged patients with neglect due to stroke were randomly assigned to the EG and received prism adaptation (PA) with a rightward optical shift (EG) or to the CG and received PA with neutral sham goggles. Each group received only one session of PA. Outcomes: Dichotic listening task performance: number of correct responses, lateralization data, fusion errors. | Both groups showed significant improvement in the total number of correct responses on the dichotic listening task from baseline to post-intervention (p<0.0005) and from baseline to 2hr post-intervention (p<0.005); the improvement in the EG was 2x that of the CG however this difference was not significant. An ANOVA comparing group, session and stimulus category for lateralization data from the dichotic listening task revealed a significant group x session interaction (p<0.05), a significant main effect of stimulus category (p<0.05) and a significant category x
session interaction (p<0.05); a smaller lateralization index was observed for phonologically similar words compared to short groups of words and the EG demonstrated a significantly greater reduction of the lateralization index post-intervention (p<0.05).

3. At post-intervention, the lateralization index of all but 1 patient in the EG improved by >20% while only 1 patient in the CG improved by 16%.

4. An ANOVA analysis comparing group and session for the number of fusion errors revealed no main effect of group or session although the interaction between factors showed a trend towards significance (p=0.052); a whole-group comparison of post-intervention data showed a significant increase in the number of fusion errors post-intervention (p<0.04).

**Mizuno et al.** (2011) Japan 7 (RCT)

34 patients with unilateral spatial neglect (classified as severe vs. mild) were allocated to a treatment or control condition. Patients within the treatment group wore prisms that shifted their visual field 12 deg to the right and underwent pointing intervention. The control group participated in the same program wearing neutral plastic glasses. Intervention consisted of 20 minute sessions, 2 times a day, 5 days a week for 2 weeks. Outcome measures were the Behavioral Inattention Test (conventional: BIT-C; behavioural: BIT-B), the Catherine Bergego Scale (CBS) and the FIM.

Assessments were administered before intervention, directly after intervention and at discharge. Authors report a length of stay for the prism group of 127.2 ± 42.2. Based on the reported length of stay, days between onset and intervention as well as the 2 week intervention period, time between end of intervention and discharge ranged between 50.1-97.9 days.

In patients with mild neglect, there was a significant difference between the prism and control group in the change BIT-C scores from baseline to discharge (p<0.05). This significant difference was not seen in the entire patient group overall, or those with severe neglect. In addition, no significant difference was found between groups during any period of time in any level of impairment on the BIT-B or CBS. However, patients with mild neglect that underwent prism treatment had a significantly greater increase in FIM scores than the control group (p<0.01).

**Ladavas et al.** (2011) Italy PCT No Score TPS\(_{\text{TPA}}\)=10mo TPS\(_{\text{CPA}}\)=7mo TPS\(_{\text{NP}}\)=15mo \(N_{\text{Start}}\)=30 \(N_{\text{End}}\)=30

<p>| Population: Terminal Prismatic Adaptation (TPA; (N=10)): Mean age=65yr; Concurrent Prismatic Adaptation (CPA; (N=10)): Mean age=64yr; Neutral Pointing (NP; (N=10)): Mean age=61yr; Gender: Males=22, Females=8. | 1. A mixed ANOVA comparing session and group (CPA and TPA) for mean pointing errors revealed a significant effect of session (p&lt;0.001), group (p&lt;0.01) and a significant interaction of group and session (p&lt;0.05); mean pointing errors decreased over time and TPA patients showed larger pointing errors than CPA patients. |
| <strong>Intervention:</strong> Patients with left hemispatial neglect due to stroke received 10 session of prism adaptation (PA) over 2wk at an intensity of 30min/d, Sd/wk. Patients were assigned to receive either TPA, CPA, or NP with neutral goggles without prismatic shift. | 2. ANOVA analysis of session, trials of each session and group (CPA and TPA) for mean pointing errors revealed a significant effect of session (p&lt;0.00001), group (p&lt;0.01) and trial |</p>
<table>
<thead>
<tr>
<th>13. Perceptual Disorders</th>
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<th><a href="http://www.ebrsr.com">www.ebrsr.com</a></th>
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</table>
| accuracy; Behavioural Inattention Test: Conventional subtest, Behavioural subtest; First saccadic endpoint. | (p<0.001), and a significant interaction of group and trial (p<0.01); pointing errors in the TPA group were significantly higher during the initial trials than in the final trials of each session (p<0.0001) while pointing errors in the CPA group were not significantly different between initial and final trials (p=0.73). The session and trial interaction was also significant (p<0.0001) with the difference in pointing errors between initial and final trials of each session decreasing over time. This is consistent with previous studies that show error reduction to occur progressively during trials of prism adaptation, especially in the TPA condition.  
3. ANOVA analysis comparing session and group (CPA and TPA) for pointing errors recorded at the beginning of each session vs. the end of each session revealed a significant effect of session (p<0.0001) but not of group (p=0.93) and no significant group session interaction (p=0.84).  
4. BIT Conventional subtest scores post-intervention were significantly higher in TPA patients compared to CPA (p<0.01) and NP (p<0.001); no significant difference was found between CPA and NP patients.  
5. BIT Behavioural subtest scores post-intervention were significantly higher in TPA patients compared to CPA (p<0.01) and NP (p<0.001); no significant difference was found between CPA and NP patients.  
6. ANOVA analysis of group (CPA and TPA) and session for reading accuracy revealed only a significant effect of session (p<0.01); reading accuracy improved over sessions but was not different between CPA and TPA patients.  
7. ANOVA analysis of group (CPA and TPA) and session for the first saccadic endpoint revealed a significant effect of session (p<0.0001) and a significant interaction of group and session (p<0.05); the first saccadic endpoint was significantly more leftward post-intervention and was displaced more leftward in TPA patients (p<0.05). |
29 patients with left visual neglect were assessed with a battery of seven visual-spatial tests. All patients were randomized by the pilot center and assigned to two different groups. “A” was treated with pointing exercises and prismatic lenses shifting their visual field 5 degrees to the right and “B” was treated with pointing exercises and neutral lenses. Each group had 5 rehabilitation sessions, lasting about 30 minutes each for five days over a period of one week. Sessions were conducted in the morning by the same investigator. Primary outcomes measures were the Albert Test, the Bells test (right and left side), the Orientation Lines test, the Bit Drawing test, the Bisection line test, the Dealing playing card test and the Objects searching test. Each group was trained with 5 rehabilitation sessions, lasting about 30 minutes each, from Monday to Friday for one week in the morning by the same investigators, in the same center.

**Population:** Mean age=67±7.3yr; Gender: Males=9, Females=7.

**Intervention:** Patients with left-sided visual neglect were trained for prism adaptation, receiving 4 training sessions each lasting 30min in duration. Participants were assessed twice at baseline (T1), after 5 to 6d (T2) right before training, right after training (T3), and at 1wk follow-up (T4).

**Outcomes:** Body orientation; Apples Test (AT); Behavioral Inattention Test (BI) Conventional subtest: Line Bisection Test (LBT); Clock Drawing Test (CDT); Reading; Early Rehabilitation Barthel Index (ERBI); Functional Independence Measure (FIM).

1. Patients showed a significant improvement on the AT from T2 to T3 (ΔM=15.4, p=0.041) and from T2 to T4 (ΔM=17.3, p=0.006).
2. Body orientation (regarding their sitting position in the wheelchair) improved from T2 to T3 (ΔM=2.5, p=0.024) and from T2 to T4 (ΔM=2.2, p=0.028).
3. The LBT score changed significantly between T2 and T3 (ΔM=-2, p=0.044), and also between T1 and T2 (ΔM=-0.5, p=0.014).
4. There was no significant change in the FIM score across all time points.
5. The ERBI scores showed a significant increase between T2 and T4 (ΔM=21.8, p=0.0118), but not for the comparison between T1 and T2 or between T2 and T3.
6. No other measure was found to be significant and no significant correlations were found.

**Population:** Limb Activation Treatment (LAT; N=10): Mean age=64.1±16.4yr; Gender: Males=5, Females=5; Prism Adaptation (PA; N=11): Mean age=68.4±10.4yr; Gender: Males=5, Females=6; Visual Scanning Training (VST; N=10): Mean age=67.6±13.3yr; Gender: Males=6, Females=5.

**Intervention:** Right-hemisphere-damaged patients who showed left neglect (LN) were quasi-randomized to receive either visual scanning training (VST), limb activation treatment (LAT), or prism adaptation (PA). Each program lasted 2wk and consisted of 20 sessions, with 1 session in the morning and 1 session in the evening, and each session lasting roughly 20min. Assessments were conducted at baseline (A1 and A2), post-intervention.

1. There was no significant main effect of intervention type observed for any of the outcomes (FT, CRT, PS, MR, CS, semi-structured ecological scale (both subtests), room description and CBS).
2. A significant difference between A1 and A2 was observed on the FT (p<0.05).
3. Significant differences between A2 and A3 were observed on the PS (p<0.05), MR (p<0.05), semi-structured ecological scale subtest C (p=0.05) and CBS (p<0.05).
4. Significant differences between A3 and A4 were observed on the semi-structured ecological scale subtest C (p<0.05) and A (p<0.05).
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<tr>
<th>Study</th>
<th>Location</th>
<th>Pre-Post</th>
<th>No Score</th>
<th>TPSmean</th>
<th>NStart</th>
<th>NEnd</th>
<th>Population</th>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
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<tbody>
<tr>
<td>Smit et al. (2013)</td>
<td>Netherlands</td>
<td>Pre-Post</td>
<td>No Score</td>
<td>63.7±37.7d</td>
<td>33</td>
<td>31</td>
<td>Mean age=60±13.3yr; Gender: Males=19, Females=14.</td>
<td>Patients with neglect due to stroke received one session of prism adaptation (PA) training using a pair of goggles with wide-field point-to-point prismatic lenses with an ipsilateral optical shift of 10 degrees. Patients were assessed at pre and post-training.</td>
<td>Outcomes: Fluff Test (FT); Comb and Razor Test (CRT); Picture Scanning subtest (PS); Menu Reading subtest (MR); Coin Sorting subtest (CR); semi-structured ecological scale [Subtest A – serving tea, Subtest C – card dealing]; Room description; Catherine Bergego Scale (CBS).</td>
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<tr>
<td>Chen et al. (2014)</td>
<td>USA</td>
<td>Pre-Post</td>
<td>No Score</td>
<td>19.3±11.9d</td>
<td>21</td>
<td>21</td>
<td>Mean age: 56.6±15.7yr; Gender: NA; No Frontal Lesion Group (NFL; N=8): Mean age: 69.6±12.4yr; Gender: NA.</td>
<td>Based on the presence or absence of a frontal lesion, patients were allocated to the corresponding groups accordingly. All patients received 10 sessions of the prism adaptation treatment (PAT) for 2wk, 5 sessions/wk, 1 session/d. Assessments were conducted after 48hr of enrollment in the study (Baseline assessment 1) and on the first day of PAT before the treatment (Baseline assessment 2). Participants were further assessed at 2wk and 1d/wk for 4wk (assessment 3 to 7).</td>
<td>Outcome: Catherine Bergego Scale (CBS); Performance on the visual-proprioceptive and proprioceptive pointing tasks; Voxel map analysis.</td>
</tr>
<tr>
<td>Schaadt et al. (2014)</td>
<td>Germany</td>
<td>Pre-Post</td>
<td>No Score</td>
<td>6.4±2.5mo</td>
<td>11</td>
<td>9</td>
<td>Stroke (N=11): Mean age=48.2±12.6yr; Gender: Males=5, Females=6; Traumatic Brain Injury (TBI; N=9): Mean age=29.0±10.7yr; Gender: Males=8, Females=1.</td>
<td>Patients with previous strokes and traumatic brain injuries received binocular vision</td>
<td>1. No significant changes in deviation from the actual center of the LBT or in the number of omissions on the cancellation tests from pre-training to post-training were found. 2. The total time taken to complete the test improved significantly after PA for the OC, LC and the LB (OC: p=0.003; LC: p=0.025; LB: p=0.021). 3. The performance time was shorter for both the contralateral and ipsilateral sides of the stimulus presentation on the OC (contralateral: p=0.004; ipsilateral: p&lt;0.0001), but only on the contralateral side on the LC (p=0.027).</td>
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</table>

1. No significant effects of intervention type by assessment point were observed for any outcome and no other significant effects were observed.
treatment for 6wk. The treatment included three devices: first, patients practiced horizontal convergent fusion with prisms second, a dichoptic device was used to display two slightly different images to each eye and third, a cheiroscope was used to separate the visual images of the left eye by a mirror. Each device was used for 20min every session for a total of 2 sessions/wk. Assessments were conducted prior to the therapy, right after the last therapy session, and at 3 and 6mo after the end of the therapy sessions.

**Outcomes:** Convergent motor fusion; Stereoacuity; Subjective reading duration; Accommodation; Exophoria; Visual acuity: near and far.

2. A main effect of treatment was found for Stereoacuity across both groups with significant improvement from pre to post-therapy (p<0.001 with no additional change at the 3mo follow-up).

3. Subjective reading duration increased significantly in both the stroke and the TBI groups from pre-therapy to post-therapy (pairwise comparison p<0.001). This effect remained stable until follow-up at 3mo (p<0.001).

4. There was a significant interaction between group and treatment for the subjective reading duration, indicating that the TBI group had a higher training benefit compared to the stroke group (p=0.032).

5. No significant changes were observed in accommodation before versus after training for either eye for the stroke and TBI groups.

6. There was a main effect of treatment for both eyes regarding near visual acuity from pre-therapy to post-therapy (left eye: p=0.017; right eye: p=0.009), but no significant change was observed in far visual acuity.

