Spatial Neglect

Spatial neglect is a common syndrome following stroke, most frequently of the right hemisphere. Up to two-thirds of acute right-hemisphere stroke patients demonstrate signs of contralesional neglect, failing to be aware of objects or people to their left in extrapersonal space. For example, when searching through a visual scene patients with left neglect tend to look at elements on the right only (Fig. 1). The syndrome may also involve 'personal' space, with patients neglecting their own contralesional body parts. Importantly, many patients are unaware they have these problems (anosognosia). Perhaps unsurprisingly, therefore, enduring neglect is a poor prognostic indicator for functional independence following stroke.

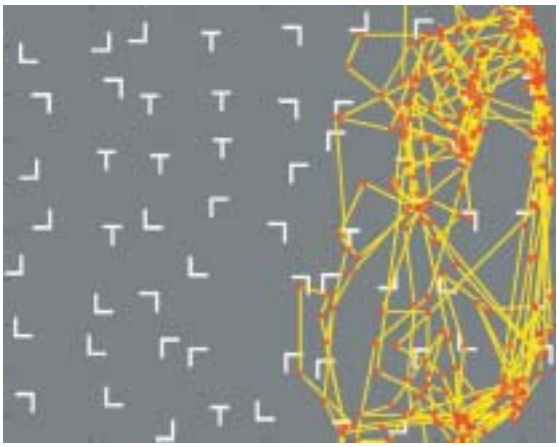

Figure 1. Measurement of the eye-movements during search for letter Ts among Ls of a typical patient with left neglect reveals a tendency to repeatedly fixate items on the right while ignoring those on the left.

Diagnosis

Severe neglect may often be diagnosed by simple observation, e.g. patients who turn their head and eyes to their extreme right and never spontaneously gaze to the left, even though leftward eye movements are intact on formal testing. In most cases, however, specific bedside assessments are required to identify neglect. Furthermore, it is important to quantify the severity of neglect in order to track patients' progress in an acute stroke unit, or in response to rehabilitation. A number of simple and rapid tests have been developed for the assessment of neglect[1, 2]. We recommend, where possible, using several of these because there is considerable variability in the tests that patients fail (probably reflecting differences in the exact nature of the underlying cognitive deficits):

- *Cancellation tasks* (Fig. 2) involve patients searching for and marking with a pen target items on a sheet of paper. Right-hemisphere neglect patients often start on the right side of the page (whereas control subjects who read left-to-right usually start on the left), and omit targets on the left of the page. The most sensitive tests have a high density of targets as well as irrelevant distracter items. Cancellation tests are the *single* most sensitive bedside test and should wherever possible be included in any test battery[2].
- In *line bisection tasks* patients mark where they perceive to be the midpoint of a long (18-20 cm) horizontal line on a sheet of paper. Neglect patients, especially those with right posterior lesions, often deviate considerably to the right of the true midpoint.
- *Object copying* (Fig. 3) and *drawing a clock face* are commonly used but they are relatively insensitive when used alone, difficult to score in a graded manner and also affected by constructional apraxia.
- When asked to *report ten objects* around the room neglect patients may predominantly choose items from the ipsilesional side of space.
- Tests of *personal neglect* include asking the patient to mime combing their hair, shaving or making-up their face. Right-hemisphere patients often fail to groom the left side of their face on such tasks, as well as in daily life.

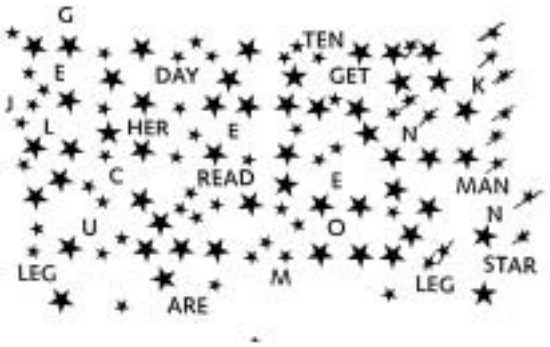

Figure 2. In a clinical cancellation task a neglect patient tends to cross out only those targets (small stars) on the right of the page.

