

Unilateral Neglect: Clinical and Experimental Studies

edited by Ian H. Robertson and John C. Marshall

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1.1 *Unilateral Neglect: Clinical and Experimental Studies* is a recent title in the series published by Lawrence Erlbaum on the theme of brain damage, behaviour and cognition, which reflects the recent growth of interest in the area of neuropsychology. Unilateral neglect is a condition which has generated a great deal of interest in the past decade, as it reveals a vast amount of often bewildering behavioural manifestations. Given the explosion of papers on the subject a coherent, well-written book is long overdue and also something of a formidable undertaking. Ian Robertson and John Marshall have managed to edit an excellent and comprehensive volume containing 15 well-written chapters from 22 contributors (see appendix). The book manages to combine the different approaches to the study of neglect in three separate sections, providing an overview of the models; it also discusses the rehabilitation of this perplexing neurological disorder. If you are a student, postgraduate researcher, or lecturer interested in visual attention or visual neglect, you will want to buy this book. Clinicians and people working with neglect patients will also find it invaluable as a reference and as a guide to the rehabilitation techniques that may help patients overcome their deficits.

1.2 Neglect most typically occurs following a stroke in the region of the right hemisphere of the brain and results in patients failing to respond to stimuli, objects and even people

located to their left (contralesional) side. The failure to respond to and report left-sided stimuli is not due to a primary visual field defect such as a left hemianopia (loss of vision for the contralesional visual field). Some patients can be shown to have intact visual fields (Walker et al., 1991) and yet still show profound neglect on a wide range of tasks. Neglect is not related to any loss of intellectual functioning in the patient. The first chapter from Ian Robertson and John Marshall sets the scene by clearly stating that neglect should be regarded as a "cognitive inability" to respond to contralesional stimuli.

1.3 Before reviewing the book it may be worth considering what neuropsychology is and what its aims are. Neuropsychology is the area of psychology which aims to find out how the brain performs certain cognitive functions by studying the range of deficits that patients show following brain damage. One of the important assumptions of neuropsychology is that the brain contains various specialised modules for processing information. An example of this modularity is the existence of two separate cortical visual pathways, one being responsible for object recognition and one for spatial analysis (Ungerleider and Mishkin, 1982; Milner and Goodale, 1993). Damage to one of these pathways can leave the patient unable to recognise 'WHAT' an object is (object agnosia), while damage to the other pathway gives rise to a problem of 'WHERE' the object is located in space. This kind of dissociation following localised brain damage can enable cognitive scientists to learn more about the way these independent modules contribute to the cognitive process of visual perception. A good example of this technique has been the study of patients who exhibit a phenomenon known as 'blindsight' (Weiskrantz et al., 1974). Blindsight patients have damage to their primary visual cortex and a genuine visual field deficit, but can still make accurate pointing responses to stimuli presented in the 'blind' regions. The interesting question is: if the patients can 'see' the stimulus well enough to point to it, why aren't they consciously aware of it? Unilateral neglect is, in a sense, the opposite side of this coin. A patient with neglect fails to respond and report objects and stimuli presented in the region opposite to the lesion site, but has an otherwise intact visual field. It has been demonstrated that the 'neglected' stimulus is processed covertly, to a high level outside of conscious awareness (Marshall and Halligan, 1988). Why is the patient no longer consciously aware of something which falls into an otherwise intact sensory field, and what can this help to show us about the nature of brain functioning?

1.4 One of the unresolved issues in neglect concerns the two different explanations commonly used to account for the phenomenon. These accounts can be summarised as follows: neglect results from damage to the attentional orienting system; alternatively, neglect is also attributed to the failure to construct a complete mental representation of contralesional space. The attentional theories of neglect suggest that patients fail to shift their attention to the left side of space and also have a tendency to automatically shift their attention to the right side of space. This reluctance to shift attention to the left, coupled with a strong tendency to orient attention to the right, results in the patient being unaware of left-sided stimuli. The representational view has received strong support from Italian workers who have demonstrated that neglect can occur for the left side of a mental image. Bisiach et al., (1979) demonstrated that neglect patients failed to report the left-sided differences of pairs of cloud-like patterns, when viewed behind a narrow central

slot. This presentation enabled the patients to view all of the pattern in central vision, but patients still failed to notice differences in the left sides of these patterns, which appears to provide strong support for the representational hypothesis. The status of these different hypotheses may become clearer as we look in detail at some of the chapters.

