Final Project Report
February 2014

Description and measurement of visual scanning training in Occupational Therapy for patients with visual search deficits following stroke

Grant holder
Dr Ailie Turton

This project was undertaken with the support of a
Research Priority Grant
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Building the evidence – creating the future

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College of Occupational Therapists
106–114 Borough High Street
London SE1 1LB
www.cot.org.uk

Grant Holder /Principal Investigator: Dr Ailie Turton
Report Author: Dr Ailie Turton

Executive Summary

Background

Visual search is a process which is integral for carrying out most activities of daily living; for example for finding utensils needed in preparing a meal or for avoiding hazards when crossing the road. This essential process is commonly disrupted by visual impairments and reduced spatial attention after stroke. Affected individuals can experience long term limitations in everyday activities due to inefficiencies in observation and visual searching. Occupational Therapists working in stroke services include visual scanning and search training within their treatment. However it is not known if the intervention is effective for improving occupational performance and visual functioning. Before the intervention can be properly evaluated for its effectiveness some essential development work is needed

Aims

This project aimed to prepare for an evaluation of effectiveness of visual scanning and search training in Occupational Therapy by achieving three important steps:

1. A detailed and systematic description of the intervention delivered in the community setting
2. Development and pilot testing of a process measure to quantify search performance in the home context
3. A feasibility study of the intervention delivered intensively over three weeks.

Methods

To obtain a description of the intervention a specialist Occupational Therapist in stroke, working in a community service, made video recordings of her treatment sessions delivered to five participants with visual field deficits after stroke. The recordings were analysed using a framework approach. The findings were presented to a reference group of Occupational Therapists interested in vision after stroke for validation of the description as good clinical practice.

A timed room search task using keys placed in different parts of a living room over 16 trials was designed to measure search performance. Point of regard during the searches was recorded from a digital video camera worn on the participant's head.

Feasibility of the defined intervention delivered three times a week for three weeks and of the room search task administered in the home before and after the intervention was tested with nine participants. In addition a patient reported outcome measure, the Visual Functioning Questionnaire (VFQ25), was administered before and after the intervention.

Summary of key findings

- A detailed description of Occupational Therapy intervention for training visual scanning and search has been developed. The intervention is task specific to participants' goal occupations and trains strategies for search using remedial activities and real tasks. The intervention was endorsed as good clinical practice by the reference group of Occupational Therapists with special interest and experience in training scanning and search in people with visual impairments after stroke.
- The treatment was found to be feasible and acceptable to participants treated intensively over three weeks.

- A room search task for assessing search performance proved to be feasible and demonstrated changes in the distribution and starting point of search after the intervention. However these changes in search behaviour did not always lead to increased speed or accuracy. Participants with more severe visual impairments were more efficient in searching after the treatment while some more mildly affected participants took longer to find the object.
- A patient reported outcome measure was tested and found to be responsive in the sample suggesting it may be a good primary outcome measure for a clinical trial. The participants reported better visual functioning on the visual functioning questionnaire after the intervention.

Recommendations for research

Further work is needed before the intervention is evaluated in a clinical trial:

Some experimental work is needed to determine the efficacy of search strategies used in the intervention. The results from our small sample suggest that strategies should be tailored to individuals' baseline performance. For example starting the search in the blind field may be helpful in some cases, but a hindrance in others. Further work is needed to identify the most effective strategies for improving search performance in different individuals and to understand the mechanisms of the intervention for improving patients' perceptions of their visual functioning.

A measure of search performance in real world tasks would be helpful to determine the mechanism for improving function, and for understanding which patients benefit. The room search task goes some way towards this, but further work is recommended to investigate the use of new technologies to achieve more flexible and more accurate recording of point of regard during real activities of daily living.

The visual functioning questionnaire,(VFQ25) would appear have potential as a primary outcome measure in a trial of clinical effectiveness of the intervention. Further research into its responsiveness and internal consistency in a larger sample of stroke participants is recommended.

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UKOTRF report February 2014

Introduction and background to the project

Visual search is a process which is integral for carrying out most activities of daily living (ADL); for example for finding utensils needed in preparing a meal or for avoiding hazards when crossing the road. This essential process is commonly disrupted after stroke.
It is not uncommon for individuals to experience long term limitations in everyday activities due to inefficiencies in observation and visual searching. One respondent to a Patient and Public Involvement consultation carried out prior to our research provided this description of her experience of lasting visual search difficulties:

"I encountered many problems due to my 'habit' of missing 'things' on one side when I eventually returned to part time work, making unnecessary mistakes, omissions and duplications. Leaving food on one side of your plate was a regular occurrence. All of these problems are annoying, embarrassing and soul destroying. Any training programme to lessen the effect of these two complaints can only enhance a stroke sufferer's life style and peace of mind".

Inpatient lengths of stay have decreased substantially in the UK and many stroke patients are now receiving more of their rehabilitation from stroke service Early Supported Discharge teams. After these teams have finished, often around six weeks post discharge from hospital, service provision in England is generally poor (Care Quality Commission 2011). In the absence of severe motor impairments, communication or swallowing difficulties, many patients with visual problems after stroke are discharged from hospital within a few days of admission. Their visual problems are often regarded as minor disabilities and they are not referred to stroke Early Supported Discharge services or to low vision rehabilitation specialists. A recently published NHS improvement report recommends that *'Community rehabilitation services should be organised around local patient need and that community services should be commissioned for all stroke survivors not just those in Early Supported Discharge* (NHS Improvement 2012). This need is also highlighted in the most recent National Clinical Stroke Guidelines (Royal College of Physicians 2012).

There is recognition within Occupational Therapy that the profession should be more active in vision rehabilitation (Warren 2011). It is not uncommon for Occupational Therapists working in stroke services to include visual search training within their treatment for people with visual or visual attention problems. However it is not known if visual scanning and search training in Occupational Therapy is effective for improving occupational performance and functioning.

Before this area of Occupational Therapy can be properly evaluated some essential development work is needed: First the content of the intervention needs to be determined. There is published guidance on how Occupational Therapists should assess and treat people with visual problems after acquired brain damage (Warren 1993; Warren 2011; Mew and Winnall 2010; Reid and Edmans 2010). However best practice Occupational Therapy for visual search training delivered in the community for people with stroke in the UK has not been well described or in sufficient detail for use in an evaluation. Second in recognition of the increasing emphasis on rehabilitation at home it is important to assess the feasibility of delivering the intervention in that setting at an intensity that is likely to be effective. Thirdly before evaluation can take place consideration of the most suitable methods for measuring visual search performance within the context of the treatment delivery is needed.

This UKOTRF research priority project aimed to prepare for an evaluation of effectiveness of visual scanning and search training in Occupational Therapy by achieving these three important steps:

1. A detailed and systematic description of the intervention delivered in the community setting
2. Development and testing of a process measure; a method for quantifying search performance in the home context and extended activities of daily living
3. A feasibility study of the intervention delivered intensively and using the process measure with patients.

Literature review

Causes of impaired visual search after stroke and its impact on daily living

Disordered visual search after stroke is caused by three common problems: visual field deficits (VFD), impaired eye movements and by impaired visuo-spatial attention or neglect (VSN). VFD is the loss of part of the field of view from both eyes; for example the person may see only the left or right part of a scene. The side and size of the VFD depends on the site in the visual pathway that is interrupted by stroke (Fahle 2003). Eye movement disorders can result in difficulty maintaining the normal position of the eyes and difficulty in moving them appropriately to look in a different direction. As well as making it difficult for them to take in their whole surroundings eye movement disorders can affect patients' perception of depth. A recent retrospective study of over 11,000 participants enrolled in stroke trials estimated the incidence of stroke related VFD or eye movement disorders to be 60%; with 35% having complete hemianopia (loss of half of visual field). Recovery of visual fields and eye movements occurs in the early weeks after stroke but about 27% are left with persisting field loss (Ali et al 2013).

VSN is a syndrome of behaviours characterised by a failure to attend to the contralesional side of space. It is a common manifestation of right middle cerebral artery strokes because the areas of cortex in the right hemisphere that are involved in spatial attention are extensive (Mort et al 2003). Estimates of the incidence of VSN after stroke are based on small studies and results vary greatly according to the samples selected and measures used (Bowen et al 1999) An estimate of recovery rates was provided by a study of 66 consecutive patients admitted to a district general hospital with right hemisphere stroke. 40% of the sample showed signs of VSN when assessed in the first week reducing to 9% when the cohort was reassessed 3 months later (Cassidy et al. 1998).

VSN can occur with VFD or alone. Although the breakdown in visual search behaviour differs between the two conditions (Mort and Kennard 2003), the domains of activities affected are similar. Stroke patients with VSN or VFD experience poor performance in grooming, eating, mobility, reading, shopping, money management and driving and so have reduced engagement in activities inside and outside the home, including work and leisure (Katz et al. 1999, Warren 2009).

Many people improve their performance of ADL to some degree in the early weeks after stroke attributable to spontaneous recovery or the adoption of compensatory strategies. However it is not uncommon for individuals to experience long term limitations in everyday activities due to inefficiencies in observation and visual searching (Warren 2009). The effect of these visual impairments can be severe and long lasting resulting in poor quality of life and sometimes institutionalisation (Gall et al. 2010; Jones and Shinton 2006). Importantly both VFD and VSN can result in falls and accidents with subsequent cost implications to the NHS and the person (Freeman et al 2007; Campbell and Matthews 2010).

Treatment options

The national clinical stroke guidelines for the treatment of VFD and VSN are vague and are based on consensus and very limited evidence (Royal College of Physicians 2012; National Institute for Health and Care Excellence 2013). Recent Cochrane reviews of rehabilitation treatments for both VSN and VFD have concluded that there are insufficient high quality studies to determine the effectiveness of treatments for improving independence in ADL, but that training patients to scan or to use compensatory visual search strategies seems to help improve performance on impairment level tests such as reading tests and paper and pencil cancellation tests (Pollock et al 2011a; Bowen et al 2013).

Visual search training methods using computers or arrays of lights have been developed (e.g. Pambakian et al.2004; Nelles et al 2001). While this approach is effective for improving performance on screen based search tasks (Mannan et al 2010), these training methods are not functional in context and therefore may not be optimal for translation of learning to activities in everyday life. Neuroscience has shown that the brain is organised for function (Carey and Seitz 2007; Schuett et al 2012). Visual search training practised in the context of daily living tasks should lead to adaptation of the wide neural networks involved in the task. Based on this theory, if it can be delivered intensively, visual search training embedded within occupations or everyday tasks is more likely to be effective for improving performance in ADL than training using computer or light displays.

A recent survey of current Occupational Therapy practice for visual problems in inpatient stroke services in Scotland found that out of 55 Occupational Therapy stroke services 45 (82%) deliver treatment to patients with VSN and 38 (69%) report treating VFD. The most common treatments for both disorders were ADL training and scanning training (Pollock et al 2011b). The respondents also reported providing information and environmental modifications. Barriers to the management of visual problems after stroke included: lack of protocols (33/55, 60%), lack of awareness of best practice treatment options (25/55; 45%) and lack of specialist training (27/55, 49%). The picture is expected to be similar in the rest of the UK.

A priority for stroke services research is that interventions should be well described and that more research is required to investigate best practice stroke care after discharge from hospital (Department of Health 2008). Taylor et al. (2011) have reported the content of a systematic treatment schedule of table top activities delivered by an Occupational Therapist that showed promise for improving participants' psychological adjustment to living with VFD.

Why this study focussed on service users with VFD and/or VSN

In this study we chose to focus on search training within Occupational Therapy for service users with VFD and/or VSN. The decision to include both visual impairments was made for three reasons:

1. Given that VFD and VSN impact occupational performance similarly and Occupational Therapists use similar assessments to screen for VFD and VSN (Pollock et al 2011b). It was anticipated that that there would be similarities in the training of compensatory strategies that Occupational Therapists use with patients with VFD and VSN to help them learn to visually search.

2. VSN and VFD commonly co-exist and it is not always easy to distinguish between the conditions using clinical tests, including perimetry (Robertson and Halligan 1999).

3. It is recognised that the ability to learn compensatory search strategies is dependent on attention (Warren 1993; Mort and Kennard 2003). People with VFD after stroke

may experience difficulties in everyday tasks because of limited attentional resources, even if they do not have VSN. The nature of the different tasks and contexts in their daily lives means that they will experience more difficulty in applying compensatory strategies in more complex tasks or more distracting environments. They may also have other impairments that affect visual search, such as eye movement disorders, that make attending to and learning compensatory strategies for effective visual searching more difficult.

Measurement of visual search

It is becoming increasingly recognised that evaluations of complex interventions should include process measures that will help to determine the reasons for success or failure to achieve improved outcome in activities or participation (Hawe et al 2004). In a recent pilot trial we found a process measure proved informative in determining the carryover effects of visuomotor learning (Turton et al 2010). Methods for measuring patients' ability to search real environments have not been developed, though it has been done in healthy subjects (Land et al 1999). Visual exploration of scenes in the real world involve eye, head and whole body movements, with head and body movements accounting for the majority of orienting over ten degrees (Land et al 1999; Guitton and Vole 1987; Freedman 2008). Few studies have examined head movements in VSN and VFD; patients with VSN may explore space with a shifted frame of reference (Karnath et al 1998) and patients with VFD may have reduced head movements (Zangemeister et al 1982). A method for measuring where the person is looking with respect to the search scene would help to inform the efficacy of the scanning training, search strategies adopted, learning rates, retention and generalisation of treatment to tasks not practiced in the training. New software to determine point of regard with areas of interest in a scene is being used with eye tracking technology, (for examples of visual mapping see http://www.youtube.com/watch?v=lXbRXq-olIw , http://www.youtube.com/watch?v=k_tZfegaVes). However eye trackers are delicate and very expensive. Since head movement is prevalent in wide field searches that are predominant in daily living, recording point of regard from a head worn camera positioned in midline may provide sufficient information for measuring search performance that is ecologically valid.