7. There was no change in exophoria values for patients in the stroke or TBI groups from pre-therapy to post-therapy.

8. At pre-therapy in the stroke group, the correlation between motor fusion and stereoacuity, and between stereoacuity and reading duration were found to be significant (p<0.001; p<0.05).

### Table:

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants</th>
<th>Interventions</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan et al. (2015)</td>
<td>Taiwan</td>
<td>Pre-Post TPS=44.5±13.0d</td>
<td>All participants with unilateral neglect underwent 3 conditions of lens color (colorless, red, and blue) and 3 conditions of flash light locations (no flash, left, and right). Outcomes were assessed at baseline and post testing.</td>
<td>Convergent motor fusion; Stereoacuity; Subjective reading duration; Accommodation; Exophoria; Visual acuity: near and far.</td>
</tr>
<tr>
<td>Ladavas et al. (2015)</td>
<td>Italy</td>
<td>PCT TPS1=2.25±0.46mo TPS2=3.36±1.69mo TPS CG=3.18±1.99mo</td>
<td>Participants with neglect were divided to receive 10 daily sessions of prism adaptation in combination with cathodal transcranial direct current stimulation (E1), anodal transcranial direct current stimulation (E2), and sham stimulation (CG).</td>
<td>Convergent motor fusion; Stereoacuity; Subjective reading duration; Accommodation; Exophoria; Visual acuity: near and far.</td>
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</table>

1. All participants showed a decrease in ipsilesional spatial bias index under left-side light flash and a red lens.
2. Right-side light flash and a blue lens induced more rightward index bias than other conditions.
3. Post-intervention BIT scores were significantly higher in the CG and E2 groups compared to the E1 group (both p<0.05).
current stimulation (E2), or sham stimulation (CG). Outcomes were assessed at baseline and post-intervention.  
**Outcomes**: Behavioral Inattention Test (BIT).

<table>
<thead>
<tr>
<th>Population</th>
<th>Methods</th>
<th>Outcomes</th>
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</thead>
<tbody>
<tr>
<td>Rode et al. (2015)</td>
<td>Experimental group (EG; n=9): Mean age=55.2±11.9yr, Gender: Male=5, Female=4. Control group (CG; n=9): Mean age=61.7±12.9yr, Gender: Male=5, Female=4.</td>
<td>1. There was a significant improvement in FIM scores over 1mo, 3mo, and 6mo compared to baseline across groups (p&lt;0.0001); however, the improvements were no different between groups (p&gt;0.05). 2. There was a significant improvement in BIT scores over 1mo, 3mo, and 6mo compared to baseline across groups (p&lt;0.0001); however, the improvements were no different between groups (p&gt;0.05).</td>
</tr>
<tr>
<td>France PCT TPS_{EG}=51.0±17.4d TPS_{CG}=52.2±19.3d N_{Start}=20 N_{End}=18</td>
<td>Intervention: Participants with spatial neglect were randomized to receive prism adaptation therapy (EG) or control (CG) for 4wk. Outcomes were assessed at baseline, 1mo, 3mo, and 6mo. <strong>Outcomes</strong>: Functional Independence Measure (FIM), Behavioural Inattention Test (BIT).</td>
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### 13.3.8 Eye-Patching and Hemispatial Glasses

#### Table 13.3.8 Eye-Patching and Hemispatial Glasses for Neglect

<table>
<thead>
<tr>
<th>Author, Year Country PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td><strong>Butter &amp; Kirsch (1992) USA No Score</strong></td>
<td>13 patients with left-sided neglect following stroke and 10 control subjects were assessed using line bisection, line cancellation, letter cancellation, reading tasks and clock construction with and without an opaque monocular patch worn over the right eye in an ABBA pattern. In a second experiment, 18 subjects with left-sided neglect following stroke, and 10 control subjects were assessed on multiple line bisection tasks to establish a baseline. They were assessed again while a) wearing an opaque eye patch over the right eye, b) receiving visual stimulation in the left field and c) both a &amp; b.</td>
<td>11 of 13 patients demonstrated improvement on at least one test conducted while wearing the eye patch (average score of 2 evaluations). The most consistent benefits were reflected in line bisection tasks. In the second condition, there was a highly significant effect associated with testing conditions (p&lt;0.0005) such that bisection errors were smaller than they were at baseline in each of the 3 treatment conditions. The effect of the combined treatment was significantly greater than eye-patching alone (p&lt;0.05). In the combined treatment, patients with more severe neglect experienced greater benefit than those with less severe neglect (p&lt;0.05).</td>
</tr>
<tr>
<td>**Soroker et al. (1994) Israel Pre-Post No Score **</td>
<td>Population: Mean age=58.7±3.0yr; Gender: Males=4, Females=2.</td>
<td>1. Regression analysis of mean signed displacement from objective midpoint, line length and viewing condition revealed a significant interaction between viewing condition and line length for 5 patients (p&lt;0.05). 2. The shorter degree of line displacement from midpoint in the monocular left viewing condition predicted to be present was only found in 1 patient; a greater degree of displacement from midline in the right monocular condition was present in 3 patients.</td>
</tr>
<tr>
<td><strong>Serfaty et al. (1995)</strong></td>
<td><strong>Population</strong>: Mean age=60.5±10.7yr; Gender:</td>
<td>1. Compared to the right eye viewing</td>
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<tr>
<td>Location</td>
<td>Study</td>
<td>Design</td>
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<tr>
<td>Japan</td>
<td>Pre-Post</td>
<td>No Score</td>
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<tr>
<td>Walker et al. (1996)</td>
<td>UK</td>
<td>4 (RCT)</td>
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<tr>
<td>Arai et al. (1997)</td>
<td>Japan</td>
<td>Pre-Post</td>
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<tr>
<td>Beis et al. (1999)</td>
<td>France</td>
<td>5 (RCT)</td>
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problems were solved using the patch and patient’s corrective lenses. Patches were worn through the day (~12 hrs) from admission to 3 months. Assessment was made without patches. difference between the control group and the right monocular patch. Half field patches affected eye movement and improved general everyday functioning.

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Study Design</th>
<th>Participants</th>
<th>Intervention</th>
<th>Comparison</th>
<th>Outcome</th>
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<tr>
<td>Zeloni et al. (2002)</td>
<td>Italy</td>
<td>3 (RCT)</td>
<td>11 patients</td>
<td>Right monocular patch</td>
<td>Control (standard rehabilitation only)</td>
<td>Group X session analysis demonstrated a significant interaction (p&lt;0.0006). Patients in the treatment group demonstrated significant improvement after one week of treatment (p&lt;0.0003), while patients in the control condition did not. Although patients in the treatment condition were more impaired at baseline, by the first assessment, they performed significantly better than the control group (p&lt;0.005). At the third assessment session (one week following the removal of the goggles), improvement seen in the treatment group was maintained – performance from time 2 – 3 was not significantly different. Overall, the greatest improvement was demonstrated on the Albert’s test. Although the control group demonstrated improvement over time, this was not significant (p&gt;0.2 for all comparisons).</td>
</tr>
<tr>
<td>Fong et al. (2007)</td>
<td>Hong Kong</td>
<td>6 (RCT)</td>
<td>54 patients</td>
<td>Half-field eye-patching</td>
<td>Control (standard rehabilitation only)</td>
<td>At the end of training, there were no significant between group differences reported on any measure. However, on the locomotion items of the FIM-motor, there was a trend toward higher scores associated with trunk rotation. At 60 days, there were also no significant differences between groups on any of the BIT (conventional or behavioural), the clock drawing test or FIM-motor scores. Therefore, the training received in either experimental condition was not better than conventional treatment either at the end of the intervention or at 60-day follow-up.</td>
</tr>
<tr>
<td>Tsang et al. (2009)</td>
<td>China</td>
<td>7 (RCT)</td>
<td>35 patients</td>
<td>Right half-field eye-patching</td>
<td>Control (standard rehabilitation only)</td>
<td>Both of the groups significantly improved their performance in all of the outcome measures.</td>
</tr>
<tr>
<td>Janes et al. (2012)</td>
<td>Italy</td>
<td></td>
<td>18 patients</td>
<td>Right half-field treatment for 8 weeks</td>
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</table>
hours a day for 15 consecutive days or visual scanning training for 40 minutes every weekday in a 15 day period. Patients were evaluated pre-treatment, post-treatment and at seven-day follow-up by means of the following outcome measures: Line Crossing test, Bells test and Line Bisection test. There were no differences of improvement between the two groups. Improvements were maintained at follow-up for both groups of patients.

| Wu et al. (2013) Taiwan RCT PEDro=7 TPS CIT+EP=13.0mo TPS CIT=10.1mo TPS Con=13.7mo N Start=27 N End=24 | Population: Constraint-Induced Therapy with Eye Patching Group (CIT+EP; N=7): Mean age=56.1±14.5yr; Gender: Males=5, Females=2; Constraint-Induced Therapy Group (CIT; N=8): Mean age=65.5±9.8yr; Gender: Males=5, Females=3; Control Group (CG; N=9): Mean age=61.3±11.2yr; Gender: Males=7, Females=2. Intervention: Participants with right side cerebral stroke were randomized to CIT+EP, CIT alone, or to the CG and received conventional rehabilitation treatment matched in intensity and duration with the other groups. The therapy was administered for 2hr, 5d/wk, for 3wk. Participants were assessed pre-treatment and at post-treatment. Outcomes: Catherine Bergego Scale (CBS); Eye movement variables: fixation amplitude, left fixation points, left fixation time; Arm-trunk movement variables: reaction time, movement time, total distance, percentage of movement time that peak velocity occurs (PPV); Trunk lateral shift. Functional performance on the CBS was significantly different post-intervention (p=0.006) with greater improvements in CIT+EP and in CIT compared to the CG (p<0.001; p=0.02). For eye movement variables, only the number of left fixation points was significantly different between groups (p=0.036) with CIT and CG showing a greater total number of left fixation points than the CIT+EP group (p=0.03; p=0.02). The reaction time of arm-trunk movement was significantly different between groups (p=0.029); only CIT improved on the reaction time of arm-trunk movements compared to the CG (p=0.01). PPV was significantly different between groups (p=0.013) with CIT+EP showing more preplanned control of the reaching movement than CIT alone and CG (p=0.02; p=0.01). No significant between group differences were observed for the arm-trunk movement variables of movement time and total distance. Trunk lateral shift was significantly different between groups (p=0.034) with CIT+EP showing greater trunk lateral shift to the left than CIT alone (p=0.01); no difference was observed between CIT and CG. | 1. Functional performance on the CBS was significantly different post-intervention (p=0.006) with greater improvements in CIT+EP and in CIT compared to the CG (p<0.001; p=0.02). 2. For eye movement variables, only the number of left fixation points was significantly different between groups (p=0.036) with CIT and CG showing a greater total number of left fixation points than the CIT+EP group (p=0.03; p=0.02). 3. The reaction time of arm-trunk movement was significantly different between groups (p=0.029); only CIT improved on the reaction time of arm-trunk movements compared to the CG (p=0.01). 4. PPV was significantly different between groups (p=0.013) with CIT+EP showing more preplanned control of the reaching movement than CIT alone and CG (p=0.02; p=0.01). 5. No significant between group differences were observed for the arm-trunk movement variables of movement time and total distance. 6. Trunk lateral shift was significantly different between groups (p=0.034) with CIT+EP showing greater trunk lateral shift to the left than CIT alone (p=0.01); no difference was observed between CIT and CG. |

| Machner et al. (2014) Germany RCT PEDro=5 TPS Exp=5d TPS Con=3d N Start=23 N End=21 | Population: Experimental Group (EG; N=11): Mean age=69±3yr; Gender: Males=8, Females=3; Control Group (CG; N=10): Mean age=69±3yr; Gender: Males=6, Females=4. Intervention: Patients were randomized to the EG and received hemifield eye patching and repetitive optokinetics stimulation (HEPOKS) in addition to the usual stroke care (physio, speech, and occupational therapy), or to the CG and received usual care only. The treatment lasted 1wk, and participants were assessed at baseline, post-treatment and at 30d follow-up. Outcomes: Catherine Bergego Scale (CBS); Barthel Index (BI); modified Rankin scale (mRS); National Institutes of Health Stroke Scale (NIHSS); Bell’s Cancellations Test (BCT); Behavioral Inattention Test. 1. There was a significant improvement in the neurophysiological test accuracy between baseline and post-treatment within both the EG and CG (p<0.001; p<0.05). 2. Additional improvement in the neurophysiological test accuracy between post-treatment and follow-up was observed in the EG (p<0.01) but not in the CG (p>0.05). 3. There was no significant difference between the two groups on the CBS. 4. CBS scores decreased significantly between post-treatment and follow-up within both the EG and CG (p<0.01; p<0.01). 5. There was no significant difference between the two groups on the BI, NIHSS, | 1. There was a significant improvement in the neurophysiological test accuracy between baseline and post-treatment within both the EG and CG (p<0.001; p<0.05). 2. Additional improvement in the neurophysiological test accuracy between post-treatment and follow-up was observed in the EG (p<0.01) but not in the CG (p>0.05). 3. There was no significant difference between the two groups on the CBS. 4. CBS scores decreased significantly between post-treatment and follow-up within both the EG and CG (p<0.01; p<0.01). 5. There was no significant difference between the two groups on the BI, NIHSS,
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1. (BIT) Conventional subtest: Star Cancellation Test (SCT), Line Bisection Test (LBT); Ogden Figure Copying Task (OFCT); Reading errors.
2. mRS, BCT, SCT, LBT, OFCT, or reading errors.
3. Only the EG showed improvements on the BCT from baseline to post-treatment (p=0.003) and from post-treatment to follow-up (p=0.007).