1.5 The book is made up of three sections entitled: 'What is neglect?'; 'The neuropsychological processes underlying neglect'; and 'The rehabilitation of neglect.'

1.6 The first section contains two chapters. The first by Halligan and Marshall provides a historical overview of neglect, while in the second Vallar has examined the 'anatomical basis of neglect in humans'. Vallar confirms that the posterior region of the inferior parietal lobe in the right hemisphere is the region most commonly associated with neglect. Cases of neglect have also been reported following damage to subcortical structures such as: the thalamus, the basal ganglia circuit and lesions to the white matter. Neglect following thalamic damage may be related to damage to the pulvinar, while basal ganglia damage could also involve damage to the substantia nigra. The parietal lobe, pulvinar region of the thalamus and basal ganglion are all interconnected. Vallar's interpretation is that neglect results from damage to these cortical and subcortical structures because they form part of a neural circuit which is involved in spatial representation and conscious awareness. Damage to selective parts of this circuit could have an influence on other structures which may help explain the distinctions between neglect for near and far space and the dissociable perceptual and motor aspects of neglect. Vallar has applied his knowledge of functional anatomy to support the representational view of neglect. However, as a proponent of the attentional view, I would suggest a different functional role of this circuit. The inferior parietal lobe, the posterior regions of the thalamus (pulvinar) and the substantia nigra (part of the basal ganglia circuit) are all structures that are involved in the production of fast eye movements (saccades). The parietal cortex receives input from the pulvinar and has efferent connections to the superior colliculus, one of whose functions is thought to be the translation of the sensory input into a motor output. Activity in the colliculus is subject to inhibition from, amongst other regions, the substantia nigra. Theories of how visual attention may be oriented have hypothesised a link between the neural systems involved in saccade generation (e.g. Rizzolatti et al., 1987; Shepherd et al., 1986). The argument is that a shift of visual attention may be performed by the same system that is required to program a saccadic eye movement. Damage to part of the system involved in producing a saccade would impair the patients' ability to shift their eyes and attention to the contralesional side of space. The lack of an attentional shift could then result in the failure of neglect patients becoming aware of the stimulus presented there.

1.7 The second part of the book, 'Neuropsychological processes underlying neglect,' contains ten chapters, covering both the attentional and representational theories of neglect. All of the chapters are good, but I will consider only a few of them. Kinsbourne's chapter reviews the development of his opponent processor model of neglect. Kinsbourne's model is based on the notion that the left hemisphere of the brain controls attentional shifts towards the right and the right hemisphere controls attentional shifts towards the left. The processes involved in producing the orienting responses are thought

to be reciprocally connected, which results in crossed inhibition. An active left hemisphere processor inhibits the right hemisphere processor and an active right hemisphere will inhibit the left. Damage to the right hemisphere will leave the left hemisphere orienting system 'over-activated' resulting in a tendency for neglect patients to bias their attention to the right. Indeed, neglect patients have been shown to make faster manual responses to visual stimuli presented further away from the fovea (further rightwards) than to stimuli presented near to the fovea. Kinsbourne's view is that the brain damage associated with neglect results in an attentional gradient present in both hemispheres, which results in attention being directed to the right regardless of the 'absolute location' of the stimulus. This idea is useful in explaining why neglect can occur for the left side of a stimulus presented briefly (tachistoscopically) entirely within the right hemifield. Kinsbourne's view of an attentional gradient biased to the right of the entire visual field is consistent with the performance of many patients who show a strong bias to attend to the right side of a stimulus wherever it appears in space.