Plan of the study

The project was divided into three work packages (WP) with identified objectives (O):

WP 1: Describing visual scanning and search training used in Occupational Therapy

O1. Record a specialist Occupational Therapist delivering intervention to eight consenting patients with VSN and/or VFD.
O2. Analyse video recordings for tasks and scanning training strategies
O3. Validate content of intervention with expert group of Occupational Therapists to check the intervention is good quality and uses methods common to clinical practice
O4. Write a brief guide for the intervention and a recording sheet for use in monitoring content of treatment sessions

WP 2: Develop an efficient method of measuring head orientation with respect to the environment (ie. point of regard) in EADL tasks

O5. Develop software and procedure for extracting scene exploration and kinematics from video recordings.
O6. Test method and its reliability on ten healthy volunteers

WP 3: Test feasibility of delivery of intensive intervention and using process measure

O7. Deliver intervention to ten stroke participants three times a week for three weeks
O8. Record participants' point of regard with respect to the scene during training and at pre training and post training visits.
O9. Analyse the profile of scene exploration for a trained task and an untrained task for individual cases over the study period.

For coherence the rest of this report is presented in two parts: Study 1 covering divided into the methods, results and discussion for WP1 and study 2: WP2 & WP3.

Ethical approval
Approval for the studies was obtained from South West Frenchay NHS Research Ethics Committee (ref. no. 11/SW/0306). Consent for participation was obtained from stroke participants and also from other adults in the household since the video recordings were made in their homes.

Study 1 - Describing visual scanning training used in Occupational Therapy

Methods

Video recording and analysis of search training delivered by a specialist Occupational Therapist in stroke working in a community service was carried out to achieve a description of the community based intervention. Community based Specialist Occupational Therapists with developed training methods for vision rehabilitation after stroke are scarce and therefore, because our description was based on only her intervention, the findings were presented to a reference group of Occupational Therapists interested in vision after stroke for validation of the description as good clinical practice.

Participants

The Specialist Occupational Therapist
The Specialist Occupational Therapist in Stroke is referred to as JA. JA has extensive experience within visual rehabilitation and has undertaken a three day course by the internationally renowned vision expert Mary Warren. JA contributed to the recent Cochrane review of Interventions for VFD in patients with stroke (Pollock et al. 2011a).

Service User participants
Consecutive service users fitting the eligibility criteria were identified by the community Stroke Care Co-Ordinator and from the local hospital's stroke rehabilitation unit.

Inclusion criteria:

- Have a diagnosis of stroke, by physician's judgement;
- Be discharged to home;
- Have limited ADL judged by an Occupational Therapist as being due to visual search problems
- Fail at least one of the following impairment tests: confrontation test (visual fields) (Pattern 1996), Star Cancellation task and line bisection from the Behavioural Inattention Test (Wilson et al.1987)
- Be judged as able to participate in the research processes and intervention,
- Consent to participation.

Exclusion Criteria:

- Previous history of severe sight impairment
- Previous history of disability affecting performance of personal care tasks (modified Rankin score 4 or more) (van Swieten et al. 1988).
- Under 18 years old
- Discharged to nursing home or residential care

Reference group

The reference group were eight UK based Occupational Therapists. Five members were already known to the researchers for their expertise in the area. Three answered an advert placed in the College of Occupational Therapists Specialist Section Neurological Practice newsletter. Two members of the group worked in inpatient stroke services, two were academic Occupational Therapists, three worked in tertiary neurorehabilitation centres and one was a consultant Occupational Therapist leading stroke services across the pathway.

Procedure

Demographic characteristics of the participants were collected: age, gender, side of stroke, lesion site, time since stroke, motor and sensory deficits and results of vision examination including perimetry.

The Specialist Occupational Therapist visited the participants on two occasions. On the first visit a vision assessment was completed, including identification of goals and deciding, with the participant, the activities to be recorded on video on the second visit. At the treatment visit the therapist set up a video camera to capture the treatment both from the perspective of viewing the therapist and the patient. On one occasion an assistant held the camera during an outdoor activity. Video files were labelled using an anonymised ID code for each participant and taken to the University of the West of England for independent analysis.

Analysis

The video recordings were analysed using a framework approach. This method allows complex cross sectional descriptive data to be managed and analysed systematically and transparently (Pope et al. 2000). Framework analysis comprises four main stages: familiarisation with the data, identification of thematic framework, indexing and charting, mapping and interpretation. The method can be used deductively as well as inductively. Four framework themes were developed following reading of visual search, motor learning and Occupational Therapy literature as well as impressions from viewing the recordings. Themes were: 1. Task and Activities; 2. Education; 3. Instructions, cues and prompts to scan and search; 4. Environment and space.

The therapist's actions were logged as events and assigned to themes. This was followed by discussion between observers to agree categories of observations. The researchers' interpretation of the therapist's actions in the video analysis was checked with JA, in a Skype interview, using open questions that were carefully worded to avoid influencing her responses.

Findings were presented to the reference group. Five members attended a meeting at the university. Those unable to attend were sent the notes from the meeting for their comments and additions by email. To avoid inhibiting discussion by group members JA did not attend the meeting.

Results

Six participants were recruited to the study, one withdrew before being recorded. Five had their Occupational Therapy recorded. The characteristics of these five and their goals are given in table 1. The activities recorded on video for each are given in table 2.

Table 1 Participants' characteristics

Participant Gender Age	Stroke lesion site	Months post stroke	Vision assessment: Impairment and reported impact	Goals
1 Male 66	Right middle cerebral artery infarct	4	Left lower quadrantanopia No inattention detected on cancellation and line bisection tests. Discussion with him and his partner revealed some bias to the right side and less attention to the left side on more complex tasks. Participant reported missing objects on the left, leaving tap running, fridge open, overfilling cup and bumping into things. Also difficulty texting	To be able to prepare and cook a snack for himself and his partner
2 Male 56	Right total anterior infarct	7	Left hemianopia plus some incongruous visual field loss on the upper right quantrant. Poor performance on line bisection and cancellation tasks. Left inattention observed on functional tasks. Difficulty sustaining attention during vision assessment. Reports it difficult at times to see things on one side, only eating half of what is on plate	To be able to play a round of golf
3 Female 77	Right occipital infarct	1	Lower left quadrantanopia Reports reduced confidence in outdoor mobility and supermarket shopping. Difficulty seeing curbs and mats on left Has not returned to cycling since stroke	To improve outdoor mobility Return to cycling To be able to shop confidently in supermarket
4 Male 82	Right total anterior cerebral infarct	3	Left homonymous hemianopia Poor performance on line bisection and cancellation tasks Difficulty reading. Not able to walk and reliant on family members to move him around in a standard wheelchair. Limited opportunities to engage with activities due to mobility.	To read more easily. To be independent with moving around so would like to learn to use a powered wheelchair.
5 Male 82	Left occipital infarct	1	Right hemianopia Reduced confidence with moving around outside the house. Difficulty reading. Not able to engage with previous hobby of repairing old motorbikes. Not able to drive.	To return to driving was hugely important. To read easily. To be confident about using small tools.

Table 2 Activities recorded

Participant	Videos
1	Prepare and cook bacon, eggs, toast and tea
2	Three holes of golf
3	Practice using visual search strategies in living room. • Searching for number and word cards, and everyday objects placed by the therapist. • Using playing cards on a table top to practice eye and head movements
4	Practice using visual search strategies in living room. • Using playing cards on a table top to practice eye and head movements • Reading exercises
5	Reading

The content of the intervention derived from the framework analysis is given under the theme headings below. The reference group was asked to consider whether the Specialist Occupational Therapist's treatment was good practice under the theme headings and to determine any differences in the content of training for impairments: VFD and VSN. The consensus of the group was that JA's clinical practice for training visual search was good Occupational Therapy practice. They added some comments and ideas to the description and these are given at the end of each of the theme sections below.

1. Tasks and activities

Participants (P) practised visual search within the context of their goals in four of the videos (P1, preparing a meal, P2 golf, P4 and 5 reading). However the opportunity to practise within the goal task was not available in all cases. P3's goals were to improve her mobility outside the home, return to cycling and shop confidently in supermarket. Constraints on filming in busy public places prevented recording these activities for this study. One of P4's goals was to be independent in driving a powered wheelchair. However at the time of the study he did not have a powered wheelchair. In these two cases (P3 and P4) the Occupational Therapist used some remedial search activities. She reasoned that these allowed participants to practise scanning and search strategies in safety before applying them in their desired activities.

The reference group agreed that activities should be related to the participant's goals. They observed that working in the community setting offered opportunities to practice a broad range of activities that take place in challenging environments such as in the street, shops or workplace. The group recognized a number of benefits for the use of vision based remedial activities:

- They are useful for determining whether patients can use a search strategy before applying them to real occupations in these challenging environments.
- They are useful for raising awareness of the impact of the impairment for the patient and for relatives in a safe environment.
- Because they are relatively simple with fewer physical and cognitive demands than a functional task, they can be practiced intensively with the therapist or family members and so strategies are well learned before being applied in a more complex occupational situation.

The group agreed that remedial activities should match the part of space to be used in the goal occupation. They also warned that some patients don't like remedial activities and their use should always be preceded with explanation of their purpose and how they are expected to lead to improved function in achieving goals, as was the case in JA's practice. The group cautioned that the therapist needs to monitor effectiveness of transfer of learning between the remedial activity and real task contexts.

The consensus of the reference group was that all these principles for task selection apply to both VFD and VSN.

2. Education

The two main strategies the therapist was training were: increasing the amplitude of head and eye movements to look to the affected side and to search the space in a systematic manner starting in the blind or neglected area of space. She consistently preceded treatment activities with an explanation of the nature and impact of the individual's visual impairment and the need for adopting compensatory strategies to improve performance. This was sometimes done using demonstration goggles with part of each eye piece masked with tape. Alternatively she used pictures of the visual fields from each eye.

(To P4) *"This shaded out area is the bit you don't see, which is why you need to turn your head far enough round to make sure this seeing bit sees what the non-seeing bit can't."*

The therapist related the visual impairment to the occupations that participants wanted to do. An example was seen when she was preparing P2 to find that the VFD and inattention to his affected side would affect his golf performance. The therapist highlighted how golf may be familiar but the participant's performance was likely to be altered.

(To P2) *"You may find it more difficult to track the ball after you have hit it, and then to locate it."*

Another example of this was observed in helping P4 and P5 understand their reading difficulties and change their behaviour. They both used a hand held magnifying glass for reading or doing crosswords. JA explained how the frame of the magnifying glass would prevent sight of the whole text and so would hinder recognition of the beginning and ends of lines.

(To P5) *"The difficulty is because you don't see so well on that one side this [the magnifying glass] could make it even more difficult. For you being further away and having a bigger picture is working better than being close up to it. What this [the magnifying glass] does is to narrow it down, cutting out a lot of information that might orient you to where things end."*

JA suggested that these participants use alternative large print media or make an optician's appointment to see if they needed new prescription glasses.

The education included helping patients to understand that recovery was a learning process. For example in explaining to P3 how conscious effort must be made to scan to the blind side she said

"The brain finds it difficult to do that initially because it finds it easy to orientate itself to the side it can see. We have to re-educate it to looking more to the side you can't see."

JA gave participants printed advice about VFD and strategies aimed at improving performance in wide field search and reading.

The reference group endorsed the importance of education to help services users with VFD and VSN to understand their visual problems and the need to use selected compensatory search strategies. It was agreed that it is important to develop patient awareness early in therapy.

3. Instructions, cues and prompts to scan and search

The therapist instructed the participant to use the strategies during activities. Verbal and visual cues and prompts were used.

(To P1) "*Think about making wide head turns towards the affected side."*

"Try making your head and eye movements quicker".

Physical demonstration of systematic scanning was used:

"*Look to this side* [therapist moved her hands and head in a deliberate fashion to the left] *and then scan to the right* ", [she completed her demonstration movement to the right side].

JA encouraged P3 to make bigger eye movements in a table top task.

"Just try and move your eyes over to the left...What can you see now?"

"Practise making eye movements to the left side so you can really capture the whole picture."

Some directions were very specific to the task. For example on the golf course P2 was directed to look to the left towards the next hole when hitting the ball. JA stood alongside P2 (on his unaffected side); she turned to her right as if getting ready to hit the ball and then looked clearly to her left. She verbally instructed*:*

"You need to look"', whilst physically demonstrating the action.

After P2 had practiced the technique the therapist asked him to consider his performance: *"can you see how it has improved now?"* She also gave him knowledge of results: *"better; and it's going in a straight line."*

She reminds him of the strategies he will need to locate the ball and provides instructions on how to implement them

"Follow the trajectory of the ball so that when you go to find it you're able to locate it easier".

Sometimes visual prompts were used to supplement verbal cues and they were continued after fading the verbal prompts. For example a picture of an eye with the written message '*Turn your head to the left,* was put on the kitchen wall in a prominent position for P1.

P4 was encouraged to place a hand by the side of a crossword to form the visual anchor point for its left edge.

The reference group recognized JA's methods for instructing and prompting use of the scanning and search strategies as good practice. However in addition it was suggested that patients may be taught to self-prompt and use imagery to develop systematic search strategy. For example by adopting the lighthouse strategy or similar scanning image (Niemeier et al. 2001). The reference group emphasised that the selection of training strategies is dependent on good assessment of the problem and there will be differences between VFD and VSN, for example short saccades are a feature of VFD and therefore instructions to increase amplitude of eye movements would be more relevant than in VSN.

4. Environment and space

The parts of space used in training were congruent with the goal task even if a remedial activity was used. For example practice for outdoor mobility with P3, who had lower left quadrantanopia and complained she missed curbs, was done using a search activity while walking with target objects that were positioned on the floor.