### Aparicio-Lopez et al. (2015)
Spain
RCT
PEDro=6
TPS=93.2d
TPSct=85.4d
NStart=12
NEnd=12

**Population:** Single Treatment Group (ST; N=7): Mean age=45.1±7.03yr; Gender: Males=3, Females=4; Combination Treatment Group (CT; N=5): Mean age=52.2±10.75yr; Gender: Males=3, Females=2.

**Intervention:** Participants were randomly allocated to the ST group and followed a cognitive rehabilitation programme including exercises for attention, memory and functional tasks, or to the CT group and followed the same cognitive treatment as the ST group combined with right hemifield eye-patching (RHEP). Participants were assessed at baseline and post-intervention.

**Outcomes:** Behavioural Inattention Test (BIT) Conventional subtest: Line Bisection Test (LBT); Bell’s Cancellation Test (BCT); Baking tray task; Reading test; Figure Copying of Ogden (FCO); Catherine Bergego Scale.

1. The ST group showed significant improvement in the LBT from pre to post-intervention (p=0.039).
2. The CT group showed significant improvement in the BCT (p=0.043) and the LBT from pre to post-intervention (p=0.043).
3. The CT group showed a significantly higher number of read words before and after treatment compared to the ST group (p=0.048).
4. No significant between group differences were observed on the LBT, BCT, FCO, Baking tray task or CBS.

### Table 13.3.9 Caloric/Vestibular Stimulation

<table>
<thead>
<tr>
<th>Author, Year Country PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubens (1985) USA No Score</td>
<td>18 right-handed patients with left sided visual neglect in the first 2 weeks after an acute right hemisphere stroke were studied. Caloric testing was carried out with 20 cc of warm or ice water slowly instilled into the external ear canal over 1 minute. Testing with ice water in the left ear was followed 30 minutes later by testing with warm water in the right. The next day, ice-water stimulation of the right ear and warm water stimulation of the left ear were carried out.</td>
<td>All patients improved during caloric stimulation on the left by cold water or on the right by warm water. Improvement seemed to be dependent on the facilitation of left lateral gaze and on past-pointing to the left.</td>
</tr>
<tr>
<td>Cappa et al. (1987) Italy No Score</td>
<td>4 stroke patients were studied. In 3 patients the left external canal was irrigated with 20 cc of ice water for 1 minute and in 1 patient, the right ear was irrigated with 20 cc of warm water. Patients were re-tested on baseline measures (extrapersonal neglect assessment and personal neglect assessment) before and then 15 minutes after caloric stimulation.</td>
<td>All patients demonstrated a temporary reduction of extrapersonal neglect after caloric stimulation followed by a return to base level after 15 minutes. Personal neglect improved in all 4 patients.</td>
</tr>
<tr>
<td>Vallar et al. (1990) Italy No Score</td>
<td>Studied 3 right-handed patients who had suffered a recent ischemic stroke in the right hemisphere. Patients were tested on extrapersonal and personal neglect, anosognosia and somatosensory deficits. All</td>
<td>Treatment induced a temporary remission of extra-personal neglect. Two patients had severe anosognosia; 1 patient was unaffected by vestibular stimulation while it produced a</td>
</tr>
</tbody>
</table>
### Vallar et al. (1993) Italy

No Score

| Patients | 20 right brain damaged patients and 11 left brain damaged patients (29 post stroke) were assessed following caloric stimulation for improvements in somatosensory deficits. Spatial hemineglect was identified in 14 patients with right-sided lesions, in 3 patients with tactile extinction and in 2 of 11 patients with left-sided damage. Caloric stimulation treatments consisted of irrigation of the external ear canal contralateral to the lesion, with 20 mL of ice water for 1 minute. | A temporary partial recovery of somatosensory deficits (hemianaesthesia or extinction) was demonstrated following caloric stimulation in patients with right-sided brain damage only (p<0.0001). Vestibular stimulation did not appear to benefit patients with left brain damage (p=0.76). Significant improvements were demonstrated immediately following treatment, but by 30 minutes there was no difference between groups. While patients with neglect demonstrated improvement in somatosensory deficits following treatment, recovery of these deficits was not dependent on the presence of neglect. |

### Adair et al. (2003) USA

PCT

No Score

| Population: Mean age=64.5yr; Gender: Males=9, Females=7. **Intervention:** Patients were stratified based on their diagnosis of attentional (unawareness of contralesional stimuli) or intentional neglect (failure to act in contralesional space). All patients received cold caloric stimulation of the contralesional ear canal before performing assessments of neglect. **Outcomes:** Line Bisection Test (LBT); Target Cancellation. | 1. Univariate ANOVA analysis of LBT results revealed a significant main effect of cold caloric stimulation (p<0.001). 2. ANOVA analysis comparing stimulation state (baseline vs. stimulated) and neglect type for the LBT revealed a significant interaction between factors (p<0.001); stimulation significantly improved LBT performance for the attentional neglect group (p<0.001), while the pre and post-stimulation performances were not significantly different for the intentional neglect group (p=0.77). 3. Attentional neglect patients cancelled significantly more targets on the contralesional side following intervention compared to intentional neglect patients (p=0.019). |

### Rode et al. (2006) France

No Score

| 9 hemiplegic patients with right brain damage and neglect and 9 patients with left brain damage post stroke received cold caloric stimulation in the ear contralateral to the site of brain damage. Assessments of motor deficit, personal neglect and anosognosia were conducted before and immediately following stimulation. | Caloric stimulation was associated with improvements in contralesional limb motricity in patients with right brain damage only (p<0.0013). Improvement in motricity was limited to lower limbs (p<0.0024). Personal neglect disappeared on post stimulation testing in 8 or 9 patients. Patients with left brain damage did not show significant improvements in limb motricity following treatment. |

### Sturt & Punt (2013) UK

No Score

| 18 participants, 6 with right brain damage and neglect, 6 with right brain damage and no neglect, and 6 with left brain damage and no neglect received caloric stimulation in the ear canal contralateral to the lesion site (60mL of cold water over a period of 60 seconds). An additional 6 participants with right brain lesion and | On the Star Cancellation Test, a significant effect of both time (F(4,30) = 5.5, p<0.01) and group (F(2,15) = 15.9, p<0.001), as well as a group x time interaction (F(4,48) = 6.2, p<0.005) was observed. Although no improvements were noted in the groups with no neglect, significant improvements |
neglect were administered caloric stimulation in the ipsilesional ear. Participants were assessed using the Star Cancellation Test and the Postural Assessment Scale for Stroke at baseline, immediately following treatment, and one hour post treatment. Results on both outcome measures were non-significant between time points for the right brain lesion and neglect group who received intervention in the ipsilesional ear.

13.3.10 Vestibular Galvanic Stimulation

Table 13.3.10 Vestibular Galvanic Stimulation Studies

<table>
<thead>
<tr>
<th>Author, Year Country PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rorsman et al. (1999)</strong> Sweden No Score</td>
<td>14 patients with right-sided lesions and left-sided neglect post stroke were assigned to either experiment 1 or experiment 2. Patients in experiment 1 received testing (line crossing, star cancellation) in the following pattern, no-stim, stim, no-stim. Patients in experiment 2 received testing in no-stim, no-stim &amp; stim conditions. Stimulation (stim) conditions consisted of individually calibrated galvanic stimulation to the right mastoid during testing.</td>
<td>Galvanic stimulation in Experiment 1 was associated with significant improvement in line crossing tests (p&lt;0.01). All 7 patients demonstrated improved line crossing performance from baseline to stimulation (p&lt;0.02). Improvements from the first no stim to the second no stim conditions were significant (p&lt;0.04). No significant differences were demonstrated on the star cancellation task. In Experiment 2, performance on star cancellation (target &amp; symmetry) was improved from the first no stimulation condition to stimulation (p&lt;0.03).</td>
</tr>
<tr>
<td><strong>Utz et al. (2011)</strong> Germany Cross-over RCT PEDro=7 TPS_{RBD+N}=2.6±1.6mo TPS_{RBD-N}=1.9±2.9mo N_{Start}=17 N_{End}=17</td>
<td><strong>Population:</strong> Right-Hemisphere Stroke and Left Sided Visuospatial Neglect (RBD+N; N=6): Mean age=70.8±4.6yr; Gender: Males=4, Females=2; Right-Hemisphere Stroke without Neglect (RBD-N; N=11): Mean age=70.3±12yr; Gender: Males=8, Females=3. <strong>Intervention:</strong> Patients received 3 sessions of galvanic vestibular stimulation (GVS) for 20min each with &gt;1d between sessions: sham GVS, left cathodal GVS and right cathodal GVS. <strong>Outcomes:</strong> Line Bisection Test (LBT): Rightward deviation, Leftward deviation, Middle deviation, Magnitude of reduction of error.</td>
<td>1. No significant differences in LBT were found in RBD- patients across all experimental conditions. 2. On the LBT, RBD+ patients showed significantly smaller rightward deviations with left cathodal GVS compared to baseline (p&lt;0.05) and right cathodal GVS compared to baseline (p&lt;0.05) while no significant difference was found with sham; significantly smaller deviations were found in right cathodal compared to sham (p&lt;0.05) and a significantly greater reduction of LBT error was found in right cathodal GVS compared to left cathodal GVS (p&lt;0.05); no other significant differences were found in LBT. 3. Analysis of deviation (left, middle, right) in...</td>
</tr>
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</table>
**Schmidt et al. (2013)**  
Germany  
Cross-over RCT  
PEDro=7  
TPSdiff mean=32.1mo  
N$_{Start}$=22  
N$_{End}$=22  

| **Population:** | Right-Hemisphere Stroke and Left Sided Visuospatial Neglect Group (RBD+N; N=7): Mean age=61.7±14.8yr; Gender: Males=6, Females=1; Right-Brain Damage without Neglect Group (RBD-N; N=15): Mean age=66.3±12.2yr; Gender: Males=14, Females=1.  
**Intervention:** | Patients were allocated to RBD+N or to RBD-N based on diagnosis. All individuals participated in 4 different experimental sessions. In session 1, all screening assessments and the first baseline test in horizontal arm position sense (APS) were carried out. In session 2 to 4, the participants performed the APS task again while receiving either left cathodal galvanic vestibular stimulation (L-GVS), right-cathodal galvanic stimulation (R-GVS), or sham-GVS, in a pseudorandomized order. The GVS lasted 20min, after which the APS was measured again to evaluate potential after effects (AE). Participants were also compared to a healthy control group (CG; N=10).  
**Outcomes:** | Arm Position Sense (APS): Right arm (R), Left arm (L).  
1. Analysis of APS for the right arm revealed no significant main effect of GVS condition or a significant interaction between condition and group.  
2. A significant main effect of GVS condition and a significant interaction between the GVS condition and group were found for APS of the left arm (p=0.017; p=0.013).  
3. RBD+N patients showed significantly smaller deviations in APS-L error in the L-GVS condition (p=0.05), and a further enhancement in the L-GVS-AE condition (p=0.012), as compared to baseline.  
4. RBD+N patients also improved significantly in APS-L after both L-GVS (p=0.000) and L-GVS-AE (p=0.008) relative to the sham.  
5. Deviation in APS of the left arm in RBD+N patients was significantly greater at baseline and under sham stimulation compared to the CG (p=0.021; p=0.015) and RBD-N (p=0.023; p=0.044).  
6. There was no significant correlation between clinical characteristics of patients with neglect and the modulation of APS by GVS found.  
7. RBD+N patient were significantly impaired in the left APS but this deficit improved significantly in the L-GVS (p=0.05) and further into the normal ranges 20min after cessation of L-GVS (p=0.012).  
8. RBD+N patients showed their best performance in APS during L-GVS and L-GVS-AE.  

**Ruet et al. (2014)**  
France  
Cross-over RCT  
PEDro=6  
TPSmean=5.4mo  
N$_{Start}$=4  
N$_{End}$=4  

| **Population:** | Mean age=58.5yr; Gender: Males=4, Females=0.  
**Intervention:** | Patients with a right hemisphere stroke received 3 sessions of galvanic vestibular stimulation (GVS) for 20min each over a period of 5d: sham GVS, left cathodal right anodal GVS (L-GVS) and left anodal right cathodal GVS (R-GVS).  
**Outcomes:** | Line Bisection Test (LBT); Star Cancellation Test (SCT).  
1. No significant differences were found between conditions on the LBT (p=0.89).  
2. No significant improvement on the SCT was found in any condition (p=0.58).  
3. Two patients showed improvement on both the LBT and SCT with R-GVS.  

**Wilkinson et al. (2014)**  
UK  
RCT  

| **Population:** | Experimental Group 1 (EG1; N=15): Mean age=66.9±10.6yr; Gender: Males=12, Females=3; Experimental Group 2 (EG2; N=18): Mean age=66.0±9.37yr; Gender: Males=12, Females=6;  
**Outcomes:** | LBT across experimental conditions revealed a significant difference only for right located lines; significant differences were found only between each condition and baseline (left cathodal: p<0.05; right cathodal: p<0.05; sham: p<0.05).  
1. Changes in BIT scores between baseline and 4wk post-GVS were statistically significant in all treatment arms (all p<0.05) however, the FSCT in EG1, and the FDT in EG2 and EG3.  

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<table>
<thead>
<tr>
<th>PEDro</th>
<th>TPSExp1</th>
<th>TPSExp2</th>
<th>TPSExp3</th>
<th>NStart</th>
<th>NEnd</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>68d</td>
<td>75d</td>
<td>96d</td>
<td>52</td>
<td>49</td>
</tr>
</tbody>
</table>

**Experimental Group 3 (EG3; N=16):** Mean age=65.7±8.7yr; Gender: Males=13, Females=3.

**Intervention:** Participants suffering from right unilateral stroke were randomized to 1 of the 3 right cathodal galvanic vestibular stimulation (GVS) treatment arms: 1 active and 9 sham treatments (EG1); or 5 active and 5 sham treatments (EG2); or 10 active and 0 sham treatments (EG3). The treatment lasted 4wk. Participants were assessed at baseline, on final day of stimulation, and at 1, 2 and 4wk post-intervention.

