

## Near and Far Visual Space in Unilateral Neglect

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A 24-year-old right-handed woman with a right temporal hematoma showed marked left visual neglect for far but not near space in a variety of tasks systematically given in near and far distance conditions. This case thus provides the dissociation opposite to Halligan and Marshall's patient, who had neglect for near but not far space after a right parietal stroke. Furthermore, although she made rightward errors in bisecting far-distant lines, our patient made smaller opposite leftward errors for near-distant lines. The evidence that unilateral neglect of far and near visual space may exist independently supports a division in the neural systems subserving attention to different compartments of the extrapersonal space in humans.

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Unilateral neglect is not a unitary disorder and can dissociate depending on the modality,<sup>1</sup> the perceptual and motor requirements of the tasks,<sup>2</sup> or the spatial frame of reference.<sup>3</sup> Likewise, space is not a unitary structure but a three-dimensional construct, and visual exploration requires directing attention to different locations at various distances in depth.<sup>4</sup> Whereas studies in monkeys<sup>5,6</sup> suggested a distinct organization of attentional mechanisms for near and far space, the principal evidence for a similar division in humans has been the patient recently reported on by Halligan and Marshall,<sup>7</sup> who showed left neglect for near but not for far visual space after a right parietal stroke. Other studies of patients with neglect failed to find a comparable dissociation.<sup>8,9</sup> Therefore, the inverse dissociation after a different lesion would convincingly support the claim of distinct representations for far and near space in humans. Moreover, because all the previous studies used only one type of task, one could question whether any dissociation would hold across different tasks.

We describe here a patient whose left visual neglect was prominent for far (extrapersonal) space but virtu-

ally absent for near (peripersonal and personal) space. Her performance in a series of identical tasks was systematically compared in near-distant and far-distant conditions.

### Patient and Methods

#### Patient

A 24-year-old right-handed woman developed sudden headaches with left hemianopia and severe left spatial inattention. Brain magnetic resonance imaging showed a right temporo-occipital hematoma in the depth of the gyri occipitotemporalis medialis and lateralis, anterior to the calcarine sulcus (Fig 1). Arteriography revealed an arteriovenous malformation just anterior to the calcarine sulcus that was surgically removed 10 days later without complication. The initially marked left inattention rapidly improved. Postoperative ophthalmologic examination showed a complete left homonymous hemianopia with macular sparing (on a standard Goldmann perimetry) and normal visual acuity. There was no other neurological deficit. The patient was oriented and cooperative. A mild prosopagnosia was the only cognitive impairment found on a detailed neuropsychological assessment (recognition of famous faces, 5/24 correct; face matching on Benton test within normal range). She complained of a disturbance in perceiving depth and distances in space. Left spatial neglect was observed for far but not near environment in her daily life (eg, problems in finding left-sided doors in the hospital but not in eating from her plate or reading from a book).<sup>10</sup> There was no extinction on auditory or tactile bilateral stimulation, no unilateral motor neglect in bimanual tasks, and no personal neglect (ie, she could touch left-sided parts of her body with her right hand and eyes closed).<sup>11</sup>