The environment was used to grade the difficulty of the search task by:

- Reducing or increasing number of distractor items in room searches (P3, P4)
- Reducing or increasing the size of the field to search in the task e.g. reading using a blank piece of paper to reveal the text line-by-line and to mask distracting lines on the rest of the page (P3, P5)
- Placing cards closer to the front edge of the table and on the left side led the participant with lower left quandrantanopia to make bigger eye movements into the blind field (P3)

The reference group recognised the use of the environment for grading task difficulty as JA had done. They added the notion of 'pop-out', using contrast, to enhance the visibility of target objects to make search easier. In the home setting this can be done by using brightly coloured objects against less vibrant distractor objects and background. The group observed that outdoor environments in particular may be subject to temporal changes. For example outdoor mobility may be more challenging on the day that rubbish bins are put out for collection along the street; shops and roads may be busier at some times than at others. The reference group did not identify any differences for VFD and VSN in the use of the environment for training visual search.

Discussion

Using systematic analysis of video recordings of the Specialist Occupational Therapist's intervention a detailed description of community based Occupational Therapy for training visual scanning and search in people with VFD and VSN post stroke has been achieved. Only one therapist was observed, but the intervention was endorsed as good practice by the reference group of Occupational Therapists with special interest and experience in rehabilitation of people with visual problems after stroke.

The intervention follows an adaptive compensatory or functional approach (Ivey and Mew 2010) with repetition of specific functional tasks and or remedial activities to enable the person to learn how to compensate for visual impairments. It assumes improved performance despite the persistence of neurological deficits. For this compensatory approach to work it is essential that the person understands their visual impairment and the impact that it can have on occupational performance. Thus education was an important part of the intervention.

JA's intervention was influenced by her years of clinical experience, awareness of the clinical trials literature (e.g. Pollock et al. 2011a) and knowledge gained from Mary Warren's course. Elements such as stressing the importance of using the seeing portion of the visual field to search both left and right sides of the scene, the use of preparatory activities for practising systematic search strategies starting on the affected side and real practice of everyday tasks in real environments are advised by Mary Warren (Warren 1993, Warren 2011].

The Occupational therapy visual search training reflected principle components of training from the cognitive psychology / neuropsychology literature. Many of these components are applied to computerised training programmes.

I. Most importantly visual search training in Occupational Therapy is task specific. A recent study has demonstrated that training-related improvements in reading and visual exploration are highly task-dependent (Schuett et al 2012). Occupational Therapy uses real tasks or the next best option, a task practised in a similar area of space and in a similar posture. This may be the greatest advantage that Occupational Therapy has over other interventions.

II. Patients with VFD need training to increase amplitudes of saccades (Zihl 2003). JA was observed to do this using table top activities in which P3 was asked to keep the head still and to find target cards using large eye movements. The Occupational Therapist used instructions and placement of objects in the environment to train increased amplitudes of eye and head movements and to manipulate attention into the blind field or neglected space.

III. Intensive practice with lots of repetitions is a feature of visual search training. This is easily achieved using computer based training (for examples see. Nelles et al. 2001, Mannan et al. 2010). The use of remedial activities in Occupational Therapy allows massed practice of search strategies but the amount of practice even if several minutes long is inevitably less than the large number of trials that can be achieved with automated systems.

IV. Task difficulty was graded by demands of the activity in allocating attention to an area of space. The boundaries of space to be searched were manipulated and so was the complexity of the environment, particularly in the remedial activities which are easy to manipulate. In real everyday activities the therapist was observed to increase task difficulty by adding clutter in environment. Conversely reading was made less challenging by reducing the text visible on the page using a mask to occlude some of the lines. This strategy for grading by increasing or decreasing distractor items is commonly used in computerised training programmes (Mort and Kennard 2003)

V. The therapist employed verbal instructions and cueing during task performance. She gave knowledge of performance and knowledge of results which are valuable coaching techniques for improving motor learning (Schmidt and Wrisberg 2008). The therapist encouraged spatial anchoring using the participant's arm to mark the boundary for reading. Cueing with limb activation was not observed, but later questioning revealed that JA uses the technique with people with VSN as their predominant problem, who are able to move the affected arm. Robertson and North (1992) showed this technique to be helpful for improving performance of pencil and paper search tasks in VSN.

Limitations of the study

The description of the intervention was based on therapy delivered by a single community based specialist Occupational Therapist. It is possible we might have found others with similar experience and expert knowledge. However with limited resources available we chose to use JA as our model and to consult a reference group of expert Occupational Therapists. The group endorsed the treatment content as good practice and the study benefitted from the supplementary ideas and advice from eight experts in the field.

A second limitation was the small sample size of stroke participants. Efforts were made to increase recruitment by engaging the Stroke Research Network nurses in the acute stroke service to identify potential patients for recruitment. However the time taken to complete the governance procedures necessary to add the acute trust as a site was too long to fit within the time line for studies one. The five participants recruited were typical of JA's case load, having VFD and sometimes, in addition, VSN. The sample ranged from being immobile within the home to being ambulant and wanting to engage with activities outside the home. The strategies being trained were common between them and so although the range of activities may not have reached saturation it is felt that the training strategies were well represented. The sample did not include anyone considered to have VSN without VFD therefore difference in training strategies between the two conditions were not identified from the data; though they were considered by the reference group.

Thirdly the activities used in the study were restricted by the data collection method. Video recordings were limited to quiet locations away from other people and so we were unable to capture the therapist training participants when navigating in busy streets or in shops. Nevertheless we consider that a more systematic and detailed description of treatment resulted from video analysis than would have occurred using alternative means of data collection, for example, by Interview.

Conclusion study 1

The first aim of the project was to construct a detailed and systematic description of the intervention delivered in the community setting. Study 1 has achieved this aim: a detailed description of good practice in Occupational Therapy for training visual scanning and search in community based stroke rehabilitation has been produced. This is a first step on the way to evaluating the effectiveness of this Occupational Therapy intervention.

A guide for visual search training in Occupational Therapy in the home or community was written, based on the results of study 1, using the participant case studies to illustrate the principles determined for the intervention. This and a treatment recording sheet devised to enable adherence to the intervention to be assessed were outcomes of study 1 that were used in study 2.

The authors in consultation with the UKOTRF have decided not to make the guide available at this point in time. This is because it is expected that the materials will be used in an evaluation of effectiveness of the intervention and releasing them may result in confounding differences between the intervention and usual care arms of a trial.

Study 2: Developing a method of measuring process of visual search and testing feasibility of delivery of intensive intervention and using the process measure

Methods

Developing a method of measuring visual search performance

Our objective was to map the point of regard from a camera worn on the participant's head to the environment and to areas of interest within the scene, which would include search tasks in which the participant moved around in the environment. This would allow quantification of the areas of the environment that were searched and sequence of locations searched during trained and untrained tasks (Objective 9). Our intention was to use vision mapping software developed by computer scientists at the University of Bristol to allow us to achieve this. To test the method and its reliability healthy volunteers were recorded while making a hot drink in a standardised environment. However the software proved to be unsuitable for the purpose. At best it picked up only 30% of the areas of interest and to accomplish that degree of accuracy required a high degree of texture to be placed in the scene. Even if the success rate for picking up areas of interest had been satisfactory the requirement for a highly textured scene would mean the method is impractical in uncontrolled environments such as the homes of service users. The software needed major investment, beyond the resources allocated to this project, to be fit for our purpose.

An alternative method for measuring visual search which could be used in varied home environments was developed. Because of the necessity to manually analyse video recordings the task had to be limited in to a search in which the participant was not moving around. We chose a room search task in which an object belonging to the participant was searched for. The object should be small and familiar and not too obtrusive, and would be placed in different parts of the room for the participant to find.

Procedure for the room search task

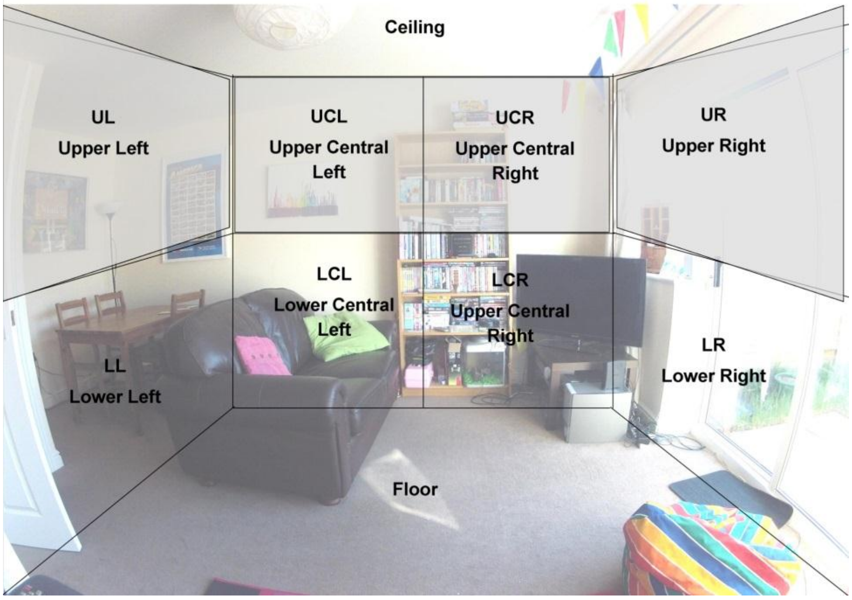
The task was standardised as much as possible within the participant's home. A digital video camera was carefully placed on the participant's head and secured with an elastic strap. The position of the camera was calibrated using a laser pointer to ensure the camera was facing straight ahead when the participant was looking at an object directly in front of them. Figure 1 shows the head camera, the laser pointer is fixed securely to the side of it.

The participant was seated in a central position along one wall of the room. This gave scope for them to search the room directly in front of them and to their extreme left and right sides. The room was divided into eight sections from the point of view of the participant. The facing wall and area in front of the participant was divided to central left upper and lower quadrants and each peripheral wall or space was divided into upper and lower halves (see figure 2). There were no physical boundary lines marked for these sections of the room. The tester kept these imagined room divisions in her mind in order to place the target object in the different sections.

Sixteen searches were performed with the object being placed twice in each of eight sections of the room in pseudo random order. The participant was seated with eyes closed while the object was quietly placed to minimise auditory cues. The participant was told when to open eyes to start each search. Each search was video-recorded from the head camera and timed manually using a stopwatch up to 120 seconds. It was considered important to have a reasonable cut off time to prevent frustration, demoralisation or boredom. The recordings were analysed for frequency of point of regard in each of the room sections and the opening sequence of fixations to each section. A grid drawn by the tester and overlaid on the scene of the room on the computer screen was used for the analysis (figure 2).

Figure 1. Head camera

Figure 2. Grid applied to room for analysis of search



Reliability of room search measures in healthy volunteers

The room search task was piloted with ten healthy volunteers: 6 male and 4 females, ages ranging from 25 to 61. Each participant was tested twice to give an indication of consistency of performance: search times, distribution of search and starting point of search.

Search times
Mean search times between participants ranged from 5-30 seconds, (see table 3). Differences in mean times between tests ranged from 2-15 seconds, but on average were different by 5 seconds.

Table 3 Mean Search times

Subject	Test 1	Test 2	Absolute difference
1	15.6	5.3	10.3
2	10.6	7.4	3.2
3	16.9	15.1	1.8
4	22.8	11.9	10.9
5	26.3	11.1	15.2
6	5.4	7.6	2.3
7	12.4	9.2	3.2
8	13.0	11.2	1.8
9	17.6	16.2	1.4
10	30.6	26.5	4.1
mean	**17.1**	**12.2**	**5.4**
sd	7.6	6.1	4.9
2sd	**15.2**	**12.1**	**9.7**

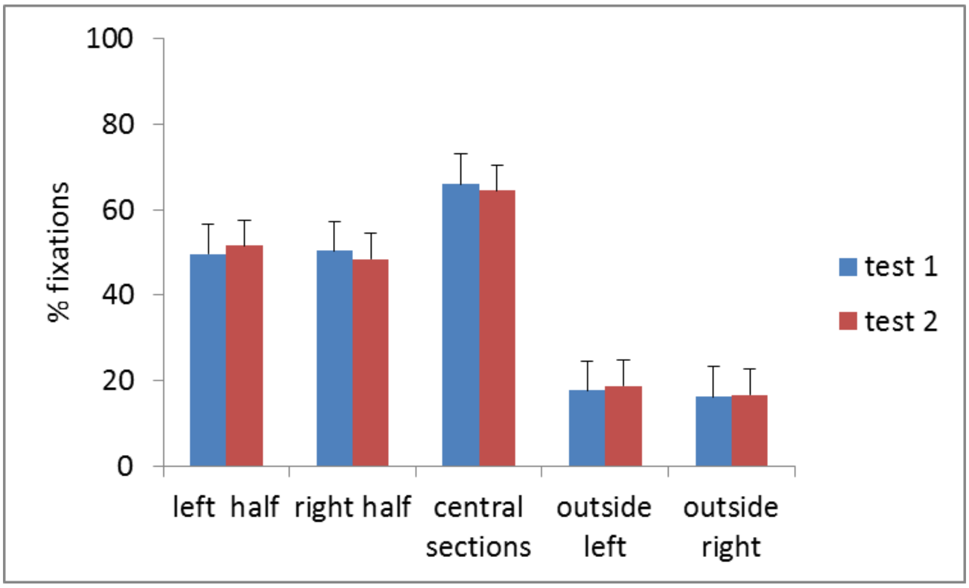
Distribution of search

Distribution of search across the ten subjects was symmetrical across the room in terms of the percentage of fixations in the left and right halves of the space and to the outside left and right sections of the space (see table 4). Two thirds of fixations were made in the central sections, and this is to be expected as this territory is crossed both in searching left to right and right to left. Percentage fixations were consistent across the tests; figure 3 is arranged for easy comparison of test 1 and test 2.

Table 4 Mean (SD) percentage fixations in left and right halves of the room, central and outside sections

Section of room	Test 1	Test 2
left half	49.6 (8.3)	51.6 (6.6)
right half	50.4 (8.3)	48.4 (6.6)
central sections	66.0 (6.6)	64.4 (5.7)
outside left	17.7 (5.9)	18.8 (6.7)
outside right	16.3 (7.9)	16.8 (4.0)

Figure 3 Percentage fixations across room sections (collapsed) on tests 1 and 2.