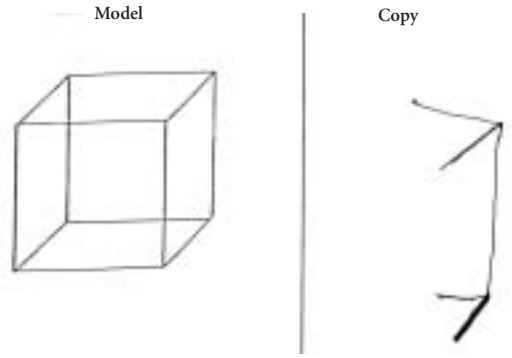

Figure 3. When copying a model line drawing of a cube neglect patients may omit leftward features.

Anatomy of neglect

Most neglect patients have suffered large right-hemisphere MCA strokes but the syndrome has been more specifically associated with damage to the following regions (Fig. 4):

- The right inferior parietal lobe (IPL) or nearby temporo-parietal junction (TPJ), considered the 'classical' cortical sites[3].
- The right inferior frontal lobe, which tends to lead to more transient neglect[4].
- Subcortical ischaemic lesions in the territory of the right MCA involving the basal ganglia or thalamus, although this may be due to diaschisis or hypoperfusion in overlying parietal and frontal regions[5].
- Large posterior cerebral artery (PCA) territory strokes extending from occipital to medial temporal lobe. It remains to be determined whether neglect following such extensive PCA infarction is in fact due to parietal diaschisis, or is a separate disorder distinguished by unique underlying component deficits.

Cognitive deficits underlying neglect

Many different cognitive deficits, either in isolation or combination, are considered to contribute to the neglect syndrome. The following important spatially lateralised

Andrew Parton is Post-Doctoral Research Associate in the Department of Visual Neuroscience at Imperial College London, Charing Cross Hospital. His research interests are the cognitive neuroscience of attention, eye movements and spatial representation.

Masud Husain is Wellcome Trust Senior Fellow and Reader in Neurology at Imperial College London, Charing Cross Hospital. He has a special interest in disorders of visuospatial cognition and attention.

Figure 1 reproduced from "Impaired spatial working memory across saccades contributes to abnormal search in parietal neglect. Brain 2001;124(Pt 5):941-52." by permission of Oxford University Press.

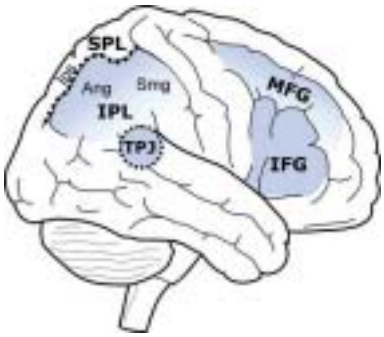

Figure 4. Cortical right hemisphere brain regions associated with neglect include the angular (Ang) and supramarginal (Smg) gyri of the inferior parietal lobe (IPL), the temporo-parietal junction (TPJ), and the inferior (IFG) and middle frontal (MFG) gyri. Additionally, the diagram also shows the superior parietal lobe (SPL) and intraparietal sulcus (IPS).

components (worse to the left in right-hemisphere patients) have been proposed to underlie neglect:

- A deficit in directing attention to the left – due either to a graded bias in directing attention rightwards[6], items on the right invariably 'winning' over objects to the left in the competition for attentional selection[7], or a difficulty in disengaging attention and shifting it leftward[8].
- An impaired representation of space - which may occur in multiple frames of reference (e.g. retinotopic, head-centred, trunk-centred) or be specific to near or far space[9].
- A directional motor impairment, with patients experiencing difficulty in initiating or programming leftward movements[10].

In addition to these lateralised impairments (worse to the left following right-hemisphere stroke), it is increasingly becoming apparent that the neglect syndrome also consists of *non-spatially lateralised* deficits, involving both sides of space. Different patients may suffer different combinations of lateralised and non-lateralised deficits, depending upon the precise location and extent of their lesions. Furthermore, the severity of a patient's neglect may be determined by the interaction between their lateralised and non-lateralised impairments, which could help to explain why some patients recover poorly[11]. Non-spatially lateralised components of neglect include:

- Impairments in sustained attention[12]
- A bias to local features in the visual scene[13]
- A deficit in spatial working memory[14]
- Prolonged time-course of visual processing[15]

Treatment and Rehabilitation

Initial attempts to rehabilitate neglect encouraged patients to direct their gaze towards contralesional space. But although these approaches showed some success in reducing neglect within a particular task (e.g. in reading, by cueing patients to find a red line marked on the left margin), patients typically demonstrated little generalisation of their improved scanning behaviour to tasks outside of the training environment[16]. Unfortunately, many neglect patients are often unaware of their deficit and in complex real-world environments, cues to remind them to look left (e.g. red lines) are not readily available.