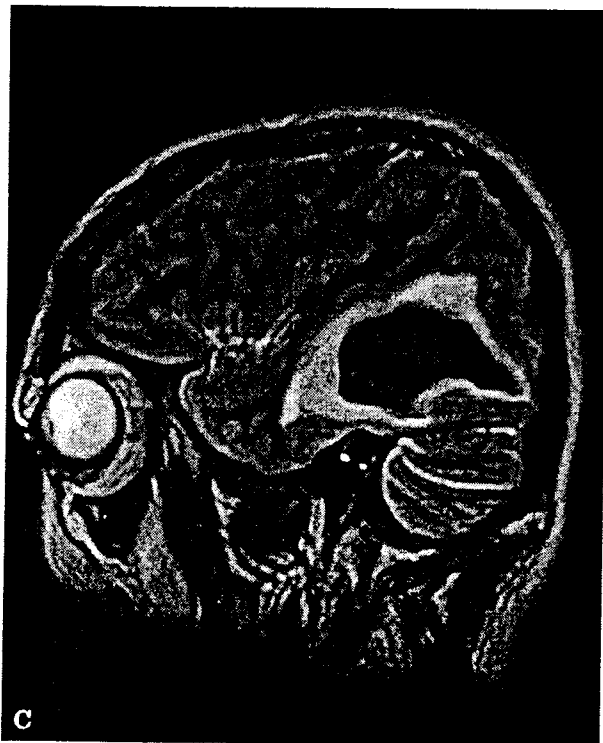
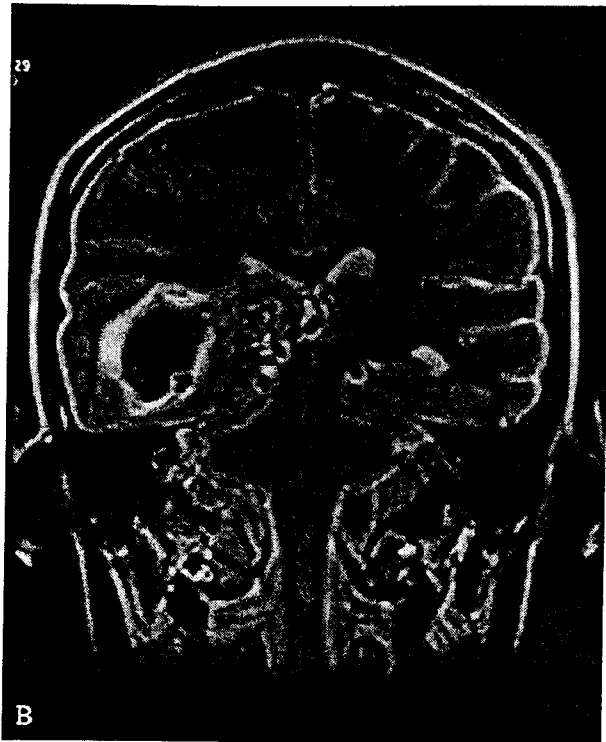
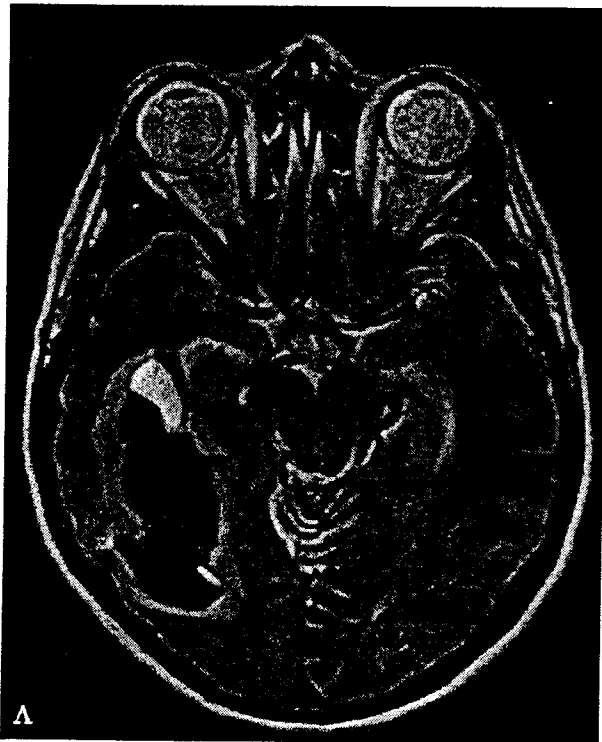
#### Methods

Six different neglect tasks were systematically given both in near space (NS) and far space (FS) (Table). NS tasks were presented in standard paper-and-pencil conditions using 29 × 21-cm white sheets placed on a desk about 35 cm in front of the patient. FS tasks were presented on a 2.5 × 2.0-m white screen placed about 3.5 m in front of the patient with its center approximately at eye level. FS tasks used exactly the same material as NS tasks, which was reproduced on transparent film copies to be projected on the screen. The magnitude of increase in the stimuli real size was approximately 10, keeping the visual angle of stimuli in FS the same as in NS. In tasks that required manual responses the patient used a pencil in NS condition and a laser pointer in FS condition. Only the right hand was used. For tasks given in FS, the examiner copied the patient's responses directly on the projected transparent film as indicated with the laser pointer, so that she could monitor her performance in NS and FS identically. In this way, differences in performance between the two conditions could not be accounted for by different visual feedback from the display.<sup>12</sup> To control for any effects of learning, the tasks were alternated in pseudo-random order, and FS and NS conditions within one task never followed one another. Furthermore, tasks 1 (star cancellation), 2 (letter cancellation), and 3 (line bisection) were given in an ABA design (FS-NS-FS). No task was time constrained. All investigations took place in a single session 22 days after stroke.

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*Fig 1. Brain magnetic resonance imaging was performed on the second day after stroke. Axial (A), coronal (B), and sagittal (C) T2-weighted images show a large hematoma involving the right temporal lobe and an arteriovenous malformation centered in the region of the medial and inferior temporo-occipital junction, anterior to the calcarine region. The hematoma extended to the posterior parahippocampal gyrus on the mesial portion of the temporal lobe. The posterior thalamus and the tectum of the mesencephalon were not involved.*