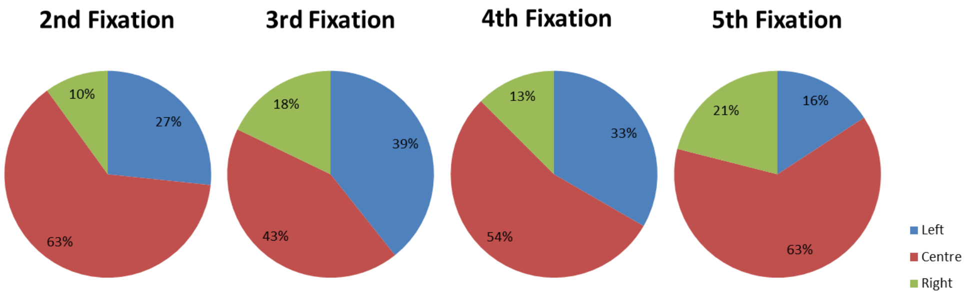


Mean percentages of fixations are shown in the bars with error bars indicating standard deviations.

Starting point of search

One of the strategies used in training visual search is to encourage systematic searching starting at the outside of the scene in the blind field, so someone with left hemianopia would be encouraged to start their search on the far left side of the scene. Normal subjects were not asked to start in any particular place. The first five fixations were analysed with the room treated in three parts: far left (upper and lower left sections) central (upper central left, lower central left, upper central right and lower central right) and far right (upper right and lower right sections). The first fixation, was when looking straight ahead on the go signal, at the beginning of each trial was discarded. Figure 5 shows the percentage of fixations 2-5 to the left right and centre of the scene in one of the healthy subjects.

Figure 5 Mean percentage early fixations in central and left and right sections for single healthy subject



There was very wide variation between individuals in their early search patterns. In order to examine within subject consistency percentage mean fixations in the central sections were compared between tests 1 and test 2. Mean differences ranges from 5 to 40%, indicating very different individual patterns of search between tests within the group.

Conclusion

The healthy subjects varied widely in their times to complete the search, but their performance was reasonably consistent between tests. The distribution of search for the group was spatially unbiased across the room and was consistent between tests. However the starting point of search varied widely both between and within subjects. We have an indication of the confidence within which the distribution of search and search times can be treated. However there is a need for caution since this testing has involved only a small sample of ten subjects who are typically younger than the patient population.

Testing feasibility of delivery of intensive intervention and using process measure

Recruitment of participants

Participants with the same inclusion criteria as for study 1 were recruited to test the feasibility of the intervention.

Participants were recruited via the Stroke Research Network Officers in the local acute stroke service or by JA in the community Occupational Therapy stroke service. Demographic characteristics of the participants were collected: age, gender, side of stroke, lesion site, time since stroke, motor and sensory deficits, results of vision examination including perimetry.

Assessment

Before commencing treatment an assessment, goal setting and treatment planning visit was carried out. JA used her own vision assessments and goal setting procedure. The room search task and a patient reported measure of visual functioning, the National Eye Institute's 25 item Visual Functioning Questionnaire (VFQ25) (Mangione et al 2001], was also carried out. The VFQ25 represents 11 vision related constructs: general vision (one item), ocular pain (two items), near vision (three items), distance vision (three items), driving (two items), peripheral vision (one item), colour vision (one item), role limitations (two items), dependency (three items), social function (two items), and mental health (four items), plus an additional single item general health question. The purpose of this assessment was to test feasibility for use as a responsive primary outcome measure in a future trial.

The VFQ-25 has demonstrated good reliability and construct validity as a measure of vision-related functioning outcomes in patients with age related macular degeneration (Revicki et al 2010). Rasch analysis has suggested it may have better internal consistency without the items for general health, pain around the eyes, and driving, and that its constructs could be collapsed into visual functioning and socio-emotional scales, respectively (Marella et al 2010). Its psychometric qualities have not been tested with people with stroke.

The room search task and VFQ25 were repeated in the week after completion of the intervention.

Intervention

Participants received an intensive course of scanning and search training in Occupational Therapy with three one hour visits a week for three weeks. The intervention was delivered by two part time Occupational Therapy Technicians who were supervised by JA. An ADL task or two tasks were selected for practice according to the participant's goals. These could be indoor tasks such as preparing food or drinks, playing a card game, or steering a powered wheelchair, or outdoor tasks such as walking in the street. The training strategies outlined in the intervention guide produced following study 1 were applied. To increase fidelity to the treatment guide the Occupational Therapy technicians completed structured treatment logs giving details of the activities, their purpose and examples of search strategies and comments on the participant's performance. In addition the tasks were video recorded using the head camera worn by the participant for later checking of fidelity to the intervention.

Participants were asked to keep a diary about their experiences of the Occupational Therapy visits. The purpose of this was to remind them of their thoughts when at the end of their participation they were asked to answer a structured questionnaire. This was to determine acceptability of the intervention and recording procedures. The questionnaire was completed after the final assessment visits and administered by a research officer from the South West Research Network who is independent of the project team. The project team in Cornwall administered the questionnaire to participants who were unable to complete the telephone interview with the Stroke Research Network officer.

Data Analysis

The number of intervention visits was counted and the tasks and activities summarised. Video recordings of the room search task were independently analysed by a researcher at the University of the West of England to obtain measures of frequency of fixations in each section of the room and the opening sequences of search fixations. Search times were summarised as medians because the searches were terminated at 120 seconds, if the target object was not found. VFQ25 raw scores were recoded according the instructions in the test manual and change scores for each subsection were determined. Responses to the questionnaire were collated.

Results

Fourteen participants were recruited to the study. However five withdrew before participation. This was due to changing circumstances between their recruitment by the stroke research officers in the acute service and readiness to participate once home: Two had recovered; one was too ill, one was discharged into care and one no longer wanted to take part.

The characteristics of the nine who participated are given in table 4. Ages ranged from 54 to 84 years of age. The first five participants (A-E) and the final participant (I) were spared hemiparesis and their functional limitations, which were largely explained by their visual impairments, were in areas such as outdoor mobility, being unable to drive and in reading; though participant I also had some visual agnosia and cognitive impairments which limited his extended activities of daily living. Participants F, G and H had more severe physical effects of stroke and were very dependent on others for their personal care and for moving around inside their homes.

Two of the participants wanted to return to work, three wanted to improve their ability to work on a computer and three wanted to improve their reading performance. Three of the participants wanted to walk outside with confidence and five wanted to return to driving. Three wanted to be independent and safe in moving around inside the home.
Their goals and the activities used in their treatment are given in table 5.

Table 4 Participants' characteristics

P. Gender Age	Stroke lesion site	Months post stroke	Vision assessment: Impairment and reported impact
A Male 64	left temporo-occipital infarct	7	Right homonymous hemianopia, good corrected acuity for near and distance vision. Normal performance on cancellation and line bisection tests. No evident ocular motor deficits. No restriction of neck movement. Reported difficulty reading and using computer and was not driving due to visual impairment
B male 58	right middle cerebral artery infarct	2	Left inferior quadrantanopia, good corrected acuity for near and distance. Normal performance on cancellation and line bisection tests. No evident ocular motor deficits, but he finds it more difficult to switch his gaze to the left. No restriction of neck movement Perceived visual problems are "a problem with his left side, which is intermittent, sporadic and pertinent when he is not paying attention". He reports that he can be "impulsive and not good at acknowledging items on his left side". Bumps into things on left when walking outside. Not driving because of his visual deficit. Therapist considered visual inattention in extra-personal space was probable
C male 65	right middle cerebral artery infarct	6	Left homonymous hemianopia, good corrected acuity for near and distance vision. Normal performance on cancellation and line bisection tests. No evident ocular motor deficits. Range of neck movement is full for flexion and rotation, but reduced in extension. Reported that he "cannot see detail, it's like a sheet of polythene is hanging down on the left hand side. If I look straight ahead I cannot see on the left". Not driving because of his visual deficit.
D, female 73	small haemorrhage posterior to the right internal capsule.	2	Left homonymous hemianopia plus peripheral vision to the right on perimetry. Good corrected acuity for near and distance vision. Some scarring in right eye following an infection. Passed the line bisection tests, but errors to the left and right on star cancellation test (37/54) Difficulty with ocular pursuits, particularly when attempting to track to the left. Full range of rotational neck movements, but flexion and extension restricted by pain. Perceived visual problems: describes as "seeing things but difficulty registering that I have seen them". And not seeing clearly on the left side. Some difficulty with face recognition.
E male 54	right sided occipital infarction	3	Left homonymous hemianopia, good corrected acuity for near and distance vision. Reports lack of confidence in walking outside. He is unable to drive and this is his main concern as it affects his ability to work. Vision is worse first thing in morning. Gets tired, takes longer than it used to do activities.

Table 4. Continued

P. Gender Age	Stroke lesion site	Months post stroke	Vision assessment: Impairment and reported impact
F Female 84	Right middle cerebral artery infarct	5	Left sided homonymous hemianopia, and visual neglect. Only cancelling far right column of stars on star cancellation test. Good corrected acuity for near and distance vision, impaired eye movements, unable to direct gaze to left. Unable to read Restricted to 2/3 range of neck rotation, left and right. Dependent in personal care, household tasks, transfers and meals and in moving around.
G Female 75	Right cerebral haemorrhage	30	Left hemianopia, good corrected acuity for near and distance vision, possibly some left sided inattention - Missed a couple of stars to far left on star cancellation and line bisection tests. No evident ocular motor deficits. Restricted to 2/3 of neck rotation, left and right. Dependent in personal care, household tasks, transfers and meals and in moving around.
H Female 66	Right cerebral haemorrhage	36	Left hemianopia and inattention to left; (missed a couple of stars mid right on star cancellation). Good corrected acuity for near and distance vision. Asygmatism left eye since childhood. Limited range of movement in her neck, particularly in extension, and rotation to the left. Complains she does not see well on both sides, she bumps into things and would not be able to cross roads.
I Male 83	Right Occipital lobe, Posterior circulation infarct	2	Partial visual field loss on the left, with macular involvement. Passed the line bisection tests and cancellation tests. Difficulties with reading, particularly in near vision. Visual deficit impacts on kitchen tasks, and moving around the home, as he tends to bump into things. Complains he cannot see as he used to. Bumps into things, can’t read, use the computer or attend to his financial affairs and is unable to drive.

Table 5 Goals and activities used in intervention

P	Goals	Activities used in intervention
A	To improve reading ability & speed. To improve use of computer. To drive on public roads.	Reading written instructions Computer game of Mahjong Driving around campsite. Finding tools in tool shed. *Remedial activities* to improve amplitude of eye movements Search training – spelling out words from letters on post-its on wall. Sorting words across table.
B	To return to work To drive (essential for work) To walk outside independently To use computer for work-based tasks	Outdoor mobility, walking, crossing roads and riding bicycle on side road. Computer game 'Dr Monocle's Mansion' visual scanning. Working on case study on the computer *Remedial activities* to encourage starting search on the left: searching for items around house. Catch and throw game to increase speed of orientation to the left. Searching for laser pointer dot at speed. Spelling words on from letters on post-it notes placed over the wall.
C	To be able to drive again. To be able to go out and about in community with confidence. To be able to prepare food at home.	Walking outside Shopping in familiar supermarket and in unfamiliar supermarket. Searching for items in kitchen. Searching for items in garage. Searching of post-its on tree trunks outside. Visit to park and searching for wildlife. The therapist took participant out in her car, as a passenger, and he was asked to point out things of interest on the left as they drove along. *Remedial search activities*: card games such as solitaire, and matching games
D	To be able to vacuum the carpet in the house. To walk around outside with confidence, including fetching grandchildren from school To be able to get her own meals.	Kitchen tasks incorporating visual searching: organising freezer, making a cup of tea with items moved to different places than usual Outdoor mobility was the main focus of treatment. Walking outside and crossing road. *Remedial search activities* to train systematic search starting from the affected side: Searching for pegs with high contrast tape and without. Searching for features in pictures. Card search.
E	To return to work as a chef in busy kitchens, being confident and quick when using knives. Driving	Cooking, preparing more complex meals as the treatment progressed and to simulate a restaurant kitchen tasks were timed. Mobility outdoors: walking and negotiating roads whilst talking. Visit to job centre with the therapist to discuss options for access to work. *Remedial search activities* to promote his insight into his visual deficit.
F	To read the newspaper, do crossword puzzles and word search To be able to go out to look at the shops To be able to use a powered wheelchair	Selecting clothes in wardrobe, kitchen search for tins, pouring water from jug to mug, preparation of ingredients for baking buns Wheelchair driving in side Washing and dressing including finding objects and clothing needed Hovering and dusting *Remedial search activities*- Letter search on post it notes table top

Table 5 continued

G	To be able to use a powered wheelchair in the home environment. To be able to put the washing in the washing machine. To make a snack for herself. Gardening.	visual search with kitchen items picture matching over wide field on floor throwing and catching ball making bed loading washing machine using long handled reacher making sandwich reading from magazine mobility in powered wheelchair *Remedial search activities* – table top card game
H	To be able to attend to people on the left side. To attend to objects on the left side when eating. To be able to move safely around the house without bumping into things. To be able to complete tasks such as cooking and ironing.	preparing a sandwich silk painting craft dressing ironing games on ipad kitchen tasks, cleaning cutlery drawer, cleaning grill machine *Remedial search activities-* playing cards and post it note word search
I	To be able to drive To be able to read and use the computer To manage simple kitchen tasks	keyboard search room searches: kitchen, office, garage ball throwing and catching making hot drink sorting filing system outdoor mobility and locating things in environment and shops *Remedial search activities-* narrow field table top post it note and card searches

Activities used were related to the participants' goals. Recognising that she was not in a position to make decisions regarding safety to drive, the therapist addressed the goal to return to driving by trying to improve the participants' awareness and scanning to the affected side; reasoning that this learning may influence future performance on driving assessments. (There is a new process for applications for a provisional driving licence for those with a static visual field defect. This will allow the applicant to have driving lessons and is designed to demonstrate whether or not the filed defect is affecting the person's ability to drive safely (www.gov.uk/goverment/publications/static-visual-field).

