Object-Centered Visual Neglect, or Relative Egocentric Neglect?

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There has been much recent interest in the spatial frame(s)-of-reference that may influence visual neglect after brain injury (Pouget & Driver, 1999; Bisiach, 1996; Driver, Baylis, Goodrich, & Rafal, 1994). In principle, a patient with left neglect after right-hemisphere damage might neglect information towards the left of their retina, towards the left of their head, or their body (Moscovitch & Behrmann, 1994; Karnath, Christ, & Hartje, 1993; Vallar, Guariglia, Nico, & Bisiach, 1993; Farah, Brunn, Wong, Wallace, & Carpenter, 1990; Ladavas, 1987; Bisiach, Capitani, & Porta, 1985), and so on. Neglect operating relative to some part(s) or other of the patient has been termed *egocentric* neglect. Recent research has contrasted such egocentric deficits with a form of neglect that initially seems to be more ''allocentric,'' applying to one side of individual objects (Tipper & Behrmann, 1996; Behrmann & Moscovitch, 1994; Arguin & Bub, 1993; Driver & Halligan, 1991; Caramazza & Hillis, 1990). For instance, several studies have now found that patients may neglect the left side of an object (or figure, or perceptual group) whether or not it appears in the left or right hemifield with respect to the patient's eyes, head, and body (e.g., Humphreys, Olson, Romani, & Riddoch, 1996; Walker, 1995; Halligan & Marshall, 1994; Arguin & Bub, 1993; Young, Hellawell, & Welsh, 1992; Driver & Halligan, 1991; Driver, Baylis, & Rafal, 1992; Rapcsak, Varfaelli, Fleet, & Heilman, 1989). Such findings have often been interpreted (e.g., see Vallar, 1998) as indicating ''allocentric object-centered'' neglect, as opposed to neglect within egocentric representations of space. A recent study by Pavlovskaya, Glass, Soroker, Blum, and Grosswasser (1997) made strong new claims in this respect. Here, we argue that their data, and, likewise, many previous reports of putatively ''object-centered'' neglect, can actually be explained in purely egocentric terms, provided that *relative* egocentric position matters in addition to absolute egocentric position (Driver, 1998; Pouget & Sejnowski, 1997; Driver et al., 1994).

The reason for this is illustrated in Figure 1. Figure 1A represents the popular notion of an egocentric gradient of impairment in neglect following right-parietal injury (Pouget & Sejnowski, 1997; Anderson, 1996; Driver et al., 1994; Mozer & Behrmann, 1990; Kinsbourne, 1987). The neural response to stimuli is increasingly impaired toward the patient's egocentric left. Figure 1A represents this by a decreasing number of parietal cells in the lesioned system for positions toward the retinal left, in accordance with neurophysiological data on the distribution of receptive fields between the hemispheres (see Pouget & Sejnowski, 1997). However, the general points made below would still hold if the graded deficit affected leftward positions relative to the head or body (i.e., within other egocentric coordinates), as well as on the retina; and hold regardless of the exact shape of the depicted function, provided that it declines monotonically towards the egocentric left. Figure 1B illustrates the hypothetical response strength for different lateral regions of a schematic object, shown in either the left or right egocentric hemispace, given the pathological gradient shown in Figure 1A. Note that while the overall level of response is lower for the left visual field, the left side of the object still induces a weaker response than the right side of the object within both fields. This alone is sufficient to explain many reports of putatively ''object-centered'' neglect, within purely egocentric terms, without the need to postulate specifically object-centered representations. Neglect for the retinally left side of an object within either visual field might, thus, more properly be called ''relative egocentric neglect,'' rather than truly ''object-centered neglect.'' The results from a few studies (e.g., Driver et al., 1992) do require that the affected visual object gets segmented from its background before the graded impairment applies. Nevertheless, the latter impairment, which causes the neglect, would still be entirely egocentric; that is, the side of the segmented object that is further to the patient's left is the side that suffers.

Pavlovskaya et al. (1997) claim to have obtained new evidence for truly object-centered, ''allocentric'' visual neglect. They suggest that in cases with left neglect of this kind, the patient should be better at recognizing objects when forced to allocate attention to the left side of each object. To test this, they attempted to hold attention at a constant egocentric position (where a central fixation point appeared) while manipulating