**Outcomes:** Behavioral Inattention Test (BIT) Conventional subtest: Star Cancellation Test (SCT), Letter Cancellation Test (LetterCT), Line Bisection Test (LBT), Line Crossing Test (LineCT), Figure and Shape Copying Test (FSCT), Free Drawing Test (FDT).

Experimental Group 3 showed no improvement.

2. There was no significant difference between the treatment arms with respect to the BIT scores at all time points.
3. The time since stroke did not significantly affect outcome.

**Nakamura et al.** (2015) Japan Cross-over RCT PEDro=7 TPSMean=154.8±53.8d NStart=7 NEnd=7

**Population:** Mean age=75.4±9yr; Gender: Males=3, Females=4.

**Intervention:** Patients with right-hemisphere damage due to stroke underwent three different stimulation conditions in a pseudorandomized sequence. The sessions included right anodal left cathodal galvanic vestibular stimulation (L-GVS), right cathodal left anodal GVS (R-GVS), and sham stimulation. Each session was carried out at 48hr intervals to avoid carry-over effects. Each session was delivered for 20min. Patients were assessed before the session, at 10min, and at 20min after the start of the GVS.

**Outcomes:** Behavioral Inattention Test (BIT) Conventional subtest: Line Cancellation Test (LCT).

- ANOVA analyses showed a significant main effect of time (p=0.004) and the condition x time interaction (p=0.005) on LCT scores.
- LCT scores were significantly increased following 10 and 20min of L-GVS, with a greater increase observed following the latter (before vs. 10min: p=0.017; before vs. 20min: p<0.0001; 10min vs. 20min: p=0.04).
- The R-GVS condition did not significantly change LCT scores.
- The sham condition did not significantly change the LCT score.
- Correlation analyses revealed a significant correlation between the BIT scores and the amount of change in the LCT score on L-GVS (p=0.008).
- The R-GVS condition did not reveal a significant correlation between the BIT scores and the amount of change in the LCT score.

**Oppenländer et al.** (2015) Germany Pre-Post No Score TPSmedian=2mo NStart=24 NEnd=24

**Population:** Mean age=63.3yr; Gender: Males=14, Females=10.

**Intervention:** Patients with a right hemisphere stroke received 3 sessions of galvanic vestibular stimulation (GVS) for 20min each over a period of 5d: sham/baseline GVS, left cathodal right anodal GVS (L-GVS) and left anodal right cathodal GVS (R-GVS). For each task, patients were divided into impaired (RBD+) or normal (RBD-) groups based on performance in comparison with literature or healthy subjects.

**Outcomes:** Number Cancellation: Center of Cancellation (CoC); Copy of symmetrical figures; Line Bisection Test (LBT); Text copying.

- An ANOVA comparing group (RBD + vs. -) and stimulation condition for CoC revealed a significant main effect of stimulus condition (p<0.001) and a significant interaction between factors (p=0.009); in RBD+ patients, a significant reduction of CoC was found with R-GVS compared to sham (p=0.005) but no difference was found between R-GVS and L-GVS or L-GVS and sham; in RBD- patients, significantly reduced CoC was found in L-GVS compared to R-GVS (p=0.017) and sham (p=0.014) but not in R-GVS compared to sham.
- For the Copy of symmetrical figures, in the RBD+ group, a significant difference was only found in R-GVS compared to sham.
13. An ANOVA comparing group and stimulation condition for the LBT revealed a significant effect of stimulation condition (p=0.017) and group (p<0.001) and a significant interaction between factors (p=0.006); in RBD+ patients, a significant reduction of error was found only with L-GVS compared to sham (p=0.002); no significant differences were found in the RBD- group.

4. For text copying, RBD+ patients showed a significant reduction in omissions in L-GVS compared to sham (p=0.002); no other significant differences were found in RBD+ or RBD- patients.

### 13.3.11 Optokinetic Stimulation

Table 13.3.11 Studies Assessing Optokinetic Stimulation

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vallar et al. (1993)</td>
<td>Italy</td>
<td>Pre-Post</td>
<td>10 right brain damaged patients with spatial neglect post stroke, 10 right brain damaged patients without neglect post stroke, 10 patients with left brain damage and 10 control subjects participated in the study. Optokinetic stimulation consisted of a pattern of 20 dots of light, projected on a screen, which moved in a constant, linear left or rightward fashion with an angular velocity of 45°/second. Personal position sense relating to the position of the forearm (both contralateral and ipsilateral) was assessed before and during stimulation.</td>
<td>On personal position sense tasks, control subjects attained perfect scores. With no stimulation, neglect patients performed significantly worse than those without neglect. Performance of other patient groups approached that of the control group. Optokinetic stimulation affected only the performance of right-brain damaged patients with neglect (p&lt;0.0001). Leftward movement of the dot pattern was associated with a significant improvement in position sense (p&lt;0.0001). In patients with right-sided damage and neglect, position sense deficits were noted using the contralateral and ipsilateral arm. In patients without neglect, minor deficits were noted using the arm contralateral to the lesion only.</td>
</tr>
<tr>
<td>Karnath (1996)</td>
<td>Germany</td>
<td>No Score</td>
<td>3 patients with right brain damage and spatial neglect along with 6 control patients with unilateral brain damage and no neglect were subjected to optokinetic stimulation. Stimulation consisted of a linear moving pattern of random white dots. The influence of stimulation on judgement of “straight ahead” was assessed under the following conditions: no stimulation, pattern movement to the left, pattern movement to the right.</td>
<td>The straight ahead position moved significantly to the right for patients with neglect as compared to control groups with leftward movement of the dot pattern (p=0.005). Rightward movement of the dot pattern increased the displaced judgement of straight ahead in patients with neglect.</td>
</tr>
<tr>
<td>Pizzamiglio et al. (2004)</td>
<td>Italy</td>
<td></td>
<td>22 patients with right-sided stroke and hemispatial neglect were randomly allocated to receive either optokinetic stimulation plus standard neglect</td>
<td>Rehabilitation for neglect was associated with significant improvements on a standard battery of neglect assessments (Line cancellation, letter</td>
</tr>
</tbody>
</table>
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5 (RCT) Rehabilitation (n=11) or just standard rehabilitation for neglect (n=11). Standard rehabilitation for neglect consisted of visual scanning training, reading and copying training, copying line drawings and figure description. Treatments consisted of 30 sessions, 5 times per week. Sessions were 1 hour in length. cancellation, reading, Wundt-Jaslow Area Illusion test) in both groups (p<0.000) from pre to mid to post treatment. Both groups demonstrated significant improvements on functional evaluation of extra-personal neglect (p<0.001 for pre – mid treatment and p<0.05 for mid to post treatment). There were no significant improvements demonstrated on the Scale for Personal Neglect in either group. There were no significant differences in performance between study groups.

Schroder et al. (2008) Germany 4 (RCT) 30 patients with left-sided neglect post stroke were randomly assigned to receive one of three treatments: 1) Transcranial electrical nerve stimulation (TENS) (applied to the left trapezius muscle throughout each training session) + computerised exploration (scanning) training, 2) optokinetic stimulation (OKS) + exploration training 3) exploration training only (control group). All patients received 20 exploration/scanning training sessions. OKS consisted of 50 randomly-distributed, white squares presented on a black background moving from right to left on a computer monitor. OKS was presented each training session in 2 10-minute blocks – one before and one after 10 – 20 minutes of exploration training. Assessments included line & star cancellation tests, line bisection, figure copying and freehand drawing, attention, electronic reading and dictation (writing a dictated sentence. Tests were administered at baseline, after the 10th & 20th sessions and 1-week post-treatment.

Thimm et al. (2009) Germany Pre-Post No Score TPSmean=8.4mo Nstart=7 Nend=7 Population: Mean age=65.7yr; Gender: Males=4, Females=2.

Intervention: Patients with visuospatial neglect received a 3wk optokinetic stimulation (OKS) program consisting of 14 sessions, each lasting 45min. Assessments were conducted at baseline (2 measures separated by 3wk, pre 1 and pre 2), 1d post OKS (post 1) and 4wk post OKS (post 2). Results were compared to previously reported results from a visual alertness training program with the same intensity (Thim 2006).

Outcomes: Total number of improved test results: Test Battery of Attentional Performance: Visual field, Visual scanning; Cancellation task; Line Bisection Test; Letter cancellation; Star cancellation; Line cancellation.

1. Median percentage changes for each initially impaired test showed significant improvement at post 1 and post 2 compared to baseline (p=0.039; p=0.031).
2. The number of improved test results post-OKS was significantly greater than the number of improved tests during baseline (p=0.042).
3. The number of improved test results 4wk post-OKS was significantly greater than the number of improved tests during baseline (p=0.033).
4. The number of improved test results post-OKS was non-significantly greater than the number of improved tests post alertness training (p=0.08).
5. The number of improved test results 4wk post-OKS was significantly greater than the number of improved tests 4wk post alertness training (p<0.001).

Keller et al. (2009) Population: Mean age=58.8yr; Gender: Males=5, Females=2. 1. Compared to VST, patients improved
<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reinhart et al. (2011)</strong></td>
<td>Right Hemisphere Damage with Neglect (RHD+N; N=9): Mean age=54.2yr; Gender: Males=6, Females=3; Right Hemisphere Damage without Neglect (RHD−N; N=7): Mean age=52.2yr; Gender: Males=3, Females=4.</td>
<td>Right hemisphere damaged patients with unilateral spatial neglect due to stroke received a single session of 4 different treatments lasting for 30min each in a span of 4d. The treatments were optokinetic stimulation with pursuit eye movements (OKSP), visual scanning treatment (VST), OKSP with prism adaptation (OKSP + P) and OKSP with arm movements (OKSP + A). <strong>Outcomes:</strong> Line Bisection Test (LBT); Tactile Search Test; Text Reading; Cancellation Task.</td>
<td>1. Compared to VST, patients improved to a significantly greater degree following OKSP + P only on the Cancellation task (p=0.045). 2. No significant differences were observed on any outcome measures following OKSP + A compared to VST. 3. Following treatment, patients improved on every measure except for Tactile Search Test following VST and all measures for OKSP + A.</td>
</tr>
<tr>
<td><strong>Kerkhoff et al. (2012)</strong></td>
<td>20 patients with a single, right side, stroke, visual neglect and left side auditory neglect participated in the study which examined the effect of optokinetic stimulation (OKS) to the contralesional side. Participants were randomized to either an intervention or a control group. The intervention involved the appearance of a 150 yellow square pattern on a black background which continuously moved. Participants were instructed to follow these squares with their eyes while completing an Auditory Subjective Median Plane (ASMP) task in which they were required to identify whether upcoming sounds were in their subjective median plane, or to the left/ right of it. Control patients performed the same task; however, the yellow square pattern remained stationary. Sessions lasted 20 minutes for both intervention and control groups. Three baseline assessments of ASMP were assessed on 3 different days within a 7 day period. Two post ASMP assessments were performed; one within 30 minutes of the experimental condition and one 24 hours following the experiment. Both groups showed a shift to the right side of their Auditory Subjective Median Plane (ASMP). The experimental group demonstrated normalization of the shift of ASMP during leftward OKS. This lasted for 30 minutes post intervention, and had returned to baseline after 24 hours. These changes were not observed in the control group.</td>
<td>1. A significant reduction in omissions of single words on the left side was found in the left OKS condition compared to baseline (p=0.028), right OKS (p=0.028) and post-intervention (p=0.008); no other significant differences were found for omission errors on the left side. 2. A significant reduction in omissions of single words on the right side was found in left OKS compared to post-intervention (p=0.012) and right OKS (p=0.012); no other significant differences were found for omission errors on the right side. 3. No significant differences were found in stimulus centered errors.</td>
<td></td>
</tr>
<tr>
<td><strong>Sturm et al. (2013)</strong></td>
<td>Population: Mean age=60yr; Gender: Males=4, Females=2.</td>
<td>1. The total number of improved test results was not significantly different between...</td>
<td></td>
</tr>
</tbody>
</table>
Pre-Post No Score TPS\textsubscript{mean}=4.1mo
\(N\text{Start}=6\) \(N\text{End}=6\)

**Intervention:** Patients with hemispatial neglect received 7 sessions of a visual alertness training (45min/session) for 2wk followed by 7 sessions of optokinetic stimulation (OKS) (45min/session) for 2wk. Comparisons were made between alertness training only and OKS + alertness. Assessments were conducted at baseline (2 measures separated by 3wk, pre 1 and pre 2), post alertness training (post 0.5), post OKS (post 1) and 3wk following OKS (post 2).

**Outcomes:** Total number of improved test results: Cancellation (letters, lines, stars), Line Bisection, Text copying, Test Battery of Attentional Performance (Visual field, Neglect task, Visual scanning).

Kerkhoff et al. (2013) Germany RCT PED\textsubscript{ro}=6 TPS\textsubscript{con}=5.2mo TPS\textsubscript{exp}=3.6mo
\(N\text{Start}=50\) \(N\text{End}=45\)

**Population:** Smooth Pursuit Training (SPT; \(N=24\)): Mean age=58.5yr; Gender: Males=16, Females=8; Visual Scanning Training (VST; \(N=21\)): Mean age=59.9yr; Gender: Males=14, Females=7.