Powered wheelchairs were obtained for participants F and G. One of these particpants had been denied a powered chair in earlier rehabilitation due to concerns about safety due to her vision.

Remedial activities were used in all cases to train the use of search strategies and increase the amplitude of eye and head movements to the affected side.

Eight of the participants had all nine treatment visits; participant E received eight visits.

Visual Functioning Questionnaire results

VFQ 25 questionnaire items are scored so that a high score represents better functioning. In accordance with the VFQ manual raw scores are converted to a 0-100 scale and in this format are considered percentages of the total possible score. Items within each subscale are averaged together to create subscale scores. An overall composite score represents the average of the sub-scale scores.

The participants' composite percentage scores ranged widely from 24 to 94 out of 100 before training. Participants A and G were reporting only mild limitations in visual function, the rest of the group were reporting more severe deficits in visual function with socio-emotional impact. . All the participants' overall composite scores were better after treatment; with C, D, E and F making the considerable gains (see table 6).

Gains after treatment were seen across the subscales and not just in peripheral vision which was the main focus of intervention. Table 7 gives the *difference* in scores (after-before) treatment, so positive values represent improved scores; negative values a reduction in reported function. Despite improved in composite scores in there were some negative changes in subscales in two participants H and I in dependency, I in mental health scores and H in distance visual function.

Table 6 Composite Visual functioning scores

Participant	**A**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Before training	84	51	24	56	50	94	59	47
After training	93	89	64	87	71	97	73	57

Table 7 Differences in Visual functioning scores after treatment

Participant	**A**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Visual function								
Gen vision	0	0	20	20	20	0	40	20
Ocular pain	0	0	13	25	0	0	50	38
Near	-3	25	17	25	33	0	25	8
Distance	0	59	25	67	0	*	-9	0
Peripheral	50	50	25	25	*	*	25	0
Colour **	0	50	75	0	75	*	0	0
Socio-emotional function								
Social function	0	75	50	25	0	0	0	25
Role	25	100	38	75	37	25	12	63
Dependency	0	25	75	25	33	0	-9	-34
Mental health	13	-6	63	31	37	0	6	-19
Composite score* **	8	38	40	32	21	3	14	10

** Participant B did not complete VFQ25 post intervention ** Colour vision item is a question that asks participants to rate how much difficulty they have picking out and matching clothes because of eyesight. Participants in this study may have difficulty picking out clothing due to search difficulties rather than due to colour vision. Peripheral vision item is a question that asks 'Because of your eyesight, how much difficulty do you have noticing objects off to the side while you are walking along? Participants F & G could not answer this question since they are unable to walk. ***Composite score is the average score for each subscale*

Room search results

The room search results: distribution of search and area of room searched first and search times, are first presented on a page per participant on the following pages before summarising results for the group.

The intervention was aimed at improving search into the space on the participants' blind side. The percentage of fixations in the left and right halves of the space and to the outside left and right sections of the space is represented in bar charts.

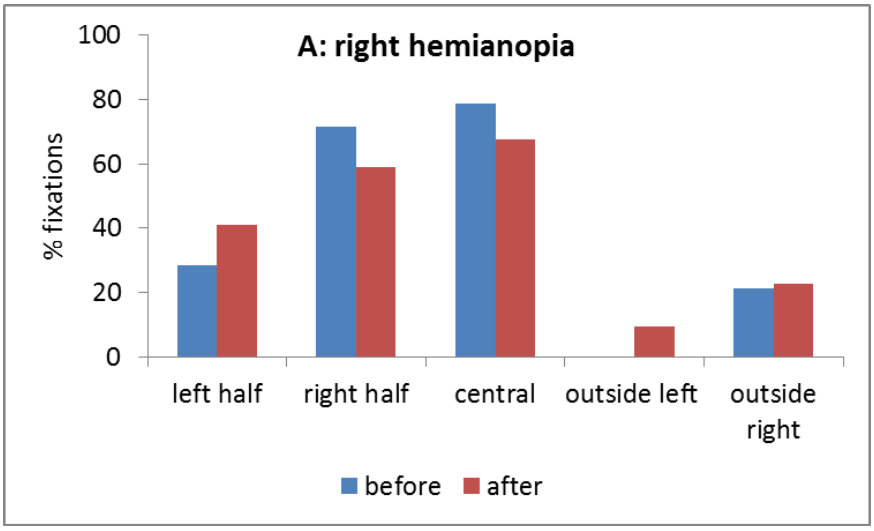
A common strategy used in training was to instruct participants to start the search on the extreme sides of the room on their blind side. The areas of space for early fixations indicate the search strategy. The percentage of early fixations (2-5) made to the left, right and centre of the scene is represented in pie charts.

To explore differences in search times with the object placed on participants' seeing and blind sides of the room sections have been collapsed into halves. The median time was calculated since search times were truncated at 120 seconds.

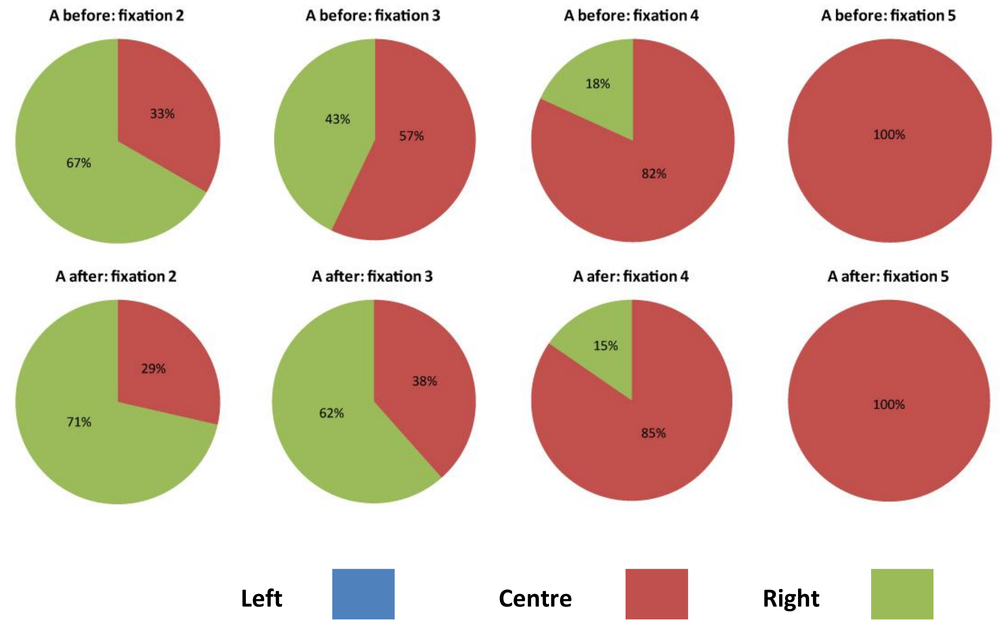
Participant A, right hemianopia

Before the intervention participant A was searching well into the outside space on his blind sides. However he had few fixations on the outside of the room on his seeing side. After training he increased searching in this area by 10%, Participant A took longer to search post treatment and the difference was seen when the keys were placed in the space on the participant's seeing side. The strategy of increasing early searching in the blind field cost him time when the keys were placed on his seeing side.

Figure 6A, i. Distribution of search



ii. Early fixations



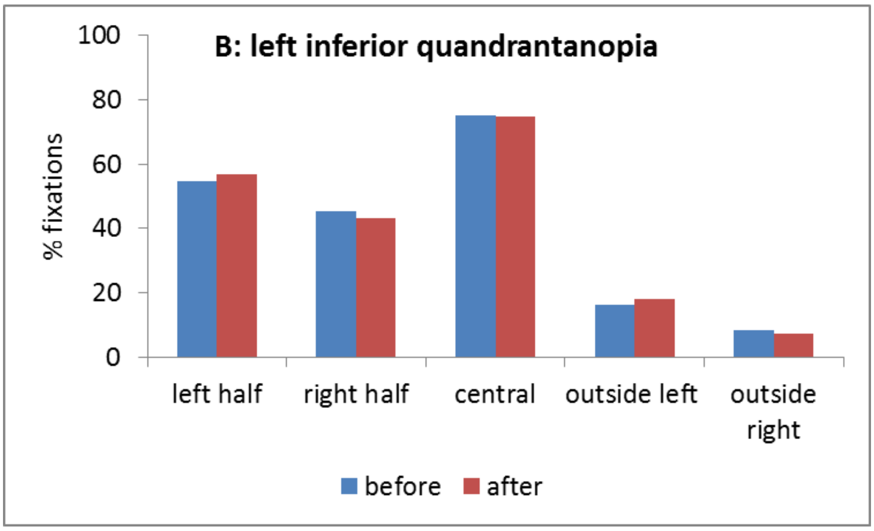
A: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
16	9	1 (blind side)	30	10	1 (blind side)

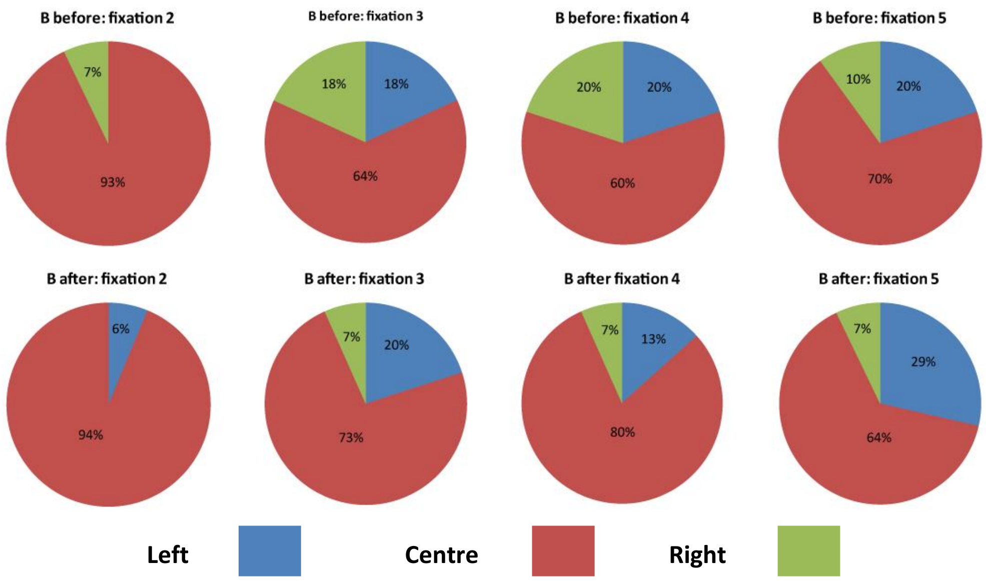
Participant B left inferior quandrantanopia

Before the intervention participant B was searching with a good spatial distribution, but a little infrequent on the far right seeing side. There was no change with treatment. He took longer to search post treatment and the difference was seen when the keys were placed in the space on his seeing side. The strategy of decreasing early searching in the right field cost him time when the keys were placed on this, his seeing, side.

Figure 6B, i. Distribution of search



ii. Early fixations



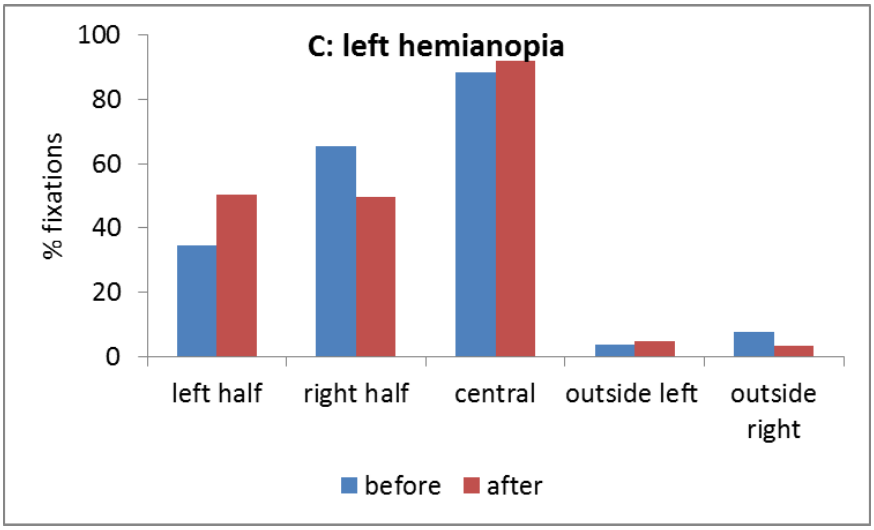
B: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
26	47	1 seeing side, 1blind	62	43	3 on seeing side

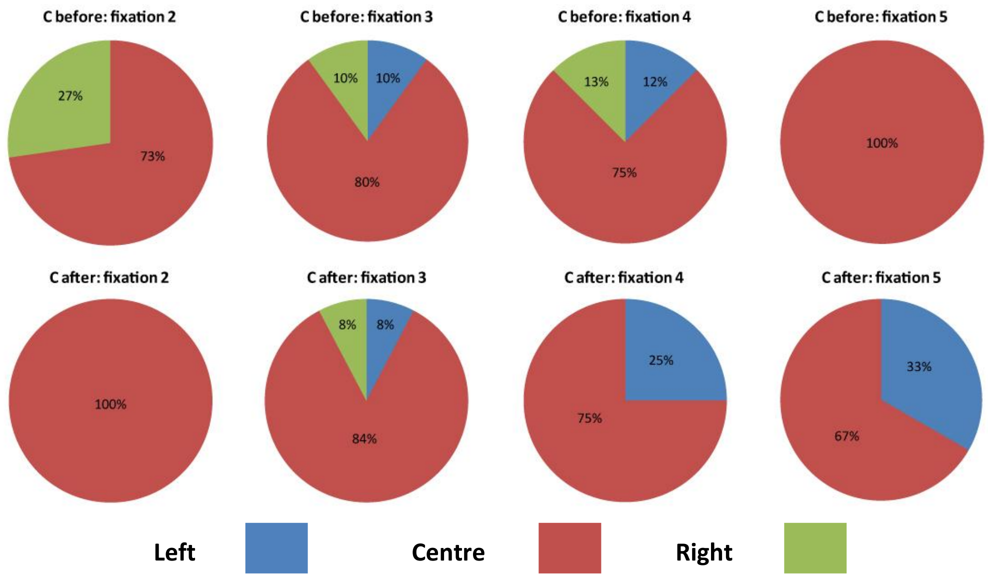
Participant C left hemianopia

Participant C had poor distribution of search in the left half of the room and on the periphery on both left and right sides. Searching in the left half increased to be equal to the right side after treatment, though she still had few fixations on the outside edges. She was searching unsystematically before treatment. This is evident from the mixed pattern of early fixations. After training the percentage of early fixations to the outside seeing side decreased, while those on the outside blind side increased. This strategy cost time when the keys were placed on the seeing, side.

