Rehabilitation of Hemianopic Visual Field Defects

Visual function is distributed over large areas of the cerebral cortex. Consequently, visual field defects (VFD), and in particular homonymous defects, are very common after cerebral insults such as stroke and traumatic brain injury (TBI). Population-based studies have shown a prevalence of VFD of 0.8%. In chronic stroke, the proportion of homonymous VFD has been reported to vary between 8.3% and 16%, while in the acute and subacute period, VFD occur in 25% of stroke and 39% of TBI patients. Visual field defects tend to improve in the first few months after insult as a result of resolution of oedema and diaschisis, with improvement of neurotransmission near and remote to the lesion. However, by three to six months after insult, VFD are unlikely to continue improving and only about 5% resolve completely.

The disability that attends VFD is significant. Fluent reading requires preserved function in the central 5° of vision; as most VFD extend to the vertical meridian, affected individuals have problems identifying half a word and finding the next line of text, resulting in hemianopic alexia. Standards for driving vary by country and, in the US, also by state, but most require at least 120° of vision, and in some cases as much as 140°; therefore, many of those with a VFD are unfit to drive. Collisions with obstacles and people in crowded areas, difficulty seeing televisions and finding icons on a computer screen are commonly reported and result from both vision-related and health-related quality of life measures; these show worse quality of life compared to both healthy subjects and stroke patients without a VFD.

In spite of their frequency and the disability imposed by their presence, in the past little attention was paid to rehabilitating homonymous VFD. However, developments in the last two decades have advanced the field, with three main lines of research: substitutive methods with the use of prisms, compensatory strategies with saccadic therapy, and restorative approaches.

Substitutive methods use optical devices, namely prisms, to enlarge and shift the visual field. Although there are encouraging reports about their tolerability and efficacy, others have reported lack of translation of visual field function into activities of daily living. New prism designs attempt to avoid the diplopia reported in prior studies. But their tolerability remains an important issue. In a prospective report, only 47% were still using prisms at one year, the main reasons for discontinuing their use included image confusion and distress over sudden appearance of objects in the visual field. Although reasonable as a rehabilitative approach, substitutive therapy requires training in the use of the devices, and poor adherence due to visual distortion remains an issue.

Compensatory strategies use the intact residual function of eye movements and can be broadly categorised into reading training and exploratory training. A controlled trial of patients with right homonymous hemianopia and hemianopic alexia found that a home-based intervention that induced optokinetic nystagmus delivered through right-to-left moving text increased reading speed by 18% (>17 words per minute). These results are smaller than those reported in non-controlled studies, in which reading training was delivered by therapists. Hemianopic patients employ multiple saccades and fixations due to disorganised and inefficient visual search. Exploratory training aims to address this issue by specifically teaching individuals to make saccades into the blind field while scanning the environment. A number of reports have noted a decrease in reaction time, improved detection and better performance in activities of daily living scales and tasks. A randomised study of exploratory saccade training found improvement towards the blind side in response time and reduced fixations in search tasks, particularly in a digit search paradigm, with no change in visual field size and without translation into reading speed. A controlled study comparing saccadic training with attentional training (without the exploratory saccadic component) also found improvement in the digit search task for exploratory training, but other visual search tasks and reading improved similarly in both treatment arms, suggesting that attention plays a vital role in saccadic visual rehabilitation.

Restorative approaches are based on the premise that the visual system is plastic and that neural reorganisation can be achieved through targeted and repetitive photostimulation. The most studied approach is denominated vision...
restoration therapy (VRT), where therapy is directed to the border between the seeing and the blind field with thousands of stimuli over weeks and months. This tactic has resulted in expansion of the visual field by about 5°. In a randomised controlled study of 19 patients with retrochiasmatic lesions, those treated with VRT showed a 4.9° improvement in central visual field compared to controls. Large retrospective studies employing VRT in the US and Europe also confirmed an expansion of 5° of the central visual field, representing a 10-13% increase in the number of detected stimuli. The figure exemplifies a case treated with VRT. Between two thirds and three quarters of patients treated show visual field improvement, but predicting who will respond has proven difficult; age, time from lesion and type of visual field defect were not shown to be good predictors of response.