**Intervention:** Patients with left-sided neglect were randomly allocated to receive either smooth pursuit eye movement training (SPT), or to receive standard visual scanning therapy (VST). The participants received 5 treatment sessions. Assessments were carried out at 4 time points: 2wk prior to starting the training, at baseline (right before training began), at post-test, and at 2wk follow-up after the post-test.

**Outcomes:** Single Digit Cancellation Task (SDCT); Double Digit Cancellation Task (DDCT); Paragraph reading test; Motor and perceptual line bisection task; Auditory Subjective Midline Test (ASMT).

1. A significant effect of time (\(p=0.001\)), group (\(p=0.001\)), and group x time interaction (\(p=0.003\)) was found on the ASMT.
2. A significant reduction of the rightward deviation in the auditory midline after SPT from baseline to post-test (\(\Delta M=8.45, p<0.001\)) and from baseline to follow-up (\(\Delta M=7.75, p<0.001\)) was found. This effect was not observed in the VST group.
3. A main effect of time (\(p<0.001\)) on the paragraph reading test was found, but no significant effect of group was found.
4. For the paragraph reading task, the SPT group showed a reduction of omissions from baseline to post-test (\(\Delta M=6.30, p<0.001\)), and to follow-up (\(\Delta M=7.12, p<0.001\)). This effect was not observed in the VST group.
5. An ANOVA comparing time and group for the perceptual line bisection task revealed a significant main effect of time (\(p=0.001\)) but no effect of group or interaction between factors. There was a significant reduction in rightward deviation after SPT from baseline to post-test (\(\Delta M=13.27, p=0.009\)), and from baseline to follow-up (\(\Delta M=13.42, p=0.004\)). No significant improvement was found in the VST group.
6. An ANOVA comparing time and group for the motor line bisection task revealed only a significant main effect of time (\(p<0.001\)) and no interaction between factors. The SPT was the only group that benefited from the therapy, with a significant reduction in rightward deviation from baseline to post-treatment (\(\Delta M=11.29, p=0.002\)) and from baseline to follow-up (\(\Delta M=0.001, p=0.001\)). No main effect of time was found in the VST group.
7. In both the SDCT and DDCT, the percent of
left-field omissions was significantly reduced from baseline to post-test (both p<0.05) and from baseline to follow-up (both p<0.05) for the SPT group but not for the VST group.

8. A significant main effect of time (p<0.001), side (p<0.001), group (p=0.027), and group x time (p=0.004) and side x time (p=0.003) was found on the SDCT.

9. The SPT group demonstrated a significant effect on the left side (p<0.001) and on the right side (0.004) of the SDCT which was not shown in the VST group.

10. A significant change from baseline to follow-up (left-sided: ΔM=2.94, p<0.001; right-sided: ΔM=1.02, p=0.003) was found in the SPT group but not in the VST group.

11. A significant effect of time (p<0.001), side (p<0.001), group (p=0.050), group x time interaction (p<0.001), side x time interaction (p=0.002), and group x side x time interaction (p=0.036) was found on the DDCT.

12. Significant left-sided (ΔM=7.23, p<0.001) and right-sided ((ΔM=2.94, p=0.001) omissions after SPT from baseline to post-test and from baseline to follow-up (left-sided: ΔM=5.90, p<0.001; right-sided: ΔM=2.27, p=0.007) were found. This effect was not found to be significant in the VST group for the DDCT.

Machner et al. (2014) Germany
Population: Experimental Group (EG; N=11): Mean age=69±3yr; Gender: Males=6, Females=5; Control Group (CG; N=10): Mean age=69±3yr; Gender: Males=6, Females=4.
Intervention: Patients were randomized to the EG and received hemifield eye patching and repetitive optokinetics stimulation (HEPOKS) in addition to the usual stroke care (physio, speech, and occupational therapy), or to the CG and received usual care only. The treatment lasted 1wk, and participants were assessed at baseline, post-treatment and at 30d follow-up.
Outcomes: Catherine Bergego Scale (CBS); Barthel Index (BI); modified Rankin scale (mRS); National Institutes of Health Stroke Scale (NIHSS); Bell’s Cancellations Test (BCT); Behavioral Inattention Test (BIT) Conventional subtest: Star Cancellation Test (SCT), Line Bisection Test (LBT); Ogden Figure Copying Task (OFCT); Reading errors.

1. There was a significant improvement in the neurophysiological test accuracy between baseline and post-treatment within both the EG and CG (p<0.001; p<0.05).
2. Additional improvement in the neurophysiological test accuracy between post-treatment and follow-up was observed in the EG (p<0.01) but not in the CG (p>0.05).
3. There was no significant difference between the two groups on the CBS.
4. CBS scores decreased significantly between post-treatment and follow-up within both the EG and CG (p<0.01; p<0.01).
5. There was no significant difference between the two groups on the BI; NIHSS, mRS, BCT, SCT, LBT, OFCT, or reading errors.
6. Only the EG showed improvements on the BCT from baseline to post-treatment (p=0.003) and from post-treatment to follow-up (p=0.007).

Kerkhoff et al. (2014) Germany
Population: Smooth Pursuit Training (SPT; N=12): Mean age=54±3yr; Gender: Males=7, Females=5; Visual Scanning Training (VST; N=12): Mean age=54±3yr; Gender: Males=7, Females=5.

1. The interaction between time points and group allocation was found to be significant (p=0.006) for the FNI.
RCT  
PEDro=8  
TPSVST=37d  
TPSSPT=30d  
NStart=24  
NEnd=24

age=64±3yr; Gender: Males=8, Females=4.

**Intervention:** Participants were randomly allocated to either receive smooth pursuit eye movement training (SPT) or to receive visual scanning training (VST). Both groups received 20 treatment sessions lasting 30min each at the bedside for 4wk. Participants were assessed at baseline (before training), post-treatment, and at follow-up (2wk).

**Outcomes:** Functional Neglect Index (FNI); Unawareness and Behavioral Neglect Index (UBNI); Help Index (HI); Barthel Index (BI).

1. Statically significant differences across the 4

**Kim et al.** (2015)  
**Population:** Mean age=73.1±5.8yr; Gender: Males=9, Females=4.
### South Korea

**Pre-Post**

No Score

TPS<sub>Mean</sub>=NA

N<sub>Start</sub>=14

N<sub>End</sub>=14

Females=5.

**Intervention:** Patients with hemispatial neglect performed line bisection tasks displayed on a computer screen with/without optokinetic stimulation (OKS) projected on the same screen or on a head-mounted display (HMD). Four conditions were tested: screen + OKS, screen – OKS, HMD + OKS, and HMD – OKS.

**Outcomes:** Line Bisection Test (LBT).

Conditions were present on the LBT (p<0.001).

1. LBT results did not differ between screen – OKS and HMD – OKS conditions.

2. Significant leftward deviation was found with the screen + OKS condition compared to screen – OKS (p<0.05).

3. Significant leftward deviation was found with the HMD + OKS condition compared to HMD – OKS (p<0.05).

4. Significantly greater leftward deviation was found with screen + OKS compared to HMD + OKS (p<0.05); HMD + OKS corrected rightward deviation more toward the actual midline than screen + OKS.

### Pitteri et al. (2015)

**Italy**

PCT

No Score

TPS<sub>SD</sub>N=6±6.9mo

TPS<sub>N</sub>=42.2±96mo

N<sub>Start</sub>=12

N<sub>End</sub>=12

**Population:** Right Hemisphere Damage with Neglect (RHD+N; N=6): Mean age=61.1±10.2yr; Gender: Males=5, Females=1; Right Hemisphere Damage without Neglect (RHD–N; N=6): Mean age=54.1±11.9yr; Gender: Males=4, Females=2.

**Intervention:** Patients completed visual line bisection with static, leftward, rightward and mixed optokinetic stimulation (OKS) (experiment 1). In the second experiment, patients completed a mental number interval bisection task under the same conditions of OKS.

**Outcomes:**

1. Line Bisection Test (LBT): Difference between observed and correct response (dO-C); Number Interval Bisection (NIB): Difference between observed and correct response (dO-C).

### Hopfner et al. (2015)

**UK**

PCT

No Score

TPS<sub>EG</sub>=32.42±11.95d

TPS<sub>CG</sub>=31.0±16.5d

N<sub>Start</sub>=18

N<sub>End</sub>=18

**Population:** Experimental group (EG; n=12): Mean age=62.0±10.6yr, Gender: Male=5, Female=7. Control group (CG; n=6): Mean age=65.4±15.2yr, Gender: Male=4, Female=2.

**Intervention:** The experimental group (EG) completed a bird cancellation task at baseline, after 1<sup>st</sup> session of smooth pursuit training (SPT), and after a 2<sup>nd</sup> session of SPT in combination with continuous theta burst stimulation (cTBS) or sham presented randomly. The control group (CG) performed the exact same sequence, however no SPT took place. Outcomes of the bird cancellation task were assessed at baseline and post training.

1. COC score was significantly improved following a single session of SPT in both the cTBS session and sham session (p<0.01 and p<0.05, respectively) for the 1<sup>st</sup> pursuit; however, only cTBS showed a further significant improvement after the 2<sup>nd</sup> pursuit (p<0.01).

2. NOC was significantly improved following a single session of SPT in only the cTBS session (p<0.05) for the 1<sup>st</sup> pursuit; furthermore, only cTBS showed a further significant improvement after the 2<sup>nd</sup> pursuit (p<0.01).
Outcomes: Centre of Cancellation (COC), Number of Cancellations (NOC).

Takamura et al. (2016) Japan PCT TPS_NC=46.4±27.1d TPS_CO=1029.3±1009.5d TPS_CG=245.5±595.7d N_Start=49 N_End=49

**Population:** No Compensate group (NC; n=15): Mean age=67.7±11.6yr. Compensate group (CO; n=10): Mean age=54.9±13.5yr. No Neglect Control group (CG; n=24): Mean age=62.9±13.4yr.

**Intervention:** Participants with (NC and CO) and without (CG) unilateral spatial neglect participated in eye pursuit-based choice reaction tasks and were asked to pursue one of five horizontally located circular objects flashed on a computer display. The task consisted of 25 trials with 4s intervals. Outcomes were assessed at baseline and post-intervention.

**Outcomes:** Behavioural Inattention Test (BIT), Catherine Bergego Scale (CBS).

1. The BIT score was significantly lower in the NC group than in the CO and CG groups (both p<0.01); however, there was no significant difference in BIT scores between the CO and CG groups.
2. Additionally, the NC group had higher CBS difference than the CO and CG groups (both p<0.01); however, there was no significant difference between the CO and CG groups in CBS difference.

Schaadt et al. (2016) Germany PCT TPS_EG=4.5±3.1mo TPS_CG=4.7±4.1mo N_Start=20 N_End=20

**Population:** Experimental group (EG; n=10): Mean age=57±9.1yr, Gender: Male=5, Female=5. Control group (CG; n=10): Mean age=54±10.4yr, Gender: Male=7, Female=3.

**Intervention:** Participants with (EG) and without (CG) spatial neglect completed a line task with 3 background conditions: static, counterclockwise, and clockwise rotating random dot motion background. Outcomes were assessed at baseline and post-intervention.

**Outcomes:** Tilt Deficit.

1. At baseline condition with static background the EG group showed a significant counterclockwise tilt (p<0.05).
2. Clockwise rotating random dot motion significantly normalized the tilt deficit in the EG group (p<0.05).

### 13.3.12 Trunk Rotation Therapy

#### 13.3.12.1 Studies Assessing Trunk Rotation Therapy

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinelli &amp; DiRusso (1996)</td>
<td>Italy</td>
<td>No Score</td>
<td>4 patients with unilateral spatial neglect and 4 patients with left brain damage and no neglect were assessed for visual evoked potentials in response to visual stimuli presented in the left and/or right visual fields. Patients were tested while seated so that their trunk and head faced the monitor and with their trunk rotated at a 45 degree angle to the left (head remained straight). Responses to stimuli were measured as visual evoked potentials.</td>
<td>In the baseline (straight) condition, left visual field responses were delayed in patients with neglect when compared with the left brain damage group. In the trunk rotation condition, visual evoked potentials were similar in both groups. Trunk rotation had no effect on subjects with left brain damage.</td>
</tr>
<tr>
<td>Wiart et al. (1997)</td>
<td>France</td>
<td>4 (RCT)</td>
<td>22 stroke patients with recent stroke of less than 3 months onset who exhibited severe unilateral neglect syndrome with line bisection &gt; 11% of right deviation, line cancellation &gt; 2% of right deviation and line cancellation &gt; 2 left omission (LO) and Bell test of &gt; 6 LO. Patients were randomized to either and</td>
<td>All 4 test results - line bisection, line cancellation, bell test, and change in Functional Independence Measure improved significantly more in the experimental group relative to the control group at 30 and 60 days.</td>
</tr>
</tbody>
</table>
experimental or to a control group. Experimental group received 1 hour a day for 20 days of the Bon Saint Come method (use of a device with attached pointer which required trunk rotation to complete scanning tasks) followed by 2 to 3 hours of traditional rehabilitation (1 to 2 hours of PT and 1 hour of OT). Control group received 3 to 4 hours of traditional rehabilitation.

**Fong et al. (2007)**

Hong Kong

6 (RCT)

54 patients with left visual neglect, admitted to inpatient rehabilitation following 1st or 2nd stroke, were randomly assigned to one of 3 groups. The first (n=19) received 60 minutes of training (45 minutes trunk rotation, 15 minutes ADL) five times/week for 1 month. The second (n=20) received the same treatment with the addition of half-field eye-patching. The remaining (n=15) patients were assigned to a control group that received conventional occupational therapy for hemiplegia (45 minutes) & 15 minutes ADL training. Assessment consisting of the BIT, Clock drawing test and FIM (motor subscale) was conducted at 0, 30 and 60 days.