Figure 6C, i. Distribution of search



ii. Early fixations



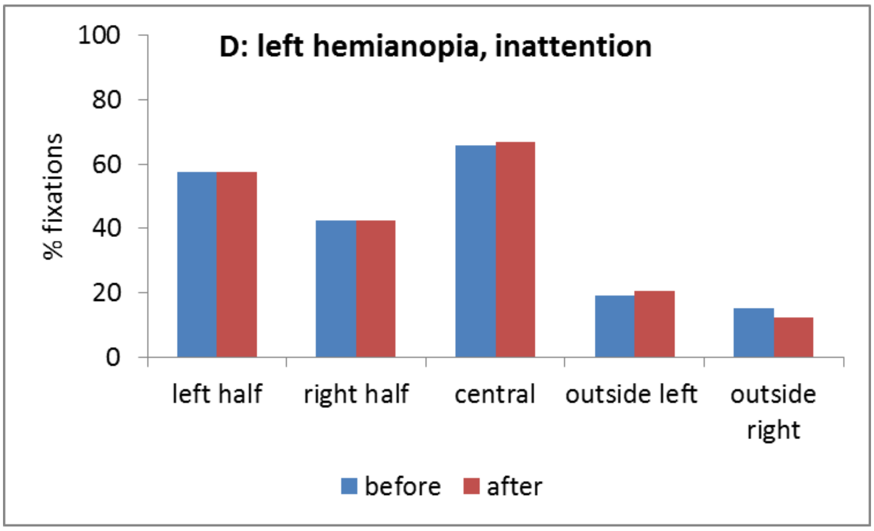
C: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
8	13	0	15	11	0

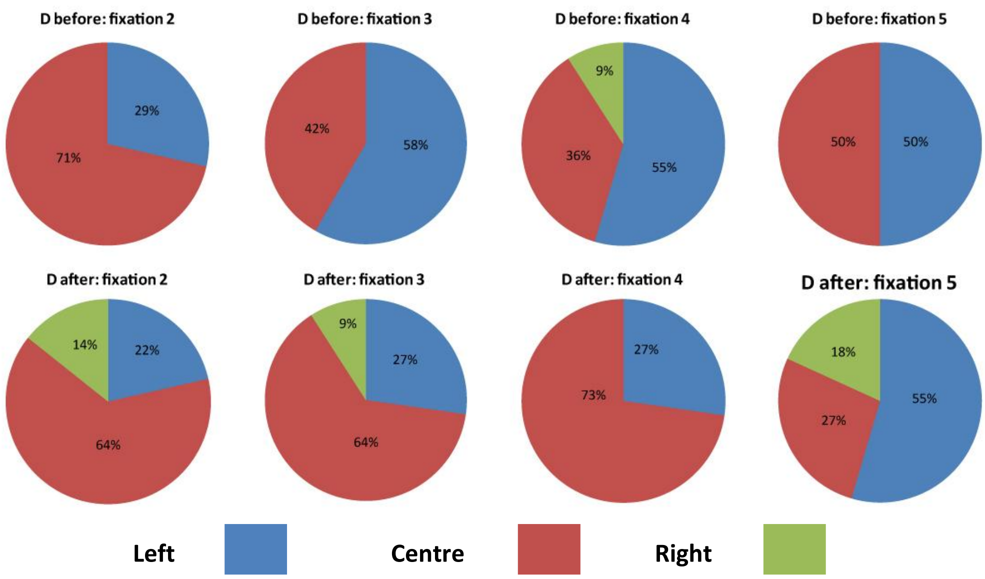
Participant D left hemianopia

D favoured the blind side of the room, his search distribution did not change after treatment. D was searching early on the blind side before treatment and less often to the seeing side. Contrary to the training, the percentage of early fixations on the blind side, outside left, decreased. Searches took longer after treatment irrespective of the side in which the keys were placed.

Figure 6D, i. Distribution of search



ii. Early fixations



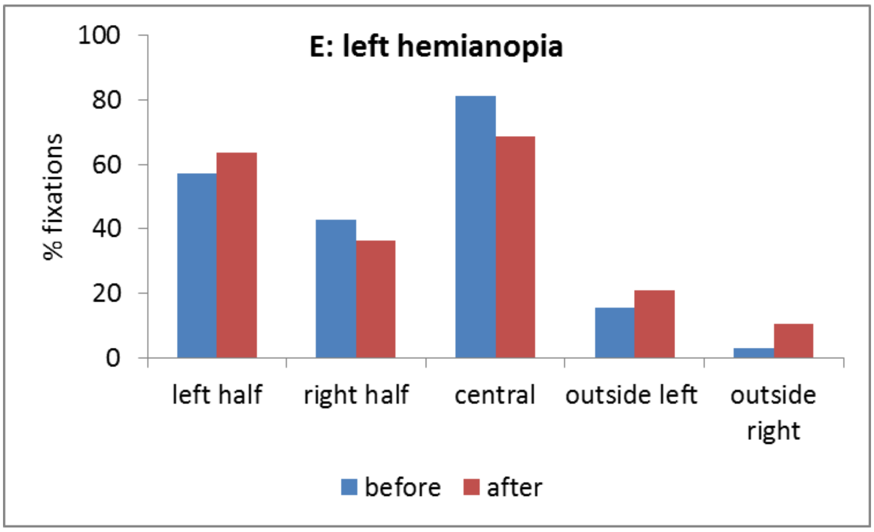
D: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
12	27	1 seeing side 1 blind side	33	45	1 seeing side, 1 blind side

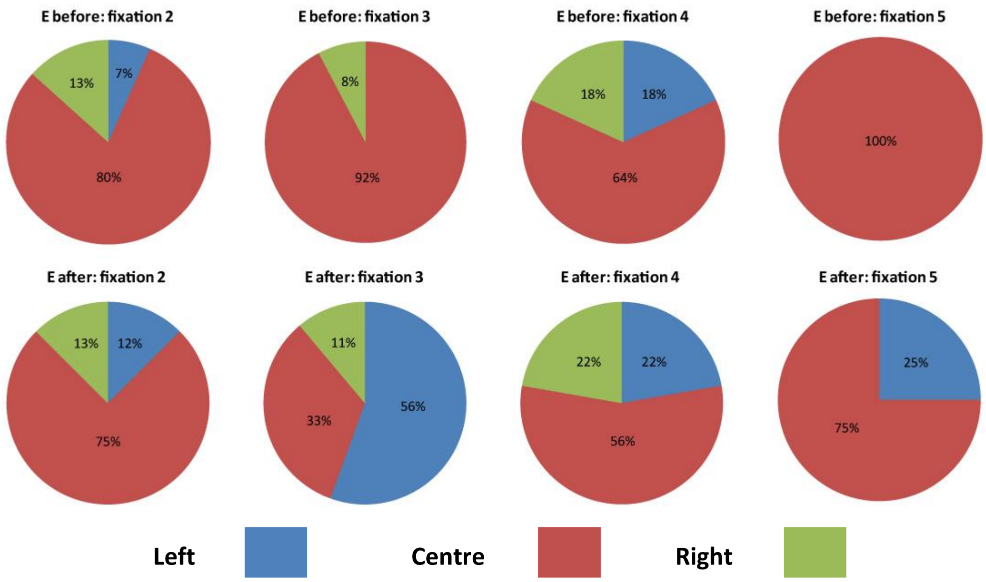
Participant E left hemianopia

Before training E was searching well into the outside space on the blind side. However he had few fixations on the outside of the room on his seeing side. After treatment he slightly increased searching in this area by 7% (equivalent to only 1 SD, in the normal subjects' frequencies).E was searching unsystematically before training. The percentage of early fixations to the outside seeing side decreased, while those on the outside blind side increased after training. E took longer to search post training when the keys were placed in the space on his seeing side.

Figure 6E, i. Distribution of search



ii. Early fixations



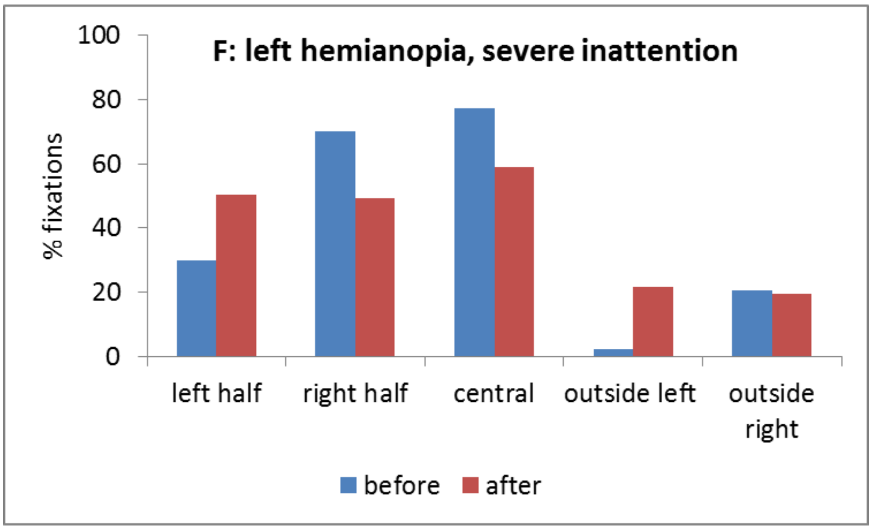
E: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
15	9	1 seeing side	32	10	1seeing side

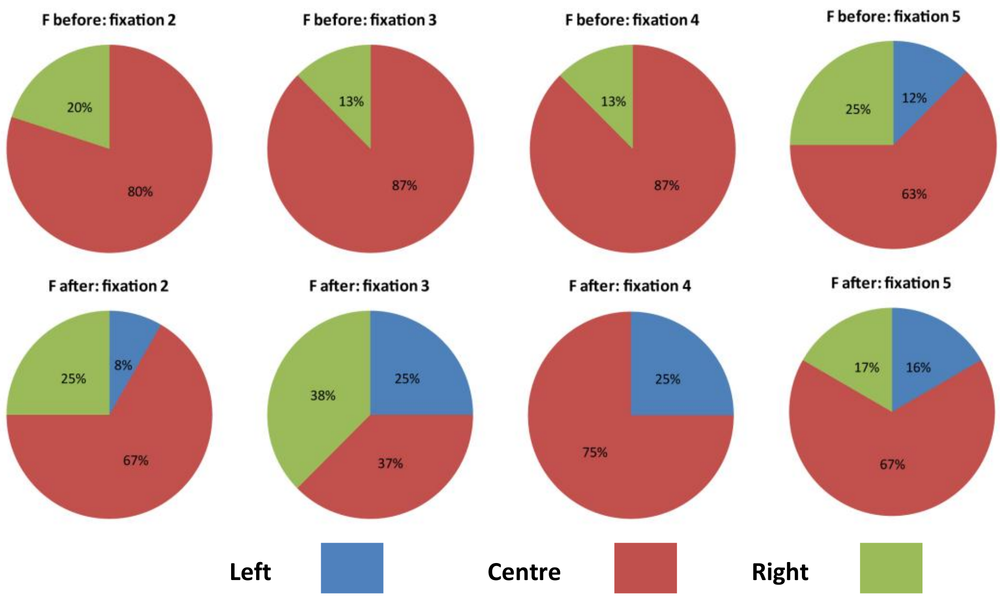
Participant F left hemianopia and severe inattention

F had only 30% fixations on the side of the room to her blind side before treatment and only 2% to the far left side. Her search to the left increased 20% after treatment, with 19% increase to the far left. The time taken for F to find the keys considerably reduced after treatment. Median times reduced from 120 seconds to only 9 seconds when the keys were placed on the blind side. This reduction in search times is explained by her increased ability to find the keys after treatment. She had five failed search in her blind field before treatment and this was reduced to only one after treatment.