1.8 The representational/attentional debate continues in the notable chapter by Rizzolatti and Berti. From the beginning they state that neglect can best be thought of as a disorder of 'spatial awareness.' Spatial awareness is thought to be derived from "joint activity of several cortical and subcortical areas, each of which has its own neural space representation." These areas are also involved in controlling motor responses, so damage to the representation would also result in impaired motor activity. Finally, they state that "attentional deficits which may accompany neglect are a secondary consequence of the lesion of space representations." Rizzolatti supports his argument first by reviewing models of attention and considering what the term 'attention' actually means. There is no one single accepted definition of attention. It has been regarded as a filtering process, as a spotlight to enhance perception and as a mechanism responsible for the selection of action. The spotlight view of attention is that it operates as a selection procedure to allow a stimulus to be identified and reach conscious awareness. Damage to the patient's ability to orient this spotlight impairs his or her conscious awareness of stimuli. Rizzolatti points out that according to this view the patient would have a lack of awareness of any type of stimulus in any part of space. A single attentional centre cannot account for the many dissociations shown in neglect. Rizzolatti also gives a good account of the 'selection for action' view of attention. According to this theory attention is seen as a modular function operating within several independent neural networks concerned with producing a motor response to a sensory stimulus. The facilitation of perception due to attentional mechanisms is accounted for by the activation of the relevant motor circuit. This is a most convincing model of attention. It fits with Rizzolatti's own pre-motor theory of attention (Rizzolatti et al., 1987) and also fits with recent work on patients with parietal lobe damage (Milner and Goodale, 1993).

1.9 Rizzolatti, however, proposes that activity in several brain centres forms a representation of space and is responsible for our conscious space awareness. Space is coded in a viewer-centred co-ordinate system, damage to this system results in neglect. The multiple spatial representations are also involved in the control of motor programmes. Any attentional deficit is thought to be a secondary consequence of damage to the representation involved in producing a motor response. Rizzolatti does not state

whether this representation of space is topographically organised in the same way that the primary visual cortex provides a retinotopic map of our visual fields. Although it is convenient to think of the brain as containing a topographical map of space, as this confirms our subjective impression of having a map of object spatial location, Stein (1992) has recently argued that our representation of external space cannot be topographically organised. Stein proposed that the role for the posterior parietal cortex is in forming part of a network concerned with transforming sensory inputs into motor coordinates; attention plays a part in mediating this transformation process. The multiple brain circuit approach advocated by Rizzolatti is useful in providing a way of explaining the dissociations shown in neglect (such as: neglect for near or far space, neglect for left sided objects or neglect for the left side of an object). This multiple spatial representational view is also very similar to the multiple attentional channels view already described. The important issue seems to be to determine what is necessary for the conscious awareness of stimuli; an intact representation of viewer centred space, or the attentional selection of a stimulus under the control of a spatial representation.

1.10 Some of the next chapters in the 'neuropsychological processes' section have taken into account the theories about normal visual functioning and related these to the findings from neglect. Like all good neuropsychology the implications from neglect are used to help model how the system may function in the intact brain. Farah's contribution takes into account the notion of parallel visual channels (WHAT and WHERE) thought to be responsible for object perception and spatial location. She examines the nature of the representation to which attention is allocated; i.e., is it allocated to an object centred representation, or to a spatial representation? Farah reviews the evidence to show that the impairment of attentional allocation in neglect can occur both in location-based and in object-based co-ordinates. She uses the example of 'neglect dyslexia' shown when patients make reading errors to the left side of single words. It has been demonstrated that neglect patients omit fewer left- sided letters from real words, than from non-words. In Farah's view this is not because the word's representation facilitates word recognition (top-down processing), but is due to attention being deployed on an object-based reference frame. The result is that attention is allocated further to the left of a real word than a non-word, which reduces left-sided letter omissions made to real words. Some support for this view comes from the finding that left-sided neglect is reduced in line bisection to a greater extent when a real word is above the line, than when a non-word is above the line. Farah holds that "attention operates on representations of spatial location," and also that "attention has considerable object knowledge." Farah's view of attention seems to be consistent with the 'zoom lens' metaphor often used to describe attentional deployment. There is, however, good evidence for attention being allocated in either object-based or spatial reference frames, and this is important for the view of distinct attentional modules needed for appropriate motor responses. The main weakness of this chapter is the lack of any discussion about what attention is.

1.11 The chapters by Humphreys and Riddoch and by Lynn Robertson and Eglin examine the performance of neglect patients on visual search tasks. Both of these chapters provide support for the attentional models of neglect. Humphreys and Riddoch emphasise in their model that attention is oriented on the basis of low-level features.