Recently researchers have attempted to develop techniques that produce an automatic change in behaviour, without relying on patients adopting a new control strategy to look leftwards. The most promising of these approaches involves *prism adaptation*, using lenses that induce a rightward horizontal displacement of patients' visual fields[17]. Recent studies have suggested that the after-effects of simple prism adaptation treatment may result in a long lasting amelioration of neglect that generalises across a wide range of deficits[18]. Further work is required to understand the mechanisms underlying such improvement, and to establish the extent of its effectiveness. Other research is being directed towards drug treatments for specific cognitive deficits underlying the neglect syndrome.

Acknowledgment

Our research programme is funded by The Wellcome Trust.

References

1. Parton A, Malhotra P, Husain, M. *Hemispatial Neglect.* J Neurol Neurosurg Psychiatry 2004;75:13–21.
2. Azouvi P, *et al. Sensitivity of clinical and behavioural tests of spatial neglect after right hemisphere stroke.* J Neurol Neurosurg Psychiatry 2002;73(2): 160-6.
3. Vallar G. *The anatomical basis of spatial hemineglect in humans in Unilateral neglect: clinical and experimental studies.* Robertson IH, Marshall JC, Editors. Hove: Lawrence Erlbaum, 1993:27-59.
4. Husain M, Kennard C. *Distractor-dependent frontal neglect.* Neuropsychologia 1997;35(6):829-41.
5. Hillis AE *et al. Subcortical aphasia and neglect in acute stroke: the role of cortical hypoperfusion.* Brain 2002;125(Pt 5):1094-104.
6. Kinsbourne M. *Orientational bias model of unilateral neglect: Evidence from attentional gradients within hemispace, in Unilateral neglect: Clinical and Experimental Studies.* Robertson IH, Marshall JC, Editors. Hove: Lawrence Erlbaum 1993:63-86.
7. Duncan J, Humphreys G, Ward R. *Competitive brain activity in visual attention.* Current Opinion in Neurobiology 1997;7:255-261.
8. Losier BJ, Klein RM. *A review of the evidence for a disengage deficit following parietal lobe damage.* Neurosci Biobehav Rev 2001; 25(1):1-13.
9. Karnath HO. *Spatial orientation and the representation of space with parietal lobe lesions.* Philos Trans R Soc Lond B Biol Sci 1997;352(1360): 1411-9.
10. Heilman KM *et al. Directional hypokinesia: prolonged reaction times for leftward movements in patients with right hemisphere lesions and neglect.* Neurology 1985; 35:855-859.
11. Husain M, Rorden C. *Non-spatially lateralized mechanisms in hemispatial neglect.* Nat Rev Neurosci 2003;4(1):26-36.
12. Robertson IH *et al. Auditory sustained attention is a marker of unilateral spatial neglect.* Neuropsychologia 1997;35(12):1527-32.
13. Robertson LC, Lamb MR, Knight RT. *Effects of lesions of temporal-parietal junction on perceptual and attentional processing in humans.* Journal of Neuroscience 1988;8:3757-3769.
14. Husain M *et al. Impaired spatial working memory across saccades contributes to abnormal search in parietal neglect.* Brain 2001;124(Pt 5):941-52.
15. Husain M *et al. Abnormal temporal dynamics of visual attention in spatial neglect patients.* Nature 1997; 385(6612):154-6.
16. Robertson IH, Marshall JC, *Unilateral Neglect: Clinical and Experimental Studies.* Hove: Lawrence Erlbaum, 1993.
17. Rossetti Y *et al. Prism adaptation to a rightward optical deviation rehabilitates left hemispatial neglect.* Nature 1998; 395(6698):166-9.
18. Frassinetti F *et al. Long-lasting amelioration of visuospatial neglect by prism adaptation.* Brain 2002;125(Pt 3):608-23.

Correspondence to:
Department of Visual Neuroscience
Division of Neuroscience & Psychological Medicine
Imperial College School of Medicine
Charing Cross Hospital
Fulham Palace Road
London W6 8RF
E-Mail: a.parton@imperial.ac.uk or m.husain@imperial.ac.uk