At the end of training, there were no significant between group differences reported on any measure. However, on the locomotion items of the FIM-motor, there was a trend toward higher scores associated with trunk rotation. At 60 days, there were also no significant differences between groups on any of the BIT (conventional or behavioural), the clock drawing test or FIM-motor scores. Therefore, the training received in either experimental condition was not better than conventional treatment either at the end of the intervention or at 60-day follow-up.

### 13.3.13 Neck Muscle Vibration

**Table 13.3.13 Neck Muscle Vibration Therapy**

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
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</thead>
<tbody>
<tr>
<td>Schindler et al. (2002)</td>
<td>UK</td>
<td>5 (RCT)</td>
<td>NStart=20 NEnd=20</td>
<td>In a crossover study, 2 groups of 10 patients each received 15 sessions of visual exploration training and combined treatment (neck muscle vibration + visual exploration training). Outcomes assessed included perception of egocentric midline, visual and tactile exploration deficits, and visual size distortion. All outcomes were assessed on 6 occasions (3 baseline, 2 post treatment assessments and one follow-up 2 months after the end of intervention). Transfer of training to ADL activities was assessed and patients completed a questionnaire regarding the everyday problems associated with neglect.</td>
</tr>
<tr>
<td>Johannsen et al. (2003)</td>
<td>Germany</td>
<td>No Score</td>
<td>6 patients with severe left spatial neglect after right-sided stroke received muscle vibration treatments for 10 days. Treatment sessions lasted 20 minutes. Neck muscle vibration treatments were in addition to conventional treatment received in inpatient stroke rehabilitation. Patients were assessed for neglect using the Bells test and the Letter cancellation test. Assessments were conducted at baseline, approximately 11 days (10 – 14 days) following treatment and again at approximately 410.5 days (112 – 866 days) following</td>
<td>Neck muscle vibration therapy was associated with a significant improvement in spatial neglect as assessed by the letter cancellation task. This improvement was sustained at the long-term follow-up. While similar improvements were made on the Bells test, these did not reach significance.</td>
</tr>
</tbody>
</table>
In a multiple-baseline study, 11 patients with unilateral spatial neglect who experienced a right-hemisphere stroke underwent treatment. The first and last treatment sessions of 3 involved conventional OT (ADL, vocational, perceptual and functional activity training) for 40 minutes, 5 days a week. The middle session included the conventional OT programme preceded by 5 minutes of neck-muscle vibration immediately before. Neglect and activities of daily living were assessed by the BIT and FIM respectively. Assessments were performed before the treatments began and every 2 weeks during the 6 week study.

Significant improvements on the BIT were found following the session including neck-muscle vibration \( (p=0.003) \), but not during the other two sessions. In fact, the average BIT score following the second session of convention OT decreased compared to the average score following neck-vibration. Total FIM scores improved significantly in comparison to the previous assessment following the first session of only conventional OT as well as the session including neck-muscle vibration \( (p=0.003 \text{ and } p=0.005 \text{ respectively}) \). Sphincter and locomotion subscales showed a significant improvement after the 2 week session following the first convention OT treatment \( (p<0.05) \), while self-care showed significant improvement following both the first session and following neck-muscle vibration \( (p=0.005) \). When comparing to pre-treatment scores on the FIM, cognition was the only sub-score to not show significant improvements \( (p<0.008) \) following neck-muscle vibration. Following the second session of convention OT, self-care, transfer and locomotion scores improved significantly in comparison to pre-treatment \( (p<0.008) \).

### 13.3.14 Music Therapy

<table>
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<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
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<tr>
<td>Chen et al. (2013)</td>
<td>Taiwan</td>
<td>No score</td>
<td>19 participants with unilateral neglect following a right hemisphere stroke participated in this within-subject study design. Participants were tested in three conditions (pleasant music, unpleasant music and white noise) within 1 week. The participants were asked to choose three pleasant and three unpleasant pieces of music of any musical genre before the experiment. The choices of musical repertoire were generated solely by participants. In each condition, participants were asked to complete three sub-tests of the Behavioural Inattention Test (the Star Cancellation Test, the Line Bisection Test and the Picture Scanning test) and a visual exploration task with everyday scenes. Eye movements in the visual exploration task were recorded simultaneously. Mood and arousal induced by different auditory stimuli were assessed using visual analogue scales, heart rate and</td>
<td>Score differences between VAS2 and VAS1 (VAS2-1) and between VAS3 and VAS2 (VAS3-2) were calculated separately for mood and arousal in each condition. The repeated measure ANOVA revealed a significant effect of condition on VAS2-1 of mood and arousal. Posthoc pairwise comparisons showed that participants registered more positive emotion and higher arousal after listening to pleasant music for 1 minute. In contrast, participants registered less positive emotion and lower arousal after listening to unpleasant music or white noise. There is significant improvement on all tasks and eye movement data, except the Line Bisection Test.</td>
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</table>
13.3.15 Transcutaneous Electrical Nerve Stimulation (TENS)

Table 13.3.15 Transcutaneous Electrical Nerve Stimulation Therapy for Neglect

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>Vallar et al. (1993)</td>
<td>Italy</td>
<td>No Score</td>
<td>14 right handed patients were studied. All patients had a unilateral lesion in the right hemisphere. 13 patients had suffered an ischemic or haemorrhagic stroke with a mean duration 2.8 months and 1 patient had an intracranial neoplasm. An AGAR 2000™ stimulator with superficial electrodes was used to stimulate the posterior left or right neck, below the occipital, just lateral to the spine. Visuo-spatial hemineglect was assessed by the letter cancellation task in three successive conditions: 1) before stimulation baseline; 2) after a 15 minute unilateral simulation of the posterior neck: post stimulation assessment; 3) 30 minutes after the completion of the preceding condition: 30 minute delay assessment. In experiment 2, effects of stimulation of the left side of the neck were assessed in two conditions: 1) free: patients were free to move their head and trunk; 2) blocked: head movement was prevented by a chin rest and trunk rotation by string fixed to the wheelchair. In experiment 3, stimulation of the left side of the neck and stimulation of dorsal surface of the left hand were assessed.</td>
<td>The stimulation of the left side of the neck improved cancellation performance in 13 (93%) of the 14 patients. Right-sided stimulation improved performance in 9 (64%) patients, had a positive effect in 4 (29%) patients and 1 patient was left unaffected by the stimulation. Left neck stimulation temporarily improved neglect when head movement was prevented by chin-rest. Stimulation of both the left hand and left neck had comparable positive effects on visuo-spatial hemineglect.</td>
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<td>Guariglia et al. (1998)</td>
<td>Italy</td>
<td>No Score</td>
<td>9 patients with moderate to severe USN were assessed on the following imaginal tasks both with and without TENS stimulation to the left and right posterior neck muscles: familiar square description from a given vantage point, free drawing of objects, abstract shape comparison.</td>
<td>Left TENS was associated with the improved performance on all tasks when compared with the no-TENS condition. Stimulation of the right neck did not significantly improve performance compared to the no-TENS condition. Improvement effects with left-TENS varied with the test used.</td>
</tr>
<tr>
<td>Perennou et al. (2001)</td>
<td>France</td>
<td>No Score</td>
<td>Investigated postural control of 22 neglect stroke patients who sat for 8 sec on a laterally rocking platform and asked to maintain an actively erect posture without movement. TENS was applied on the</td>
<td>Aborted trials were more frequent in patients than in healthy subjects. Angular dispersion was smaller in healthy adults than in patients. Less balance loss was observed during TENS condition than in BASE</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Design</td>
<td>Outcome Measures</td>
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<td>Rusconi et al.</td>
<td>Italy</td>
<td>20</td>
<td>RCT</td>
<td>Tasks to facilitate visuo-spatial scanning</td>
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<td>(2002)</td>
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<tr>
<td>Schroder et al.</td>
<td>Germany</td>
<td>30</td>
<td>RCT</td>
<td>Tasks to facilitate visuo-spatial scanning, line</td>
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<tr>
<td>(2008)</td>
<td></td>
<td></td>
<td></td>
<td>bisection, sentence reading, clock drawing, facial</td>
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<td>recognition, Raven’s coloured matrices, position</td>
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<td>sense, and judgement of drawings.</td>
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<td>Seniow et al.</td>
<td>Poland</td>
<td>15</td>
<td>RCT</td>
<td>Tasks to facilitate visuo-spatial scanning</td>
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<td>(2016)</td>
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13.3.16 Repetitive Transcranial Magnetic Stimulation

Table 13.3.16 rTMS for Unilateral Neglect Post Stroke

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
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<tbody>
<tr>
<td>Oliveri et al. (2001)</td>
<td>Italy</td>
<td>No Score</td>
<td>Seven stroke patients (two with left brain damage and 5 with right brain damage) with contralateral spatial neglect received rTMS to the parietal cortex (locations P5 &amp; P6, posterior to the intraparietal sulcus) on the undamaged side. Stimulation was given during administration of a computerized task during which subjects were presented with a series of horizontal lines bisected by a vertical line. Subjects were asked to judge the length of the total line, the left segment and right line segment. Sham rTMS trials were also interspersed with active stimulations to control for unspecified effects of rTMS.</td>
<td>No adverse effects associated with treatment were reported. There was an improvement in performance of the visual stimulation task associated with rTMS compared to sham rTMS (p=0.0004) or with baseline (p=0.00001). Transient disruption of the parietal region in the unaffected hemisphere via focal rTMS was associated with temporary reduction of neglect.</td>
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<td>Brighina et al. (2003)</td>
<td>Italy</td>
<td>No Score</td>
<td>3 patients with right brain damage and left neglect following stroke received treatment with low-frequency rTMS to the parietal cortex (area P5) in the unaffected hemisphere. A total of 7 sessions were given – every other day for a period of two weeks. The authors used the same computerized visual task as the one used by Oliveri et al. (2001). Participants were asked to complete the task 15 days prior to treatment (time 1), at the beginning of treatment (time 2), the same day as the end of treatment (time 3) and 15 days following the end of treatment (time 4).</td>
<td>At the end of treatment (time 3), there was a significant improvement in performance of the visuospatial task associated with rTMS treatment (p=0.000052) when compared to time 2 (prior to treatment). The improvement appeared to be sustained as at time 4, there was still significant change noted when compared to time 2 (p=0.000054). Subject improvement was also noted on a line bi-section task when performance at time 4 was compared to time 1 (p&lt;0.005).</td>
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<tr>
<td>Shindo et al. (2006)</td>
<td>Japan</td>
<td>No Score</td>
<td>2 patients with chronic left-sided unilateral neglect following stroke received 6 rTMS sessions to the left posterior parietal cortex over a period of 2 weeks. Assessments included the Behavioral Inattention Test, Barthel Index, MMSE and the Brunnstrom Recovery Stages. Assessments were conducted at 6 time points; 2 weeks prior to treatment, the day prior to treatment, the first day of treatment, 2 weeks later, 4 weeks later and 6 weeks following the last session.</td>
<td>Both patients reported no adverse effects associated with treatment. BIT scores improved significantly following rTMS. Peak BIT scores occurred at least 2 weeks following the completion of treatment. BIT scores at 6 weeks remained higher than those at baseline. There were no significant changes noted in cognitive function, Brunnstrom stages or in the Barthel Index.</td>
</tr>
<tr>
<td>Nyffeler et al. (2009)</td>
<td>Switzerland</td>
<td>Pre-Post</td>
<td>TPSmean=7.1mo</td>
<td>Population: Mean age=54.1yr; Gender: NA. Intervention: Patients with left sided visual neglect due to right hemisphere brain damage from stroke underwent 4 conditions of TBS: 2 TBS trains over the left contralesional posterior parietal cortex, 4 TBS trains over the contralesional posterior parietal cortex, 2 sham TBS trains and a control condition with</td>
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</table>
N_{End}=11 no intervention.

Outcomes: Number of perceived targets: Left sided, Right sided; Reaction time of perceiving visual targets: Left sided, Right sided.

(p=0.022). The number of perceived targets 1hr post-stimulation and 8hr post-stimulation was significantly greater when compared to baseline (p=0.04; p<0.01); the number of perceived targets fell to baseline levels 24hr post-stimulation in 2 patients.

4. In the sham TBS condition, no significant effect was found for time for the number of visual targets presented on the left side (p=0.615).

5. In the control condition, no significant effect was found for time for the number of visual targets presented on the left side (p=0.531).

6. In the 4x TBS condition, a significant main effect of time was found for the number of visual targets presented on the left side (p=0.0005); a significant increase compared to baseline was observed 1hr post-stimulation (p=0.048), 3hr post-stimulation (p=0.03), 8hr post-stimulation (p=0.04), 24hr post-stimulation (p=0.04) and 32hr post-stimulation (p=0.02). After 96hr, no significant difference was observed between baseline.

7. In the 2x TBS condition, a significant main effect of time was found for reaction time of perceiving left sided targets (p=0.034) but not for right sided targets; a significant decrease in reaction time of perceiving left sided targets was found 1hr post-stimulation (p=0.03) and 8hr post-stimulation (p<0.01) compared to baseline.

8. In the sham and control conditions, no significant effects of time were found for reaction times of perceiving left or right sided targets.

9. In the 4x TBS condition, a significant main effect of time was found for reaction time of perceiving left side targets (p=0.0407) but not right sided targets (p=0.0547); a significant decrease in reaction time of perceiving left sided targets was found 3hr post-stimulation (p=0.03), 8hr post-stimulation (p=0.03), 24hr post-stimulation (p=0.03) and 32hr post-stimulation. No significant difference was found 96hr post-stimulation compared to baseline.