Figure 6F, i. Distribution of search



ii. Early fixations



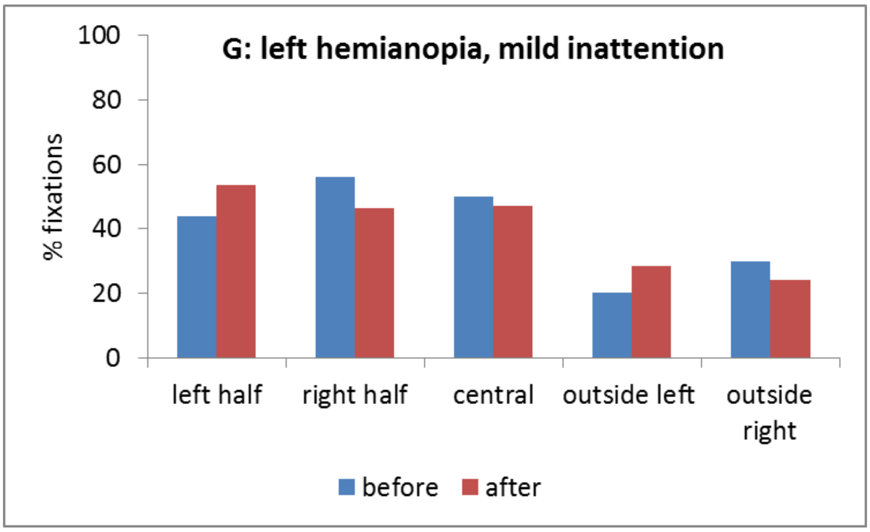
F: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
5	120	5 blind side	4	9	1 blind

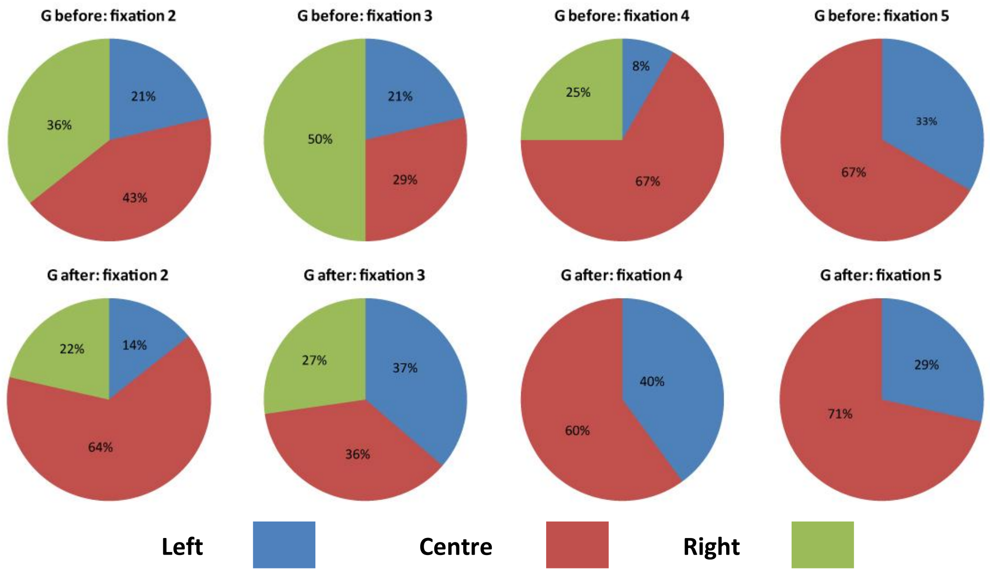
Participant G left hemianopia

G searched less on the left than the right before treatment, but her distribution of search on the left blind side was increased 10% after treatment and 8% to the far left. The percentage of early fixations to the outside seeing side decreased, while those on the outside blind side increased after training. G searched unsystematically before treatment. G reduced search times for finding the keys when on the seeing side after training.

Figure 6G i. Distribution of search



ii. Early fixations



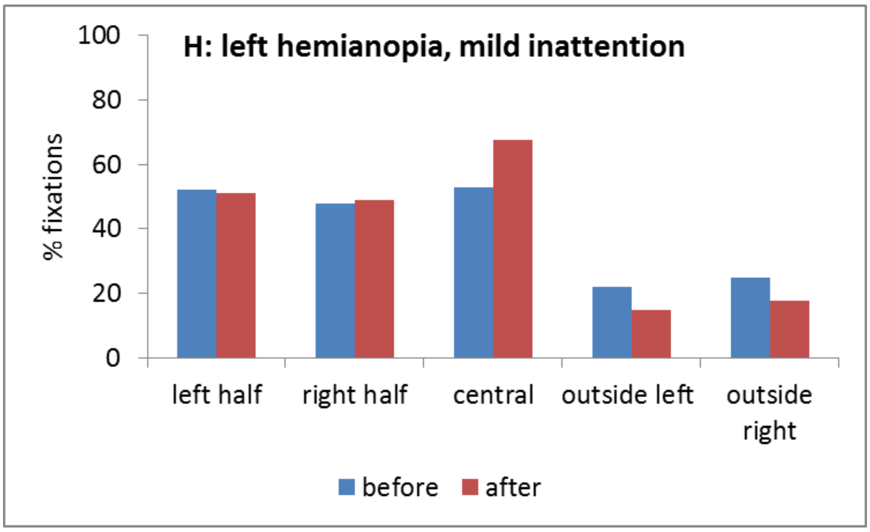
G: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
38	25	2 seeing side	14	14	1 seeing, 1 blind

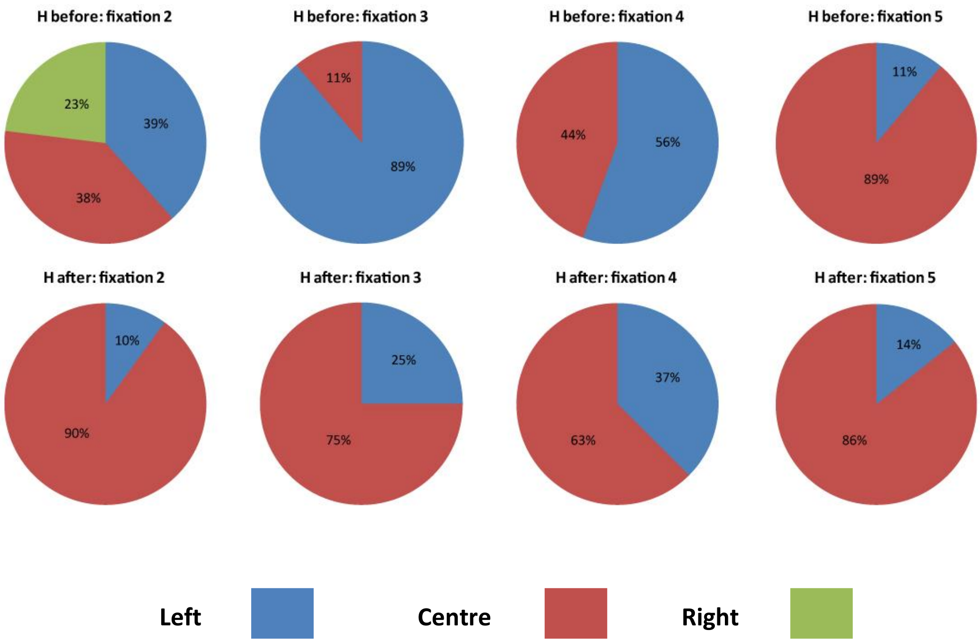
Participant H left hemianopia and mild inattention

H had an even and symmetrical distribution of search before treatment and did not change H search well to the far blind side before treatment, this was less apparent afterwards, but searching appeared to be more systematic because early fixations to the seeing side decreased. H improved search times for finding the keys when on the seeing side after treatment.

Figure 6H i. Distribution of search



ii. Early fixations



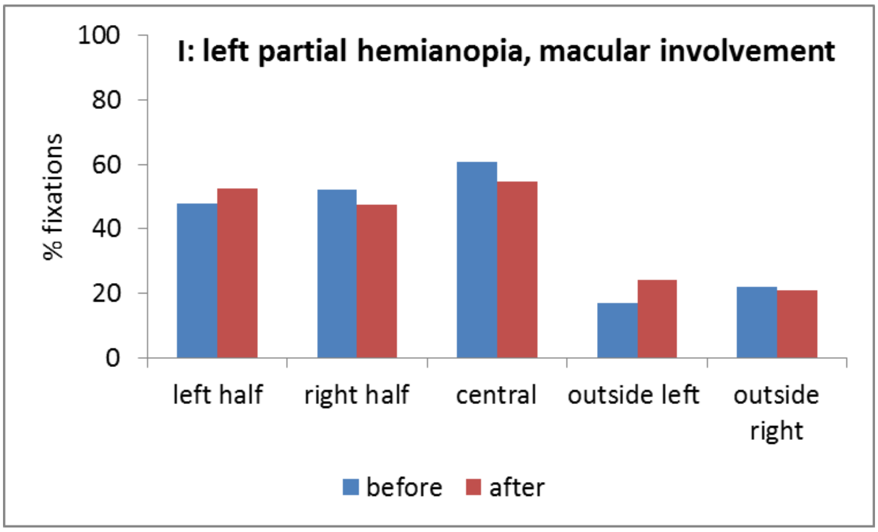
H: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
61	13	2 seeing,1 blind	35	12	1 seeing, 1blind

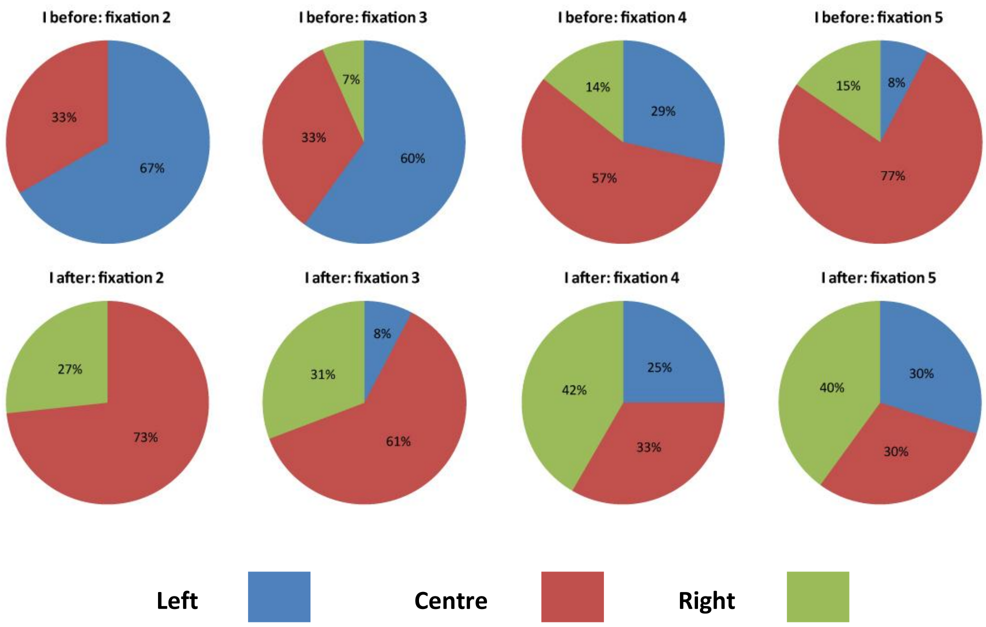
Participant I left partial visual field loss with macular involvement

Participant I was searching marginally less on his blind side at before treatment and this bias was no longer present after treatment. He was searching early on the outside left and centre before treatment and less often to the outside right. The percentage of early fixations to the seeing side on the outside right increased, while those on the blind side, outside left, decreased after training. Search times reduced for finding the keys when on the seeing side after treatment, but increased when the object was on the blind side.

Figure 6I i. Distribution of search



ii. Early fixations



I: Median search times and number of failed searches

Seeing side	Blind side	No. of Fails	Seeing side	Blind side	No. of Fails
26	11	1 seeing side	12	30	1 seeing side

Summary of room search results across participants

To enable results across the group to be examined table 8 shows search times and search distribution and early fixations for all participants.

Table 8 Changes in search after training

P	Distribution of searching before and after training	Change in percentage of early fixations on blind side	Search time
A	Before: Good distribution of search to blind side, but low on seeing side After: increased searching on seeing side	Increased	Increased when object placed on seeing side
B	Before: Good distribution of search to blind side, but low on seeing side After: increased searching on seeing side	No change	Increased when object placed on seeing side
C	Before: Poor distribution of searching on blind side and on the periphery both sides After: increased blind side but not periphery	Increased	Increased when object placed on seeing side
D	Before: Good distribution of search to blind side, but low on seeing side	Reduced	Increased irrespective of side object placement
E	Before: Good distribution of search to blind side, but low on seeing side After: increased searching on seeing side	Increased	Increased when object placed on seeing side
F	Before: Poor distribution of searching on blind side After: increased on blind side	Increased	Reduced when object placed on blind side
G	Before: Poor distribution of searching on blind side After: increased on blind side	Increased	Reduced irrespective of object placement
H	Before: symmetrical distribution of search before treatment After: no change	No change	Reduced for object placement on seeing side
I	Before: symmetrical distribution of search before treatment After: no change	Decreased	Reduced for object placement on seeing side, but increased on the blind side.

Participants B, D, F, G, H and I considerably longer in their searches before treatment than the healthy subjects tested.

Search patterns and strategies adopted by the higher functioning participants A-E and I resulted in searches taking longer. For A-E this was when the object was placed on the seeing side. Searching the room on the affected side first cost time. This time was not saved when the object was placed in the blind field.

The searches of the more severely affected participants F-H were more efficient after training with reduced search times.

Participants’ perspectives of the treatment and of wearing the head camera

We received responses to the questionnaire from eight participants. Participant E returned to work towards the end of the intervention and was not available to give his views. The respondents all found the number of visits and the treatment acceptable and thought it worth the amount of work they did. The benefits they identified together with their ratings out of ten of the perceived benefit are given in table 9 below.

Table 9

What difference has the treatment made to you?		Benefit rating out of 10
A	‘The treatment has made me more aware of my disability and has provided me with ideas of how to overcome tasks that have been difficult.’ ‘I need to scan using my eyes when completing a task.’ ‘Now I make an effort when talking to my wife when she is sitting on my right side.’	6
B	‘I pay attention more to the left side, although I still have visual problems.’	5
C	‘A great help getting me to understand the limitations that I did not realise I had. I thought when I was coming out of hospital I was fine, thought I could do everyday things. It made me realise how badly it has affected me.’ Giving an example regarding safety in the kitchen: ‘I am turning my head to look at the tomato to get the right thickness. I find it easier to hold the tomato missing my finger and thumb. It has made me safer.’	8
D	‘Helped to find objects, previously I couldn’t find objects even if they were right in front of me.’ ‘I can get my own meals now.’	7
F	I can look for things and turn my head more. My head is more central. I can do cleaning, look out of the window and see my family. I am enjoying being able to watch TV and winter sports, world affairs. I still struggle with the phone.	10
H	I am far more aware of scanning, and it has made a difference for me doing everyday tasks. Easier to find things now. I have improved considerably.	8
I	Some of the treatment was good. I feel more positive about things. It made me feel good as I feel capable of driving again. The treatment has made a difference.	6

No data from G for this question.