Once attention is oriented to a location, feedback into the separate object recognition system can enhance the processing of the object description. Robertson and Eglin show that neglect patients have three attentional deficits on visual search tasks: patients show a directional bias when scanning the right side of a display; they are generally impaired at searching anywhere in the display; and they also appear to have problems 'disengaging' attention from the right side to move attention into the left side of the display. The right-sided bias of attention shown in neglect may reflect a rightward attentional bias found in normals (cf. Kinsbourne).

1.12 The remaining chapters in this section consider the spatial dimensions of neglect (Ladavas), the reference frames involved in neglect (Werth), and neglect and visual language (Ellis, Young and Flude). Ellis et al. examine neglect-dyslexia reading errors, and the problems in spelling and writing shown by neglect patients. Along with a variety of neglect patients who make left-sided reading errors, they also review the findings from one intriguing patient, N.G., who when reading, writing and spelling made errors for the letters at the right end of the words. They also provide a good account of the implications that can be drawn from neglect for the language process. Neglect could affect the encoding of the low-level representation of the left-sided letters in a 'stimulus centred letter shape map.' The resulting (partial) representation activates the wrong entry in the orthographic lexicon, the structure that contains the memory representation of familiar words. N.G.'s performance suggests that the same disrupted representation may be involved in reading, spelling and writing. This chapter provides a good illustration of how we can learn more about the functioning of the cognitive system from the study of patients with neurological impairments.

1.13 The final chapter in this section is by Ian Robertson and highlights a further attentional deficit that may be important in neglect. Robertson argues that neglect results not only from an impairment in the orienting and disengagement of visual attention, but also from damage to an alerting or vigilance system which is located in the right hemisphere. This vigilance component is non spatial and plays a role in increasing the rate to which attention can respond to a stimuli. Damage to the right hemisphere would cause low levels of vigilance that would result in profound and sustained left-sided neglect. Patients with left hemisphere damage typically show a quick recovery from signs of right neglect. According to Robertson the left brain damage leaves the vigilance component intact enabling them to learn to compensate from their deficits of attentional orienting and disengagement.

1.14 The third section of the book contains two chapters on the rehabilitation of neglect (Ian Robertson, Halligan and Marshall; Diller and Riley). Robertson et al. considers the study of rehabilitation to be important in providing informative practical and theoretical insights into the condition. Studies that have tried to train neglect patients to scan the left side have had rather limited success in reducing the patients neglect. Two techniques have been shown to reduce neglect; namely, activation of the affected limb in the neglected hemisphere and vestibular stimulation by the injection of iced water into the left ear. The effectiveness of voluntary limb activation supports the view that neglect could be caused by an impairment from modular circuits involved in programming motor

actions. The mechanism behind vestibular stimulation is less clear. Theories of attentional orienting have suggested a link between the neural systems involved in shifting the eyes and those involved in shifting attention. The vestibular system is linked to the eye movement system, so vestibular stimulation may perhaps induce an attentional shift via this mechanism.

1.15 As an overview I find that this book is extremely informative and provides excellent discussions of the theories of visual neglect and also reflects on the implications for models of normal cognitive functioning. One criticism is the frequent use of the term 'attention' without stating exactly what the author means by the term. At times, attention becomes like an all-encompassing homunculus that guides our perceptions and actions and leads to conscious awareness. It is described as a spotlight, or zoom lens, that can be oriented and moved around, thus facilitating our perception of stimuli. Attention is also used to solve the problem of how activity in columns of single cells can be combined to form a representation of a single object when more than one object is present at nearby retinal locations (the 'binding problem'). Attention may also be involved in programming motor responses depending on the stimulus and the required motor output. A quote from Allport (1993) illustrates the difficulties associated with the term: "there can be no simple 'theory of attention', any more than there can be a simple 'theory of thought'. A humbler but also more ambitious task will be to characterise, in cognitive neurobiological terms, as much as is possible of this diversity of attentional functions." In the last chapter Marshall, Halligan and Ian Robertson consider this problem and argue that there is no single entity of neglect and that there could be whole range of attentional and representational deficits hiding behind this term. They emphasise the modular approach to the study of selective attention, and the need to further fractionate the neglect syndrome in terms of information processing models of spatial cognition. This book provides an informative review of the issues involved in the study of visual neglect, while acknowledging that, as in the case of blindsight, some of the most interesting questions still remain to be answered.

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Appendix 1

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