Lim et al. (2010) South Korea PCT No Score

14 patients with hemispatial neglect following a right hemisphere stroke were separated into a control group or a treatment group. Both groups received 30 minutes of standard neglect therapy 5 days a week for 2 weeks but patients in the treatment group received rTMS over the left parietal area for 15 minutes, 30 minutes before the standard therapy. Evaluations Patients that received rTMS before standard therapy demonstrated a trend towards greater improvement than the control group on the left-sided line-set of the line bisection test (p =0.053). However, no significant difference was seen for the centered line-set and the right sided-line set (p=0.05). Patients who did not receive rTMS.
using the line bisection test and the Albert’s test were performed one day before the intervention began and one day after it finished.

**Koch et al. (2012)**
Italy
9 (RCT)

20 patients with hemispatial neglect from a right hemispheric stroke were randomized into real or sham theta burst stimulation (TBS). This rehabilitation occurred for 4 weeks and consisted of 20 sessions each of which last 45 minutes, 5 times each week. Conventional therapy was based on computerized visuospatial scanning training. Hemispatial neglect was assessed with the BIT and conventional paper and pencil tests.

Results found that two weeks of TBS was effective in improving neglect symptoms as measured by BIT scores \( P < .05 \). TBS was effective in comparison to the sham group in improving visual spatial neglect by total BIT scores \( (P < .001) \). BIT scores improved by 16.3% after two weeks of stimulation and by 22.6% at one month follow-up. No significant adverse effects were reported by patients.

**Cazzoli et al. (2012)**
UK
RCT
PEDro=8
TPS
Mean=26.6±4.4d
NStart=24
NEnd=24

**Population:** Mean age=58±2.25yr; Gender: Males=17, Females=7.

**Intervention:** Patients with subacute left spatial neglect were randomly assigned to one of three groups: sham followed by continuous theta burst stimulation (TBS) (EG1), continuous TBS followed by sham TBS (EG2) or no stimulation control group (CG). The study aimed to investigate whether TBS could ameliorate spatial neglect on a quantitative measure of the activities of daily living during spontaneous behaviour. Eight trains of continuous theta burst repetitive transcranial magnetic stimulation were applied over two consecutive days on the left posterior parietal cortex.

**Outcomes:** Catherine Bergego Scale (CBS); Vienna Test System (VTS): left and right-sided visual targets; Random Shape Cancellation Test (RSCT); Two Part Picture Test (TPPT); Munich Reading Texts (MRT).

1. In both groups receiving stimulation there was significant reduction over time of neglect severity according to the CBS \((p<0.001)\).  
2. The reduction of neglect severity according to the CBS was also significantly greater for EG1 and EG2 in comparison to the CG \((EG1: \Delta M=0.961±0.253, p=0.04; EG2: \Delta M=0.865±0.296, p=0.043; CG: \Delta M=0.087±0.052)\).  
3. This improvement in neglect severity was significant from baseline to 3wk follow-up \((EG1: \Delta M=1.409±0.242, p=0.002; EG2: \Delta M=1.113±0.317, p=0.045; CG: \Delta M=0.359±0.131)\).  
4. The reduction in the number of omitted left-sided visual targets was significantly greater in EG1 and EG2 compared to the CG at post-intervention \((EG1: \Delta M=0.833±0.206, p=0.038; EG2: \Delta M=0.880±0.189, p=0.004; CG: \Delta M=0.165±0.128)\) and from baseline to 3wk follow-up \((EG1: \Delta M=1.089±0.312, p=0.041; EG2: \Delta M=1.157±0.260, p=0.013; CG: \Delta M=0.156±0.070)\).
5. The reduction in the number of omitted right-sided visual targets was not significantly different between groups post-intervention or at 3wk follow-up.
6. Mean reaction times to left-sided visual targets on the VTS were significantly reduced after active TBS but not sham TBS within both EG1 \((p=0.008)\) and EG2 \((p=0.003)\) but not the CG.
7. Mean reaction times to right-sided visual targets on the VTS were significantly reduced after active TBS but not sham TBS within EG2 \((p=0.002)\); no reductions in mean reaction times occurred in the sham group.
8. The number of left-side omissions after TBS were significantly reduced post-intervention in EG1 and EG2 compared to CG on the RSCT (EG1: $\Delta M=1.358\pm0.314$, $p=0.017$; EG2: $\Delta M=0.691\pm0.186$, $p=0.031$; CG: $\Delta M=0.038\pm0.200$) and the TPPT (EG1: $\Delta M=1.168\pm0.276$, $p=0.003$; EG2: $\Delta M=0.781\pm0.273$, $p=0.017$; CG: $\Delta M=0.324\pm0.217$).

9. The number of left-side omissions was significantly reduced in EG1 compared to CG from baseline to 3wk follow-up on the RSCT (EG1: $\Delta M=2.407\pm0.545$, $p=0.005$; CG: $\Delta M=0.393\pm0.273$) and the TPPT (EG1: $\Delta M=1.886\pm0.249$, $p<0.001$; CG: $\Delta M=0.340\pm0.142$).

10. The number of left-side omissions was not significantly different between EG2 and CG from baseline to 3wk follow-up.

11. No significant differences in the number of left-sided omissions were observed in EG1 and EG2 compared to CG on the MRT at post-intervention or 3wk follow-up.

12. No adverse effects from the TBS were reported.

**Kim et al.** (2013)  
Korea 7 (RCT)  
27 patients with visuospatial neglect were randomized into three groups. Patients either received low frequency rTMS, high frequency rTMS or sham stimulation. Patients all received 10 sessions of rTMS or sham of the posterior parietal cortex. Severity of visuospatial neglect was assessed pre- and post-treatment using the Motor-Free Visual Perception Test, Line Bisection test, Star Cancellation test and Catherine Bergego Scale.

Post hoc analysis found improvement in the line bisection test score for the high-frequency rTMS group that was significantly different compared to the sham stimulation group. (high vs. sham $P= .03$, low vs. sham $P=.09$, high vs. low $P= .58$). The secondary outcome measure of Korean-Modified Barthel Index (K-MBI) also found significant difference for the 2 rTMS groups in comparison to the shame group with high vs. sham $P= <.01$ and low vs sham $P=.02$ and no significant differences between low and high rTMS ($P= .75$).

**Agosta et al.** (2014)  
Italy  
Pre-Post  
No Score  
TPS_{Cont}=NA  
TPS_{Exp}=16.8d  
N_{Start}=9  
N_{End}=9  
**Population:** Right Parietal Lesion Group (RVF; N=6): Mean age=67.8±9.3yr; Gender: Males=4, Females=2; Left Parietal Lesion Group (LVF; N=3): Mean age=52yr; Gender: Males=3, Females=0; Healthy Control Group (CG; N=6): Mean age=65yr; Gender: Males=4, Females=2.  
**Intervention:** Patients underwent repetitive transcranial stimulation (rTMS) applied to the healthy left hemisphere. They received low frequency TMS to the left hemisphere and a sham control divided in two counterbalanced sessions. The patient’s attentional times for right-sided targets were observed for EG1 or CG.

1. A repeated ANOVA in RVF patients revealed a main effect of stimulation, indicating a significant improvement after active but not sham TMS ($P=0.027$), and a significant stimulation x task interaction ($p=0.025$), indicating a greater improvement in the unilateral task compared to the bilateral task after active stimulation relative to sham ($p=0.012$).
2. Analysis also demonstrated significant interaction between the stimulation x task x
tracking task was assessed before rTMS, immediately after rTMS and 30min from the end of the stimulation. Visual neglect was only present in RVF patients.

**Outcomes:** Bilateral and unilateral tracking tasks.

visual field (p=0.009), suggesting an improvement in the LVF compared to the RVF during the unilateral task compared to the bilateral task following active stimulation relative to sham.

3. T-tests also showed an improvement in the unilateral (p<0.001) and bilateral (p=0.009) conditions in the LVF after active compared to sham stimulation.

4. The difference between the immediately post-rTMS and the 30min post-rTMS conditions for the active stimulation in the unilateral and bilateral conditions was not found to be significant.

| Fu et al. (2015) | Population: Intervention Group (IG; N=10): Mean age=55.1±14.0yr; Gender: Males=8, Females=2; Control Group (CG; N=10): Mean age=59.5±12.7yr; Gender: Males=8, Females=2. | **1.** Significant differences were found between the IG and CG at Post 1 SCT scores and Post 2 SCT scores (p=0.030; p<0.001). |
| | Intervention: Participants were randomized to either the IG and received continuous theta-burst stimulation (cTBS), or the CG and received sham treatment. All participants were assessed before start of the first session of stimulation (baseline), at the end of the stimulation (Post 1), and after a follow-up of 4wk (Post 2). | 2. The SCT scores significantly improved in the IG from baseline to Post 1 (p<0.001) and from baseline to Post 2 (p<0.001) however; no significant difference was found between Post 1 and Post 2. |
| | Outcomes: Behavioral Inattention Test (BIT) Conventional subtest: Star Cancellation Test (SCT), Line Bisection Test (LBT). | 3. A significant group x time effect and a group x time interaction was observed regarding the SCT scores (p<0.001; p<0.001). |
| | | 4. There was no significant difference between groups at Post 1 in the LBT scores however, there was a significant difference at Post 2 (p=0.004). |
| | | 5. Within the IG, there were significant differences between baseline and Post 1 LBT scores (p=0.042) and between baseline and Post 2 scores (p=0.001) however; no significant difference was observed between Post 1 and Post 2 in the IG. |
| | | 6. A significant group x time effect and a group x time interaction was found regarding the LBT (p<0.001; p=0.045). |

| Yang et al. (2015) | Population: 1 Hz TBS group (01; n=9): Mean age=46.72±13.11yr, Gender: Male=6, Female=3. 10 Hz TBS group (10; n=10): Mean age=48.01±12.25yr, Gender: Male=4, Female=6. Continuous TBS group (CO; n=9): Mean age=49.45±10.78yr, Gender: Male=4, Female=6. | 1. CO group showed a significantly greater improvement in the SCT over 6wk compared to the CG and 10 groups (both p<0.05), but not the 01 group (p>0.05). |
| | Intervention: Participants with unilateral spatial neglect were randomized to receive theta burst stimulation (TBS) at 1Hz (01), 10 Hz (10), continuous TBS (CO), or sham stimulation (CG) for 2wk. Outcomes were assessed at baseline, 2wk and 6wk. | 2. CO and 01 groups showed a significantly greater improvement in LBT over 6wk compared to the CG and 10 groups (all p<0.01); however, there was no significant difference between CO and 01 groups (p>0.05). |
| | Outcomes: Star Cancellation Test (SCT), Line Bisection Test (LBT). |
### Population: Experimental group (EG; n=10):
- Mean age: 59.8±9.9 yr, Gender: Male=5, Female=5.
- Control group (CG; n=10): Mean age: 56.7±8.2 yr, Gender: Male=6, Female=4.

**Intervention:** Participants were randomly assigned to receive repetitive transcranial magnetic stimulation (EG) or sham stimulation (CG). Both groups underwent comprehensive rehabilitation therapy 5d/wk over 4wk. Outcomes were assessed at baseline and 4wk.

**Outcomes:** Motor Free Visual Perception Test (MVPT), Line Bisection Test (LBT), Albert Test (AT), Star Cancellation Test (SCT).

1. The EG group showed a significantly greater improvement in MVPT, LBT, AT, and SCT after 4wk compared to the CG group (all p<0.05).

### Population: Experimental group (EG; n=15):
- Mean age: 66.7±6.9 yr, Gender: Male=5, Female=10.
- Control group (CG; n=19): Mean age: 62.3±11.2 yr, Gender: Male=10, Female=9.

**Intervention:** Participants with hemispatial neglect were randomized to receive 10 sessions of daily repetitive transcranial magnetic stimulation over 2wk (EG) or a single session of rTMS (CG). Outcomes were assessed at baseline and 2wk.

**Outcomes:** Letter Cancellation Test (LCT), Line Bisection Test (LBT).

1. EG group showed a significantly greater improvement in LCT and LBT compared to the CG group at 2wk (all p<0.01).

### Population: Experimental group (EG; n=5):
- Mean age: 52.6±5.58 yr.
- Control group (CG; n=5): Mean age: 53.0±3.65 yr.
- Both group (BG; n=3): Mean age: 54.2±5.44 yr.

**Intervention:** Participants with left-sided hemispatial neglect were randomized to receive 2 trains of 801 pulses of continuous theta burst stimulation (EG) separated by 15min or sham stimulation (CG). Three participants received CG intervention first followed by EG intervention after 5d (BG). Outcomes were assessed at baseline and within 8hr of post-intervention.

**Outcomes:** Computer Balloon Search Test (High and Low Density).

1. The EG group showed a significantly greater number of targets detected after treatment on the left side for both the high and low density conditions (both p<0.01); however there was no significant difference on the right side for both conditions (both p>0.05).
2. There was no significant difference after treatment in the CG group on the right or left side for both high and low density conditions (all p>0.05).
3. After treatment the EG group was significantly more improved than the CG group averaging high and low conditions (p<0.05).

### Population: Experimental group (EG; n=7):
- Mean age: 55±12 yr; Gender: Males=6, Females=1.
- Control group (CG; n=6): Mean age: 62±10 yr; Gender: Males=5, Females=1.

**Intervention:** Patients with visuospatial neglect (VSN) were randomized to receive 80% resting motor threshold (RMT) intermittent theta burst stimulation (iTBS) over the left dorsolateral prefrontal cortex (EG) or 40% RMT iTBS (CG). Both groups received visual scanning training and motor function training after 1. Both EG and CG groups showed a significant improvement in LBT (p=0.018 and p=0.028, respectively); however the EG group showed a significantly greater improvement (p=0.003).
2. Both EG and CG groups showed a significant improvement in SCT (p=0.018 and p=0.043, respectively); however the EG group showed a significantly greater improvement (p=0.003).
Perceptual Disorders

iTBS treatment and took place over 10d. Outcomes were assessed at baseline and 10d. **Outcomes**: Line Bisection Task (LBT), Star Cancellation Test (SCT).