Table 10 indicates the elements of the intervention that were liked and disliked by the participants

Table 10

What did you like about the Occupational Therapy What did you not like?	
A	Liked: Reading, being timed to find keys Not liked: scanning the room, participant felt this was a memory test and his memory was too good. The search tasks were not challenging enough
B	Liked: Scanning exercises for eyes Not liked: None
C	*No responses to this question*
D	Liked: Out walking in the community, finding objects Not liked: None
F	Liked: Hopefully it will help me to turn my eyes to the right place. I am trying to do eye contact – I do not get it all the time but I try. Finding the paper bits is helpful. Picking up paper bits from floor with the hoover, picked out my clothes in the morning, put on my cream and a bit of perfume. Everything was helpful. Not liked: none
G	Liked: I have been put back on the map again. I was lifted, given another chance. Not liked: None
H	Liked: She used a lot of pressure at looking at her – eye contact, putting things out of my sight on my side. I liked doing the cutlery drawer, putting things back and turning head to look for items Not liked: When I wanted to do it one way and S wanted to do it another way – the way I do things is different. I understand why it was like this but having to learn new ways of doing things is difficult.
I	Liked: This is difficult to answer: I have not mastered the computer keyboard, going to the shop was fun. I feel more confident each time I go out. Not liked: None

All participants found wearing the head camera acceptable during the tasks selected in the study. When asked about a range of tasks that they would consider wearing a head camera acceptable for there was a preference not to wear it for personal tasks such as shaving, washing and dressing or for some more public activities in the community.

Discussion

Intervention to improve visual search performance in Occupational Therapy was delivered to nine participants whose visual functioning was affected by stroke. The Occupational Therapy treatment included tasks identified as goals by the participants. These were tasks such as walking in the street, crossing roads and shopping in supermarkets, kitchen activities, and driving a powered wheelchair indoors. Other tasks were in near space, such as use of the computer and reading. Driving was a goal for four of the participants. This goal was addressed by the therapist by driving off road (participant A) and driving with the participant as a passenger (C). Neither of these compromises was sufficiently visually challenging and it is not known whether they were beneficial, but these activities were closer to the goal task than is often experienced in Occupational Therapy. Remedial training activities were also used with all participants as means for increasing insight into the effects of VFD and to provide practice in using new search strategies. The treatment delivered by Occupational Therapy technicians was supervised by JA. A written training guide and treatment log sheets were employed to encourage fidelity to the strategies for training search determined in study one. Participants were satisfied with the intervention and perceived it as beneficial.

The treatment was delivered in one hour visits, three times a week. This intensity is far greater than is usual in the community Occupational Therapy service where visits to service users with visual problems after stroke are typically once a fortnight or once a month over several months. The study participants reported the intensity of treatment, three times a week for three weeks was acceptable. The principal of the treatment is that participants learn to search all relevant areas for the task, especially in blind or neglected space and that their search should be systematic starting on the blind side. Learning requires intensive practice and delivery of this over a short period was considered by JA to be superior to protracted delivery of the same amount of contact over many weeks. While intensity is important for learning it may be that duration of the treatment could be varied according to the needs of the individual. Some service users may learn to compensate with three visits a week for two weeks while others may need more than three weeks.

Gains in visual functioning assessed by the visual functioning scale (VFQ25) were recorded in all nine cases after the Occupational Therapy. Of course improved function may not have been due to the intervention. Without a control group and a large sample it is not possible to be certain of treatment effects. Four of the participants were within six months of stroke and it could be that natural recovery influenced the change in VFQ25 scores.

The room search task proved to be a feasible method for assessing search performance. Changes in distribution of search across the room and the starting place of search were captured allowing us to determine changes in the pattern of searching in an everyday living environment. There was a mixed pattern of changes in search behaviour. This is a small sample but the picture emerging is that the higher functioning participants did not improve search efficiency by changes adopted in their search strategy. Typically search times were longer when the object was hidden in the side of the room contralateral to the blind field, indicating that the strategy to start searching on the blind side cost time when the object was actually in a part of the room that was on their seeing side. However there did not seem to be an equivalent saving in time when the object was hidden on the side corresponding to the blind side where they searched first. On the other hand more severely affected participants appeared to improve their search times and for them starting their search in the space on the blind side and attending more to the affected side seemed to help.

The room search performances were not clearly associated with participants' improved reports of functional gains measured by the VFQ25. It could be that the intervention had more influence on confidence in managing visual disabilities rather than actual search performance. Some of the examples of perceived benefits from the intervention given by participants suggested that being made more aware of their visual performance and gaining confidence in doing things were important elements of the intervention. The mechanisms for efficacy require further investigation.

Occupational therapy is a complex intervention and is likely to have differing effects and influences on different individuals. The treatment was substantially goal directed and ideally performance measures should be relevant to the performance of tasks that the intervention is aiming to influence. Measures of visual scanning and search within real task performance are lacking. The room search task provided a performance measure of an ecologically valid task in far space, but it was a stationary task and clearly was performed as a test of search performance without all the distractions of real activities of daily living. Participants are likely to naturally adopt conscious search strategies in such an overt test situation. Their performances may not be a true reflection of their behaviour in a real life situation and may not be very informative of the process of search for many activities in which the participant is moving about in the environment, for example when walking around outside or in shops, when driving a wheelchair or in kitchen activities. Notwithstanding these limitations, the room search task represents an improvement on current process measures. Search is often measured in narrow field tasks in near space using computer screens or pencil and paper cancellation tasks (Pollock et al 2011a). While ecological tasks may have better validity for understanding how people search a wider environment, their drawback is in their reliability. The stroke participants results were described case by case looking descriptively at changes in their before and after intervention results. However there needs to be some caution in interpreting changes as being clinically meaningful. While some indication of consistency of performance in healthy subjects has been established in this study, more work is needed to determine reliability in a larger healthy sample and in the target population with visual impairment post stroke. Another consideration for reliability is the difficulty in standardising a task that is dependent on someone’s home environment. It would not be appropriate to compare search performance on the task between participants because of differences in the rooms; each will differ in the size, areas of clutter or of emptiness and lighting. To minimise noise in the results within individuals the task was performed according to a protocol and sixteen searches were carried out. While this repetition lends some confidence to median scores, it does make the assessment lengthy.

Limitations of the study

Achieving the objectives for this study proved to be challenging. There were difficulties in recruiting and retaining sufficient participants within the original timescale of the project. The strategy of recruiting, via the Stroke Research Network, from the acute stroke service was unsuccessful. While ten people were recruited in time, five of them later withdrew. This was because of circumstances changing between the time of recruitment and their discharge from hospital. Recruitment to community stroke studies is a problem that is recognised by the Stroke Research Network, since the infrastructure for identifying stroke patients who meet inclusion criteria for studies in a timely way is lacking. Identifying suitable patients via the community services proved to be more successful for retention, but in rural Cornwall, accruing participants within the project’s resources took a longer period of time than we originally had. Thanks to a no cost extension from the UKOTRF and to the generosity of the Community Occupational Therapy service we were able to continue recruiting for a further four months to achieve a total of nine out of our target of ten participants for study 2.

The second challenge was in meeting our objectives for measuring point of regard during activities of daily living. It was disappointing that the vision mapping software we intended to use was not fit for this purpose. As a consequence we had to devise a way to measure visual search performance that we could manage without the benefit of intelligent mapping software. This meant settling for a search task in which the participant was located in a fixed position within the environment. It also meant that analysing the video data would be a much more time consuming process. For these reasons we were unable to meet our objective (O9) to analyse the profile of scene exploration for a trained task and an untrained task for individual cases over the study period. It is expected that the challenges to the technology will be met in the future, opening the way for more flexible performance measurement, in which the participant will be able to carry out goal related tasks in many different environments including ones in which they are moving around. Camera technology is also improving and becoming more affordable. Our participants wore head cameras which are obtrusive. Many people would not want to wear them in busy places and because they are worn above the eyes they can only give an approximate point of regard that is prone to inaccuracy especially for tasks which require movement in the vertical vector. However in the short space of time since we started this study affordable digital video recording glasses with cameras set into the bridge of spectacles have come onto the market. These would be inconspicuous and being at eye level would be much more accurate for recording point of regard in everyday tasks.

Another limitation of the study was its size. However within the sample of nine participants a wide range of visual and physical functioning was represented. Mild to moderately affected participants wanting to improve their functioning in extended activities of daily living, shopping and outdoor mobility and more severely physically affected participants whose visual problems are not initially the most significant presenting problem for rehabilitation. Vision becomes much more significant when these patients need to be managed at home. VFD and VSN in more dependent patients can impact on more basic tasks such as safer transfers, personal care activities, interacting with carers and using a telephone. With the sample we had we were able to apply visual search training to a wide range of everyday activities to participants with wide range of physical and cognitive abilities.

Conclusion study 2

The aims for study 2 were to develop and test a process measure for quantifying search performance in the home context and extended activities of daily living and to test its feasibility in the home setting with stroke participants; and to test the feasibility of the intervention defined in study 1, delivered intensively.

The first of these aims was partially met. A process measure for quantifying search performance in the home context was developed and tested. The room search task was tested first with some healthy volunteers and then applied in before and after treatment assessments of the stroke participants. It proved to be acceptable to participants and it was feasible but it was time consuming. Further use of the task will depend on the resources available. Fulfilling the aim completely, to achieve a method for quantifying search performance that can be applied to varied extended activities of daily living, will rest on the availability of technology and software. The technology needs to be capable of mapping point of regard while participants are moving around in environments with wide ranging variation in light and texture.

The study has met the second aim. It has demonstrated that the visual search training in Occupational Therapy delivered intensively over three weeks is feasible and acceptable to participants living at home after stroke.

These are important steps in a programme of work to evaluate the effectiveness of the Occupational Therapy intervention.

Recommendations from the project

The recent James Lind Alliance priority setting exercise for stroke rehabilitation research which consulted people with stroke, their carers' and professional has 'What are the best ways to treat visual problems after stroke?' at number five in its top ten research questions (http://www.lindalliance.org/top-tens.asp). Treatment options are either using computer based training programmes, some of which are freely available in the internet (http://www.eyesearch.ucl.ac.uk/), or more task specific training such as can be offered in Occupational Therapy. Clearly Occupational Therapy is the more expensive of these, but it may be more effective for improving visual function in the real world. To answer the James Lind question it makes sense to test the clinical and cost effectiveness of the Occupational Therapy intervention against a computer based training package. However further work is needed before the intervention is evaluated in a clinical trial; this applies to both the intervention and to its evaluation.

The intervention was largely goal directed and the tasks used for training were relevant to the individuals. However it is clear that need to work towards return to driving was not adequately met. The intervention given may help service users to develop scanning and vigilance that is needed for driving, but that is its limit at present. Now that provisional driving licences holders are allowed to have driving lessons to demonstrate whether or not the VFD affects the ability to drive safely, (www.gov.uk/goverment/publications/static-visual-field), Occupational Therapists should be looking at ways to work with other agencies, such as driving assessment services and driving instructors, to help service users to return safely to driving and within the law.

Some experimental work is needed to determine the efficacy of search strategies used in the intervention. The results from our small sample suggest that starting the search in the blind field slows search without any advantage over accuracy in mildly affected patients. Further work is needed to identify the most effective strategies for improving search performance and to which individuals they should be applied.

A measure of search performance in real world tasks would be helpful to determine the mechanism for the intervention, and for understanding which patients benefit and their patterns of learning. The room search task goes some way towards this, but further work is recommended to investigate the use of new technologies to achieve more flexible and more accurate recording of point of regard during activities of daily living.

Further process evaluation to understand other mechanisms of the intervention for improving patients' perceptions of their visual functioning is needed. This could be done using some qualitative research to explore in more depth the views of participants about their experiences of visual impairment and of the intervention.

The visual functioning questionnaire would appear have potential as a primary outcome measure in a trial of clinical effectiveness of the intervention. The VFQ25 was responsive to perceived change in the participants in study 2. VFQ25 includes visual functioning in everyday activities and the socio-emotional impact. Measuring participation and well-being is considered important by NIHR funding programmes and so providing the VFQ25 is internally consistent for the population, this measure should be most acceptable. A new form of the VFQ25 that is treated as two scales: visual functioning and socio-emotional scales has been found to have acceptable reliability, validity, and unidimensionality. Software to convert raw scores into Rasch scores is available to improve the analysis of the scale as a continuous measure (Marella et al 2010). Further research into its responsiveness and internal consistency in a larger sample of stroke participants is recommended.

Project outcomes and key findings

- This project has achieved a detailed description of the content of visual search training in community based Occupational Therapy for people with visual impairment post stroke.

- The intervention is task specific to participants' goal occupations and trains strategies for search using remedial activities and real tasks.

- Based on the description a treatment guide and treatment log sheets have been produced. In addition the Occupational Therapist's assessment and treatment of participants have been written up as cases to illustrate the guide.

- The intervention was found to be feasible and acceptable to participants treated intensively over three weeks.

- A room search task for quantifying search performance in the home context was developed and tested. Searches for an object placed in the room were recorded from a camera worn on the participant's head. Recordings were analysed for spatial distribution and the starting point of search.

- This method of measuring of search proved to be feasible and demonstrated changes in the distribution of search and starting place of search after the intervention.

- A patient reported outcome measure was tested and found to be responsive in the sample suggesting it may be a good primary outcome measure for a clinical trial.

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