

UNILATERAL NEGLECT: LEARNING ABOUT IT, LEARNING FROM IT

Review of *The Cognitive and Neural Bases of Spatial Neglect* by Hans-Otto Karnath, David Milner and Giuseppe Vallar, ISBN 0-19-850833-6, Oxford: Oxford University Press, 2002, 416 pages, Price: U.K. £ 69.95; U.S. \$ 115.00.

Agnosia is a disorder of object recognition, aphasia is a disorder of language, apraxia is a disorder of motor planning, and amnesia is a disorder of memory. But what faculty is disrupted in unilateral neglect? Despite more than 30 years of intensive research (and some earlier work too), and despite the fact that neglect is far from being exotic on neurological wards, this question is not even close to resolution. In fact, it seems that this vagueness about the domain of unilateral neglect is one of the reasons that neglect is such a mind-boggling phenomenon. It is also the reason why it has attracted the interest of researchers and thinkers of so many disciplines. Is neglect a disorder of perception? Is it a disorder of spatial processing and representation? Is it a disorder of attention or perhaps of motor planning? Or is it a disorder of conscious awareness itself? It seems that neglect can tell us something and constrain the way we think about each one of these domains.

The book edited by Karnath, Milner, and Vallar reflects this multifaceted nature of neglect. Mostly, the chapters move along the two major lines of theoretical orientation – one discussing neglect as a disruption of attention mechanisms, and the other discussing neglect as a disorder of spatial representation. It is interesting to see how seemingly the same regions, especially in and around the intraparietal sulcus, can be described either as dealing with visuo-spatial/spatio-motor processing (e.g., chapters by Galletti and Fattori; Berti and Rizzolatti) or as being part of different attentional networks (Corbetta et al, Giesbrecht and Mangun), even when “objective” physiological measurements are considered. One of the main questions to us is whether these are simply two ways of describing the same system, or are there really two independent, or at least partially independent, systems at work that are perhaps mere anatomical neighbors.

The volume includes an excellent collection of chapters about many of the topics that are at the center of research related to unilateral neglect today. The chapters are dense, and seem to be directed to those deeply involved in the field. Several of the chapters report recent findings, and suggest new approaches. Although different readers may expect more of some topics and less of others, the book seems to balance chapters where neglect is a starting point for research into human/primate normal cognitive neuroscience (i.e., what we can learn *from* neglect) and those in which the focus is further exploration of the pathogenesis, phenomenology and

rehabilitation of neglect (i.e., what we have learned *about* neglect). In many chapters, both of these themes are reflected, a good example of the interplay between basic and clinical science in cognitive neuroscience.

The book is divided into 7 sections: Historical Introduction, Neural Bases of Neglect, Frameworks of Neglect, Perceptual and Motor Factors, Relation of Neglect to Attention, Cognitive Processes in Neglect, and Rehabilitation of Patients with Neglect. We will not attempt to comment on all 27 chapters, all written by authorities in their respected fields. Rather, the following is a somewhat arbitrary selection of reflections highlighting connections between chapters and suggesting emerging questions.

The book starts with a chapter by Heilman, Watson and Valestein, who provide a list of almost every hypothesis about the cognitive underpinning of neglect ever proposed in about 20 pages, a rather substantial accomplishment. For each major division of theories (attention, spatial representation, motor) they also provide a relatively detailed description of the anatomy and physiology of the relevant system. A big merit of the chapter is that for most theories it describes briefly but clearly the major experimental paradigm that gave rise to the theory. Almost too dense for most audiences, the chapter will be an excellent starting point for further reading, especially as it is assisted by eight pages of references. It is somewhat disappointing that having described so many hypothetical mechanisms of neglect, that Heilman et al. stop short of suggesting any integration or evaluation of what they believe to be the most important of the 12-13 different mechanisms to understanding the neglect syndrome. Are they all equally valid? Coming back to the question we asked above, if a patient's behavior can be accounted for by several hypothetical mechanisms, is it because several mechanisms are at play, or are these (and which ones) simply alternative descriptions of the same phenomenon?