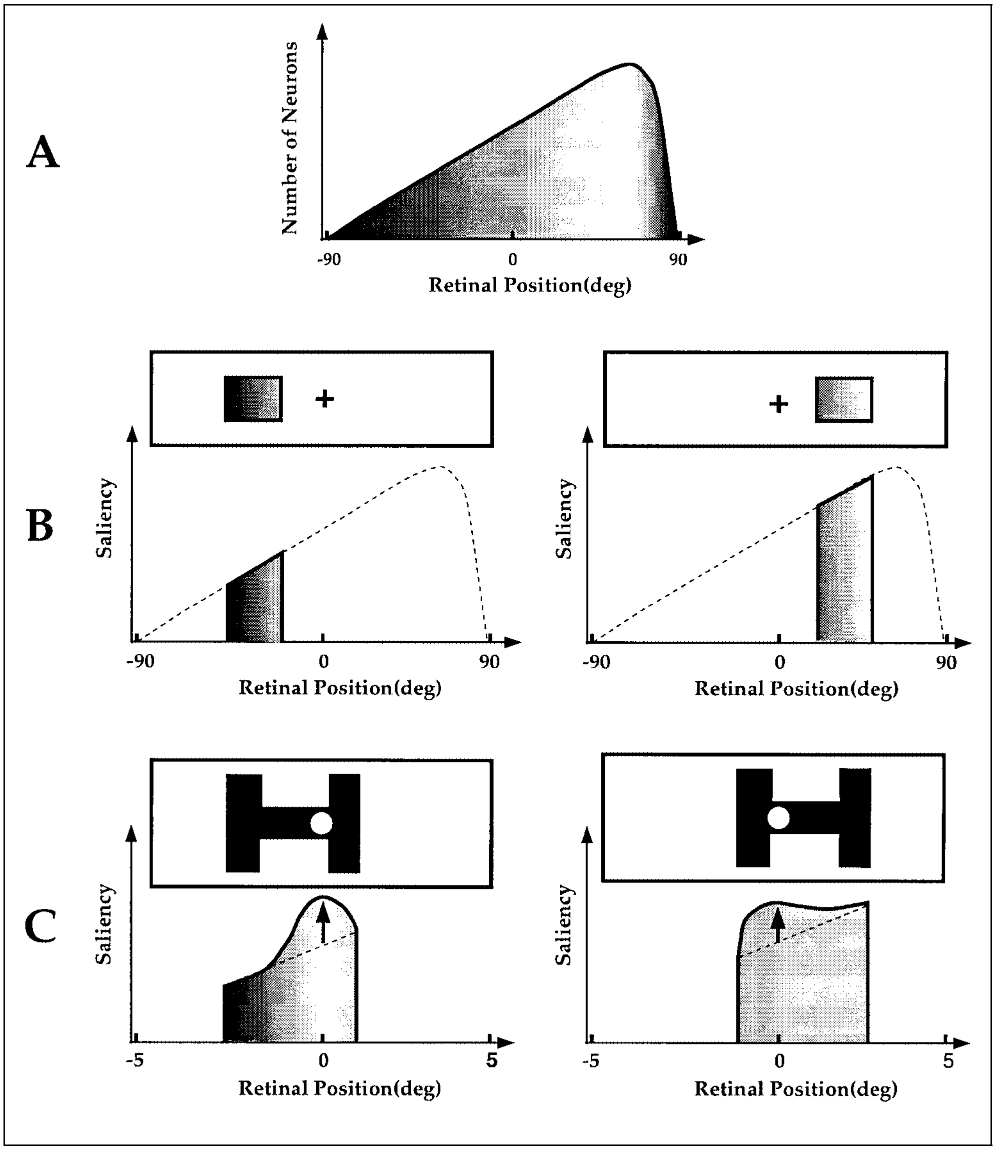

Figure 1. (A) Illustration of a hypothetical gradient of egocentric impairment in neglect. After a right-parietal lesion, the number of neurons representing each position follows a monotonic gradient, which increases from left to right (across the retina in this example). (B) The solid bars in each graph depict the saliency profile, corresponding to the number of activated neurons as derived from A, for different lateral positions across a schematic object when appearing in the left visual field (left graph) or right visual field (right graph). Although the absolute level of activity is lower when the object is in the left vs. right visual field, in both cases the left side of the object receives a weaker response than its right side, due to the gradient across the retina (dotted line). The insets illustrate the positioning of the schematized object relative to fixation (shown by a cross), and the shading across the object conveys the differential saliency across its lateral extent. (C) Illustration that the Pavloskaya et al. (1997) finding can also be explained in terms of an egocentric gradient. The left graph represents the situation when attention/fixation is directed to the right of the character (as indicated by the white circle within the inset shown above it), so that more of the character falls in the left visual field; the right graph represents the converse situation (see inset). The dotted line in each graph represents the saliency profile that the object would have ordinarily received in the patient; the solid line immediately above it shows how the manipulation of attention/fixation provides a boost in salience (marked by an arrow) to the attended side. Note that attending to the right side of the character (left graph) exaggerates the greater saliency of right versus left side (thus producing more neglect), while attending to its left (right graph) reduces the pathological gradient (reducing neglect). In Pavlovskaya et al.'s actual experiment, the direction of attention within each character was confounded with the locus of fixation. Hence, further accounts in terms of purely retinal neglect are also possible without requiring an attentional boost (see text).

whether this position corresponded to the center, left, or right of a small character, which had to be identified. Thus, the character was translated laterally from trial to trial by small amounts (up to 1.5°) in egocentric space (retinally, etc.), with the intention that a slight shift of the object to the right of the fixation point would direct attention to the left side of the object, and vice versa (see insets in Figure 1C). One unfortunate aspect of this methodology is that the direction of attention is confounded with fixation, and, thus, with retinal factors. The results showed that placing the fixation point at the luminance centroid of the character was optimal for normal observers. By contrast, directing attention/fixation further to the left side of the character was beneficial for two left-neglect patients.