In addition to expansion of visual fields, functional improvements have also been documented after VRT by structured questionnaires, validated visual functional scales and in reading and attention testing. Other modalities of repetitive stimulation close to the border of the hemianopic field have documented visual improvement. Huxlin and colleagues studied individuals with primary visual cortex V1 injury before and after direction discrimination training with dynamic stimuli while carefully monitoring eye movements, and confirmed improvement in both direction discrimination as well as other visual functions. Others have repeatedly stimulated deep in the blind field in order to enhance “blind sight” and noted significant changes in both perimetric studies as well as in contrast sensitivity.

Nonetheless, controversy has arisen regarding VRT’s efficacy after a report of 16 patients where the visual field expansion found with perimetric methods using near-threshold and supra-threshold stimuli could not be confirmed by scanning laser ophthalmoscopy. This raised the possibility that the effects of VRT are not due to a true expansion of visual fields but result from more effective eye movements. However, others argued that the scanning laser ophthalmoscopy strategy employed in that report was too complex for those with a VFD. Studies that controlled for eye movements with other controls argue against eye movements as the sole explanation of the visual field expansion seen with VRT. In a study of 15 patients whose visual fields were monitored with an eye tracker, patients treated with VRT spent 88.3% of the time within 1° and 98.9% of the time within 2° of fixation, which was actually improved from baseline; furthermore, less than 5% of all saccades were larger than 2°. In a small series of patients with direct retinal microperimetry, which controls for eye movements, all patients had visual field improvement after VRT.

Figure: A 55 year old man, 9 months after a left occipital infarct, is left with an incomplete right homonymous hemianopsia. Panel A is a superimposition of 3 consecutive visual field tests performed with suprathreshold stimuli at baseline, and panel B shows the visual field after 6 months of visual rehabilitation with VRT. Panel C is a subtraction map between the pre and post VRT visual fields, showing in blue the areas of improvement and in red the areas of worsening.
The mechanisms by which restorative approaches exert their effects are incompletely understood. As eye movements alone do not explain the effects noted, cortical reorganisation has been invoked. In motor recovery, neuro-imaging suggests that peri-lesional reorganisation is the main neurological substrate associated with functional improvement.22 Indeed, both positron emission tomography23 and functional magnetic resonance imaging (fMRI)24,25 have noted changes in visual areas after restorative approaches. Whether this represents expansion of receptive fields in the primary visual cortex is unclear.26,27 However other mechanisms may also play a role. Studies where the blind field was stimulated suggest that it is the activation of extrastriate pathways, which bypass the damaged V1 cortex, that correlate with improved function.28,29 Finally, the role of top-down focused attention on information processed in extrastriate areas is recognised, and combining attentional cues with VRT has resulted in greater visual field changes.30 fMRI studies after VRT have also documented increased BOLD activity in attentional areas.31 These mechanisms may well interact. One might hypothesise that activation of extrastriate pathways through repetitive stimulation, and expansion of receptor field size in areas close to the border of the blind field may result in greater detection; this would then shift focused attention which in turn lowers detection threshold in a particular area.32

Although the field of visual rehabilitation for hemianopic defects has recently expanded, further research is needed to: i) determine the precise mechanisms of action of the available techniques in order to enhance therapeutic approaches; ii) develop sensitive and significant measures of successful therapy; and iii) identify predictors of outcome to apply treatment to those most likely to benefit from these interventions. The modest outcomes reported to date may also be explained. For example, augmenting the effects of restorative therapies by brain electrical stimulation to improve effects and shorten the course of therapy is being explored, with initial encouraging results.33 The benefits of consecutive restorative followed by compensatory strategies should also be studied. Nevertheless, there are currently a variety of options are now clinically available for hemianopes, and clinicians should strongly consider these rehabilitative interventions in eligible patients.  

REFERENCES