A theme that emerges from several chapters is the realization that space is represented in the brain several times, both anatomically and functionally. This is overtly stressed in the updated formulation of Mesulam's network model of spatial attention, and in the chapter by Berti and Rizzolatti based on monkey and human data (where spaces are mainly described in term of effectors, like eye movements or reaching), as well as in the chapters discussing different coordinate systems in which neglect is or is

not displayed (far and near space, egocentric and object based, 'ventral/dorsal'; Behrmann and Geng, Ladavas; Milner and McIntosh). Although seeds of this conceptualization are seen in two previous volumes concerning neglect (Jeannerod, 1987; Robertson and Marshall, 1993), it looks like this shift from monolithic 'spatial representation' to a fractionation of many spaces has become well rooted over the last decade or so. However, once we accept this deconstructive approach, we should start thinking about how the different spaces are merged to create what seems subjectively as one smooth, unitary space in which we act. Is it an illusion of our conscious state that shifts ignorantly from one spatial framework to another, or is there some central hub where all spatial frameworks are coordinated (see Robertson, 2004).

Berti and Rizzolatti also argue that perceptual spatial maps are derived from motor interactions with the environment using different effectors. However, this raises many questions: 1. Primary visual cortex is not a motor area but appears to have its spatial map much before we have adequate movement to perfect this map 2. If the perceptual map (of far space) is derived from the motor map, why do they produce double dissociations (e.g., neglect of far and near space)? Single dissociations would be expected. 3. Wouldn't it be more prudent to say that there are spaces that were derived from sensory-motor interactions through development but other spaces that were derived through spatial relations that are purely perceptual? Although intuitively appealing it is premature to conclude that all of space is derived from our history of movements. Our history of perceiving may be just as important.

In addition to discussing different frameworks and different circuits of space representation, a major part of the book is devoted to space distortion, or anisometry. The discussion here is built mostly on data from line bisection tasks and their derivatives. It is quite amazing to see how many variations of one extremely simple test can be envisioned, and what insightful observations can be derived from it (see chapters by Bisiach, Neppi-Mòdona and Ricci; Milner and McIntosh; Chatterjee; Ishiai; Doricchi; Vallar and Daini). Major findings that stimulated this notion of anisometry over the last decade were that patients, given the ipsilesional half of a line or gap, overextend it to the left (Bisiach et al., 1996), and that they judge contralesional horizontal lines as being smaller than lines on the ipsilesional side (Harvey and Milner, 1995). These findings are revisited and extended in the present chapters. The explanatory framework for spatial distortion is diverse, mainly divided between oculomotor explanations (i.e., reduced contralesional scanning, Milner and McIntosh; Ishiai) and distortion of space representation (Bisiach et al.; Chatterjee), and unfortunately clear conclusions cannot be made yet. In fact, Doricchi in his chapter makes the case that

anisometry of the type described by Bisiach requires concomitant visual field deficits, questioning perhaps the centrality of anisometry to neglect *per se*. Still, despite the lack of a bottom line, this assortment of chapters presents an exciting exposition of a research field in action. One point which could be more directly addressed in these chapters (especially those who don't adhere to scanning deficit explanations) is why spatial distortions in principle should lead to lack of awareness (e.g., in cancellation tasks, or more importantly, in activities of daily living).

An important direction is presented in the chapters by Marzi, Natale and Anderson, and by Niemeier and Karnath. In both, an attempt is made to quantitatively describe the performance of patients across space, using 'saliency' coding. Marzi et al. try to apply the mathematical model of Anderson (1996) to reaction time data for a detection task along the horizontal meridian with some but only partial success. Niemeier and Karnath describe a new model in which both egocentric and object centered frameworks play a role. Most probably, both models will undergo modifications as more data are accumulated. Nevertheless, the attempt to quantify behavior and create clearly specified models at the very least provides precise predictions against which results can be compared. A question which is left open is the meaning of the term 'saliency'. Are salient items those that contain more stimulus energy, those that attract attention, those that pop out, those that increase neural firing, or what exactly? How can saliency be defined *a priori*? This seems like an especially problematic issue when thinking about neglect, a condition in which stimuli on one side are no longer detected but can continue to produce implicit effects. Does this link saliency to perceptual awareness, and if so does the term become entirely circular: Features that are salient are those that are seen first or strongest and features that are seen first or strongest are features that are salient?