<table>
<thead>
<tr>
<th>Cha &amp; Kim (2016)</th>
<th>Korea RCT PEDro=6 TPS_EG=4.13±1.13m o TPS_CG=3.86±0.83m o NStart=30 NEnd=30</th>
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</thead>
</table>
| **Population**: Experimental group (EG; n=15): Mean age=64.07±12.1yr, Gender: Male=7, Female=8. Control group (CG; n=15): Mean age=63.33±12.16yr, Gender: Male=9, Female=6. **Intervention**: Participants with unilateral neglect were randomized to receive repetitive transcranial magnetic stimulus (EG) or sham stimulation (CG). Both groups underwent comprehensive rehabilitation therapy 5d/wk over 4wk. Outcomes were assessed at baseline and 4wk. **Outcomes**: Line Bisection Test (LBT), Albert Test (AT), Box and Block Test (BBT), Grip Strength. | 1. The EG group showed a significantly greater improvement in LBT, AT, and BBT at 4wk compared to the CG group (all p<0.05).
2. There was no significant difference between groups in grip strength after 4wk (p>0.05). |

### 13.3.17 Transcranial Direct Current Stimulation

#### Table 13.3.17 Transcranial Direct Current Stimulation (tDCS)

<table>
<thead>
<tr>
<th>Author, Year Country PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>Ko et al. (2008) Korea Cross-over RCT PEDro=8</td>
<td>In a double-blind, crossover study, 15 patients with post-stroke neglect received anodal and sham DC stimulation in a randomized order. For active treatment, current was 2.0 mA, delivered for 20 minutes. In the sham treatment, current was delivered for 10 sec., then turned off. There was an interval of 48 hours between sessions. Outcomes were assessed before and immediately after sessions and included the line bisection test, a letter-structured cancellation test and shape-unstructured cancellation test.</td>
<td>On scores (percentage deviation) on the line bisection test and shape-structured cancellation test (# of omissions), there was a significant intervention X time interaction identified such that individuals receiving active tDCs demonstrated significant improvements on before and after testing (p&lt;0.05). The intervention X time interaction for the letter-structured cancellation test was not significant. In this test, the number of omissions decreased significantly in both the DC and sham conditions.</td>
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</tbody>
</table>
| Sparing et al. (2009) Switzerland Pre-Post No Score TPS_mean=NA NStart=10 NEnd=10 | **Population**: Mean age=57.3±16.9yr; Gender: Males=4, Females=6. **Intervention**: Patients with left sided visual neglect due to right hemisphere brain damage from stroke underwent 4 conditions of tDCS: tDCS anodal delivered to the unlesioned hemisphere, tDCS anodal delivered to the lesioned hemisphere, tDCS cathodal delivered to the posterior parietal cortex and sham tDCS. **Outcomes**: Test Battery of Attentional Performance (TAP): Neglect; Line Bisection Test (LBT). | 1. The number of detected or cancelled stimuli on the TAP neglect subtest within the left visual hemispace did not significantly improve following any tDCS condition.
2. On the TAP neglect subtest, patients tended to respond fastest following anodal tDCS of the lesioned hemisphere.
3. An ANOVA comparing time and tDCS condition for response time and error rate on the TAP neglect subtest revealed no significant main effects and no interaction between factors.
4. An ANOVA analysis of time and tDCS condition of the LBT revealed a main effect of time (p=0.04); anodal tDCS of the lesioned hemisphere. |
hemisphere and cathodal tDCS caused a significant reduction in the rightward bias compared to baseline (p<0.05; p<0.01).

5. No significant effects on the LBT were found for anodal tDCS of the lesioned hemisphere and sham tDCS.

Smit et al. (2015)
Netherlands
Cross-over PCT
No Score
TPSmean=58mo
NStart=5
NEnd=5

Population: Mean age=64.4±8.87yr; Gender: Males=3, Females=2.

Intervention: Patients received either transcranial direct current stimulation (tDCS) followed by placebo (sham) stimulation or tDCS after placebo treatment. tDCS or placebo treatments were applied for 20min over 5d with a 4wk washout period between treatments. Patients were assessed at baseline, at week 2 before and after the first round of treatment, at week 8 before and after the second round of treatment and at week 13 for follow-up.

Outcomes: Behavioral Inattention Test (BIT)
Conventional subtest: Star Cancellation Test (SCT), Letter Cancellation Test (LtrCT), Line Bisection Test (LBT), Line Crossing Test (LCT), Figure and Shape Copying Test (FSCT), Representational Drawing (RD); Centre of Cancellation (CoC).

1. The average difference scores were not significantly different between the two groups immediately after the treatment with respect to the cancellation tasks (tDCS: ΔM=-0.06; placebo: ΔM=2.4; p=0.188), LBT (tDCS: ΔM=-0.4; placebo: ΔM=; p=0.625), and drawing tests (tDCS: ΔM=0.4; placebo: ΔM=0; p=0.438) or for any outcome at intermediate time points or at follow-up.

2. No significant differences in the horizontal spatial distribution of cancelled items on the SCT according to the CoC was observed between treatment conditions at immediate, intermediate and follow-up assessments.

13.3.18 Pharmacological Interventions

13.3.18.1 Dopaminergic Medication Therapy

Table 13.3.18.1 Dopaminergic Medications for Neglect After Stroke

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
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<tbody>
<tr>
<td>Fleet et al. (1987)</td>
<td>USA</td>
<td>No Score</td>
<td>2 subjects with significant neglect; one 6 months post stroke, the second 2 months post stroke. Each were given 15 mg of bromocriptine daily for 3 to 4 weeks. Assessments included shoulder tapping, extinction to bilateral tactile, auditory and visual stimuli, bilateral raising of arms and timed tests of motor impersistence. In addition, patients were assessed on line bisection, line cancellation, letter cancellation and geometric figure cancellation.</td>
<td>Patient 1 improved on all measures of neglect while on bromocriptine therapy (p=0.026). Withdrawal of therapy was associated with decline in performance on all evaluations but line cancellation. Patient 2 improved on all tests administered (2 were not feasible) (p=0.017). Performance declined on all tests but extinction and line bisection (on which there continued to be improvement).</td>
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<td>Geminiani et al. (1998)</td>
<td>Italy</td>
<td>No Score</td>
<td>4 patients with right hemisphere lesions and left neglect post stroke were given 2 mg apomorphine 6-hydrochloride (a dopamine agonist) subcutaneously. On day 2, patients received placebo. Patients were evaluated using a circle crossing test and a modified Bell’s test before and after treatment with both apomorphine and the placebo.</td>
<td>No significant differences were found in performance between baseline and placebo conditions. Treatment with apomorphine was associated with significant improvements in circle crossing compared to baseline (p=0.012) and to placebo (p=0.093). Performance on counting and pointing was also improved following apomorphine when compared to baseline (p=0.068). Improvement in pointing exceeded</td>
</tr>
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Mukand et al. (2001) USA No Score
4 women with right brain stem stroke and left neglect were given a trial of carbidopa L-dopa to treat left neglect. Patients were evaluated by the modified Behavioural Inattention Test (BIT) and by the Functional Independence Measure.
3 of the 4 patients demonstrated significant improvements on the modified BIT and FIM.

Buxbaum et al. (2007) USA No Score
4 patients with chronic post-stroke neglect were treated with 100 mg twice daily amantadine, a glutamate agonist that may modulate dopamine transmission, in an ABA design. Assessment to treatment response was assessed using 17 measures. Testing sessions occurred approximately 3 times per week per patient.
There were few modest positive responses to treatment recorded. For most, treatment was associated with an ambiguous response. However, there were relatively few adverse effects reported.

Gorgoraptis et al. (2012) UK 9 (RCT)
Double blind RCT, placebo controlled study with ABA design. Sixteen (16) right-hemisphere stroke patients were recruited, all of whom completed the trial. Each patient was assessed for 20 testing sessions, in three phases: pretreatment (Phase A1), on transdermal rotigotine for 7–11 days (Phase B) and post-treatment (Phase A2), with the exact duration of each phase randomized within limits. Outcome measures included performance on cancellation (visual search), line bisection, visual working memory, selective attention and sustained attention tasks, as well as measures of motor control.
Performance on the Mesulam shape cancellation task improved significantly while on rotigotine, with the number of targets found on the left side increasing by 12.8% (P = 0.012) on treatment and spatial bias reducing by 8.1% (P = 0.016). The improvement in visual search was associated with an enhancement in selective attention but not on measures of working memory or sustained attention. There were no serious adverse effects with the treatment of rotigotine.

13.3.18.2 Acetylcholinesterase Inhibitors Therapy

Table 13.3.18.2 Acetylcholinesterase Inhibitors for Neglect After Stroke

<table>
<thead>
<tr>
<th>Author, Year Country PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
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<td>Paolucci et al. (2010) Italy 7 (RCT)</td>
<td>20 patients who experienced a stroke with unilateral spatial neglect were randomly assigned to two groups: one which received rivastigmine (RIV”) (1.5 mg twice a day for a week, then 3 mg twice a day for 8 weeks) and one which did not. Both groups received physical therapy and cognitive training consisting of visual scanning, reading and copying, copying of line drawings on a dot matrix, and description of a scene. Physical therapy was 120 minutes a day, 6 days per week and occupational therapy was 30 minutes per day, 5 days a week. Assessments were performed at baseline (at least 1 month post-stroke), at discharge and at follow-up (1-month after therapy). Assessment was a battery of tests including a letter cancellation test, the Barrage test, a sentence reading test, and the Wundt-Jastrow Area Illusion Test.</td>
<td>At discharge, the RIV&quot; group had significantly higher scores than the group receiving only rehabilitation and cognitive training on the letter cancellation test (F=5.93, p=0.026), the effectiveness on letter cancellation (F=9.59, p=0.006), the Wundt-Jastrow (Left side) (F=4.93, p=0.039), and the effectiveness on Wundt-Jastrow (F=5.45, p=0.031). No other significant treatment effects were reported. At follow-up, significant between group differences were no longer observed on any measure. This was attributed to improvements in the control group over time (p=0.014) while scores in the treatment group remained stable over time.</td>
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### 13.3.18.3 Nicotine Therapy

**Table 13.3.18.3 Nicotine for Neglect after Stroke**

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Country</th>
<th>PEDro Score</th>
<th>Methods</th>
<th>Outcomes</th>
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</table>
| **Vossel et al.** (2010) | Germany      | Pre-Post No Score | TPS\_mean=22.1±2.6mo N\_start=11 N\_end=9 | \textbf{Population}: Mean age=67.0±3.7yr; Gender: Males=8, Females=1.  
\textbf{Intervention}: Patients with chronic spatial neglect following right hemisphere damage received one treatment of a nicotine gum and one with placebo gum with each session separated by a period of 1wk.  
\textbf{Outcomes}: Location cueing paradigm: Accuracy, Reaction time. |
| **Lucas et al.** (2013) | Switzerland  | Cross-over RCT | PEDro=7 TPS\_mean=6.4mo N\_start=10 N\_end=10 | \textbf{Population}: Mean age=64.1±22.1yr; Gender: Males=2, Females=8.  
\textbf{Intervention}: Participants with spatial neglect after a first-ever unilateral right-hemispheric stroke were randomized in the order the received a nicotine patch (Nicorette, 10 mg) and a placebo patch. On day 1, baseline performance was measured. On day 2, patients received either the nicotine patch or the placebo patch. On day 3, 24hr following administration of the first patch, the other treatment was given. On days 1, 2, and 4, neglect was assessed. Neuropsychological effects were assessed 6-8hr after the patch was applied.  
\textbf{Outcomes}: Bell’s Cancellation Task (BCT); Behavioural Inattention Test (BIT) Conventional subtest: Letter Cancellation Task (LCT), Shape Cancellation Task (SCT), Compound-Word Reading Task (CWRT); Line Bisection Task; Lateralized Visual Detection Task (LVDT); Cued Detection Task |

1. No significant differences were found in accuracy of the Location cueing task between left and right targets and between the placebo and nicotine sessions.  
2. An ANOVA comparing cue (valid, invalid) and hemifield (left, right) for reaction time of the location cueing task in the placebo session revealed significant main effects for both factors (p<0.05 for both) and a significant interaction between factors (p<0.05); slower responses were found for invalidly cued targets on the left side.  
3. An ANOVA comparing cue (valid, invalid), hemifield (left, right) and drug for reaction time of location cueing revealed significant main effects of all factors (p<0.01; p<0.01; p<0.05 respectively) and a significant interaction between cue and hemifield (p<0.05) but no interaction with drug; nicotine decreased reaction time nonspecifically with no different effect for left invalidly cued trials.  
4. An ANOVA comparing cue (neutral, no), hemifield (left, right) and drug for reaction time of location cueing revealed no significant main effect or interaction effects of drug.
13. Perceptual Disorders

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<th>(Posner’s paradigm, CDT); Quadruplet Detection Task (QDT); MRicro and SPM lesion mapping analysis.</th>
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<td><strong>4.</strong> Efficiency for target detection on the CDT was significantly improved by nicotine treatment relative to baseline ($p&lt;0.05$), and placebo ($p&lt;0.05$).</td>
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<td><strong>5.</strong> No effect of nicotine treatment on neglect symptoms was found for the LBT, CWRT or on the QDT on either the miser or the correct time for contralateral targets.</td>
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<td><strong>6.</strong> MRI lesion analysis showed that neglect severity did not correlate with lesion volume and that greater improvement did not correlate with consistent involvement of particular brain regions.</td>
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References


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