Contrary to Pavlovskaya et al.'s conclusions, these new results can be explained in purely egocentric terms, simply by combining the graded impairment illustrated in Figure 1A and B, with the standard idea that attending/fixating a particular region will boost its representation. This will lead to the pathological egocentric left–right gradient being exaggerated when the patients attend/fixate towards the right of an object (thus, worsening neglect), and being reduced when they attend/fixate its left (thus, lessening neglect; see Figure 1C). Pavalovskaya et al.'s patient results can thus

be explained without invoking "object-centered" representations at all.

Moreover, these results could still be explained by an egocentric gradient even if one discounted the highly plausible attention/fixation boost illustrated in Figure 1C. All that would be required is for the gradient of impairment to get steeper as one moves further to the retinal left, in keeping with several previous suggestions (e.g. Kinsbourne, 1993). Given an accelerated gradient (rather than the strictly linear fall-off that was depicted for simplicity in Figure 1A), a greater imbalance in the neural response for the left versus right side of an object (and, thus, more neglect) would be found when fixating the object's right rather than left (just as Pavlovskaya et al. found), simply because this manipulation would shift the entire object further to the retinal left, and, thus, into the steeper portion of the egocentric gradient.

Given the small size of the characters (2–3°) and displacements (up to 1.5°) that Pavlovskaya et al. used, this particular account in terms of an accelerated pathological gradient would require fairly rapid changes in that gradient over a small extent of retinal space, near the fovea. Indeed, one of the most intriguing aspects of Pavlovskaya et al.'s study is that fairly small changes in the direction of fixation/attention produced a reliable influence on neglect. This may in part be due to cortical magnification around the fovea, but could potentially involve some normalization of size for the attended object as well (so that the gradient would get scaled to apply to the current object, rather than to the entire retina). Note, however, that even on such a normalization account, the pathological gradient itself would still be purely egocentric. Moreover, while the existence of severe neglect within even quite small objects has received insufficient emphasis in recent theorizing, it is familiar clinically, and has been shown experimentally before (e.g., Driver et al., 1994). This aspect of the neglect syndrome may involve the bias towards fine local details, which is a known consequence of damage to the right-temporo-parietal junction (Robertson, Lamb, & Knight, 1988), an area involved in most of the extensive lesions that typically produce neglect.

The main purpose of our commentary has been to show that numerous previous findings which have been taken to demonstrate "object-centered" representations in neglect (e.g., Vallar, 1998; Humphreys et al., 1996; Walker, 1995; Halligan & Marshall, 1994; Arguin & Bub, 1993; Young et al., 1992; Driver & Halligan, 1991; Driver et al., 1992), plus Pavlovskaya et al.'s new findings on this issue, can, in fact, all be readily explained by egocentric neglect. Indeed, the model depicted schematically in Figure 1 illustrates that these results might all be due to neglect arising for information that is leftwards in retinal terms, once it is appreciated that *relative* retinal position can matter as much as absolute retinal location (Driver, 1998; Pouget & Sejnowski, 1997; Driver et al., 1994; Kinsbourne, 1993). While truly object-centered representations may exist, they certainly cannot be revealed merely by comparing performance for stimuli presented at different lateral positions on the retina in neglect patients (for some of the further manipulations that are required, see Tipper & Behrmann, 1996; Behrmann & Moscovitch, 1994; Driver et al., 1994; Driver, 1998; Caramazza & Hillis, 1990; Farah et al., 1990; and for related neurophysiological studies, see Breznen, Sabes, & Andersen, 1998; Gettner & Olson, 1998). Hence, Pavlovskaya et al.'s neglect findings emphatically do not support their conclusion that an "object-centered" coordinate-frame ascribes "intrinsic handedness" to objects (cf. their p. 829). Essentially, their patient data show only that those parts of a character that are further to the retinal left than other parts will tend to be neglected. All that is surprising about this is the very small scale over which it can arise. The Pavlovskaya et al. study, as with many previous examples of so-called "object-centered" neglect, actually suggests egocentric neglect of relative rather than absolute form; it certainly does not demonstrate an allocentric form of neglect.

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