Berti discusses implicit processing in neglect, and this issue is also present in several other chapters. It is well documented and seems accepted now that a great deal of processing is achieved for neglected stimuli. Perhaps it is time now to ask more detailed questions about these implicit representations. Berti's chapter seems to show that implicit representations contain 3D structure in tactile perception, but is this true for vision too? Are features bound properly in implicit processing (e.g., color, form, orientation)? How much detail is present? How many objects can be individuated in implicit space? Most critically, why are the spaces that support implicit effects not sufficient for awareness? Are there spaces that are necessary for awareness and in turn can there be awareness without space? (cf. Deouell, 2002)

Halligan and Marshall keep their tradition of steering the field with thought provoking questions

(cf. (Halligan and Marshall, 1992). They raise the question of whether so-called 'primary' deficits can really be dissociated from 'higher-level' deficits of cognition. They point out that in clinical practice, disorders such as visual field defects (VFD) and neglect are dissociated mostly by the tasks used to define them, as in principle they both result in the same symptom – failure to report contralesional stimuli. The ironic part is that traditionally the field was concerned with showing that neglect is not a result of primary sensory loss, and now Halligan and Marshall question whether VFD is not in fact confluent with the neglect. They convincingly argue that task demands of the tests used to assess 'primary' vision, like confrontation or perimetry are likely affected by higher-order attentional dysfunction, which is traditionally in the realm of neglect. Hence, regions of VFD as defined by these tests can just as likely be a manifestation of an attentional disorder as a manifestation of genuine primary visual disorder. Most convincing is the epidemiological finding, attributed to Sterzi et al. (1993), that patients with right hemisphere damage show a significantly higher incidence of VFD diagnosis relative to those with left hemisphere damage. The fact that neglect can masquerade as part of a VFD is a very common diagnostic challenge in everyday clinical settings, and most clinicians are by now aware of this (or should be). Some manipulations can be used to assess whether the apparent field cut is retinotopic or spatial (e.g., the technique developed by Kooistra and Heilman, 1989, and the degree to which attentional manipulations can help to overcome a field cut). In some cases, the lesion location (e.g., PCA infarct) can help establish damage to primary cortex or optic radiation, emphasizing sensory loss over attention. However, Halligan and Marshall's point seems more than a warning against an erroneous diagnosis. It questions the validity of the distinction between bottom-up and top-down processes in an era in which we know that these 'streams' co-exist in almost every cortical level. This is reminiscent of the shift from the 'apperceptive' vs. 'associative' agnosias to a less dichotomous view as it became apparent that the seemingly associative agnosics were not normal in all perceptual tasks.

A chapter by Mattingley gives an interesting review of several issues regarding extinction. In one of the rare references to non-visual symptoms in this book, cross-modal effects are briefly discussed. Considering the interest over the last few years in multisensory processing and cross-modal effects in healthy subjects and in patients, we would like to have seen more extensive discussion of these findings, maybe a separate chapter or at least a more comprehensive list of references. For example, auditory-visual cross modal effects are not mentioned (cf., Frassinetti et al., 2002). Mattingley also presents intriguing results on motor extinction, a seldom studied effect in which actions by the

contralesional hands is impaired during bimanual tasks. Rarely tested, it would be interesting to see if this effect is ubiquitous among patients, and whether it has distinct anatomical correlates. Mattingley also discusses temporal effects in extinction, a refreshing note given the emphasis on space throughout the rest of the chapters. Specifically, the 'prior entry' phenomenon is discussed, where patients judge left and right sided stimuli as occurring simultaneously only when the right stimulus is delayed. Mattingley notes the apparent paradox in the fact that patients are still worse at detecting left stimuli which are objectively simultaneous with right sided stimuli (and therefore subjectively non-synchronous, Pellegrino et al., 1997; Baylis et al., 2002). This paradox will undoubtedly be a source for further research and theoretical development. Is it a result of different task demands or is it that the prior entry phenomenon pertains to conscious timing of the stimuli, whereas extinction involves biased competition at a pre-conscious level?

Interestingly, several chapters later, Riddoch and Humphreys describe a patient (G.K., a long studied patient with bilateral posterior lesions) who detects contralesional stimuli better with bilateral simultaneous stimulation than on unilateral trials, an odd phenomenon described once before (Goodrich and Ward, 1997) and nicknamed 'anti-extinction'. The existence of anti-extinction is a critical phenomenon in the debate about whether extinction and neglect can be doubly dissociated. While extinction without neglect is common, it is unclear whether 'neglect without extinction' exists. All of the previous reports of such a situation were based on different tests for neglect and for extinction, and thus left the question open: is it possible for a patient to detect a contralesional stimulus better when accompanied by an ipsilesional stimulus (i.e., to have neglect without extinction)? Goodrich and Ward's case suggested that this is possible. Riddoch and Humphreys' data from patient GK suggest that this seemingly counter-intuitive phenomenon exists only under specific conditions of very short stimulus exposure times. The reason for this discrepancy deserves further research, especially if it is found that under these conditions anti-extinction is a common phenomenon. This finding also raises again the question of whether a double dissociation can be established between neglect and extinction *across* patients, supporting functional independence.

An important part of the book, which was largely missing in previous volumes about neglect (for obvious reasons), are the 2 chapters that discuss functional neuroimaging of attention systems in the human brain (Corbetta, Kincade and Shulman; Giesbrecht and Mangun). Corbetta et al., who in recent years explored brain activity in several attention cueing paradigms, summarize their data in a new model of attention control. Contrary to the anterior-posterior attentional systems suggested by Posner and colleagues based mainly on lesion data,

Corbetta et al., suggest a dorsal parieto-frontal network involved in stimulus and response selection (akin perhaps to Posner's anterior attentional system's role) and a more ventral inferior parietal - inferior frontal system involved in sensory driven reorienting (more akin to Posner's posterior system). Corbetta et al., suggest that the latter system may be the culprit in neglect, both because it is right hemisphere dominant, and because most lesion studies of neglect point to the TPJ/IPL region as critical for disengaging spatial attention. Corbetta et al.'s model is a welcome attempt to resolve disagreements between some neuroimaging data and the anatomy of lesions in neglect. However, the last point will remain tenuous until the issue of the critical lesion site(s) in neglect is clarified. It is a bit unfortunate that the book does not have a chapter (or more) discussing this issue of the anatomical bases of neglect based on lesion studies. This became a hot topic since the papers of Karnath et al. (2001) and Mort et al. (2003) have indicated the critical site as the superior temporal lobe or the angular gyrus respectively.

Two updated reviews of neglect rehabilitation end the book. Both chapters show the eagerness to achieve more effective, evidence-based rehabilitation methods, with promising recent results. However, both reveal that much work remains to be done. Especially in view of the variety of deficits described in other chapters of this book, it will be pertinent to find out what deficits are central to the disabilities of the patients and therefore mandate intensive rehabilitation, and which are not.

Although the book is fairly comprehensive, there are gaps. For instance, it lacks any detailed discussion of non-visual neglect. There are only hints to the fact that both neglect and extinction can be frequently found in other modalities. Auditory neglect, for example, has found renewed interest among scientific investigations of neglect (see Pavani et al., 2003 for recent review). A more direct discussion of the neural correlates of conscious awareness would have also made this volume more complete. This field has developed exponentially over the last few years, and neglect/extinction phenomena are frequently used as examples in this field (see for example Metzinger, 2000 and Dehaene and Naccache, 2001) We should not forget that it is this perplexing lack of awareness of information in contralesional space that made neglect such an intriguing phenomenon to study in the first place.

To conclude, this book is a highly recommended resource for anyone in the field of

cognitive neuroscience investigating neglect or related topics (attention, spatial processing, awareness). It provides an overview from leaders in the field of the current state of knowledge and the major controversies that arise from this strange but intriguing neuropsychological syndrome.

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