## Results

A marked left neglect was observed for far but not near visual space in all tasks (see Table). In both cancellation tasks, omissions of left-sided targets were approximately 10 times as many in FS as in NS (all  $p < 0.0005$  on first and second testing, Fisher's exact test). Her performance in FS also deteriorated in comparison with NS for central and right-sided targets, the far-to-

near ratio of omissions being however only twice. In NS, there was no left-right difference in the number of omissions. There was no difference between the first and the second testing on letter cancellation, thus ruling out a "learning" effect. On star cancellation, the right/left difference decreased in the second testing but the FS performance remained significantly poorer than in NS ( $p < 0.003$ ). Similar results were found when

Table. Comparison of Neglect Tasks in Far and Near Space

Tasks	Conditions		
	Near Space	Far Space	
		First Test	Second Test
Letter cancellation			
Total correct	51/56	15/56	22/56
Left-side targets	19/21	2/21	2/21
Central targets	13/14	6/14	7/14
Right-side targets	19/21	9/21	13/21
Star cancellation			
Total correct	56/60	25/60	35/60
Left-side targets	22/22	2/22	11/22
Central targets	13/16	11/16	8/16
Right-side targets	21/22	12/22	16/22
Circle counting			
Total correct	12/12	5/12	
Left-side circles	6/6	0/6	
Right-side circles	6/6	5/6	
Line bisection (deviation) <sup>a</sup>			
100 mm			
Mean (SD)	-8 (2) <sup>a</sup>	+28 (4) <sup>a</sup>	+7 (8) <sup>a</sup>
Percent	-8%	+28%	+7%
120 mm			
Mean (SD)	-13 (6) <sup>a</sup>	+21 (23) <sup>a</sup>	+16 (5) <sup>a</sup>
Percent	-11%	+17%	+13%
140 mm			
Mean (SD)	-16 (9) <sup>a</sup>	+18 (6) <sup>a</sup>	+8 (8) <sup>a</sup>
Percent	-11%	+13%	+6%
200 mm			
Mean (SD)	-16 (2) <sup>a</sup>		
Percent	-8%		
240 mm			
Mean (SD)	-12 (2) <sup>a</sup>		
Percent	-5%		
280 mm			
Mean (SD)	-17 (7) <sup>a</sup>		
Percent	-7%		
Word reading			
Total correct	15/15	12/15	
Left-side column	5/5	3/5	
Central column	5/5	5/5	
Right-side column	5/5	4/5	
Square completion			
Total correct	8/8	7/8	
Open squares	6/6	5/6	
Full squares	2/2	2/2	

<sup>a</sup>Line bisection errors are calculated as the mean of displacement from the true center of the line (in millimeters), and percentage is the proportion of the bisection error divided by the line length, with positive numbers denoting bisections to the right of the actual midpoint and negative numbers denoting bisections to the left.

series of circles were displayed for counting, a task that required no manual responses: omissions occurred only in FS, with neglect of all the left circles.

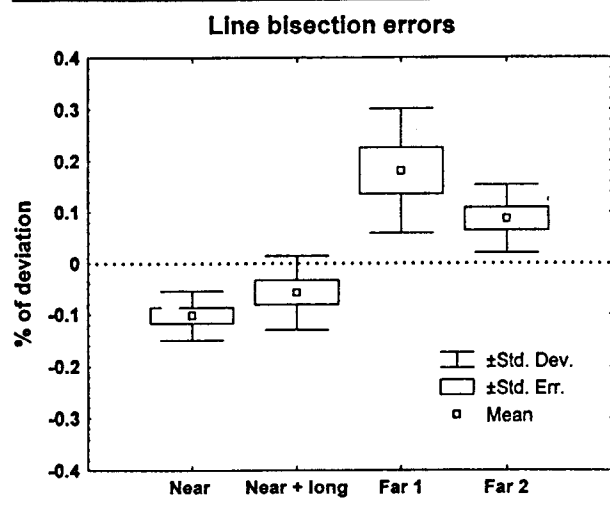
In the bisection task, where the patient had to mark the midpoint of horizontal lines (nine 1-mm thick lines of three different lengths were used: 10, 12, and 14 cm, each placed once on the left, central, and right

side of the display, respectively), there was a marked rightward bias for far-distant lines but a consistent opposite leftward bias for near-distant lines, regardless of the line's length or position ( $p = 0.018$  for deviations in NS compared with those in FS, Wilcoxon rank sum test) (Fig 2). Because neglect in line bisection has been shown to increase with increasing line length,<sup>13</sup> differences in bisection bias for the far-projected lines might have been confounded by an increase in their vertical physical length. We had therefore the patient bisect longer lines (three series of 20, 24, and 28 cm each) on a larger display (42 × 29 cm) similarly placed in near space, but this did not alter the magnitude of her leftward displacements ( $p = 0.14$ ). Only a minimal and nonsignificant repetition effect was observed between the first and second testing in FS ( $p = 0.31$ ).

Left neglect in reading occurred only for words in far space (15 French words were given at the same relative location in both NS and FS: five placed on the left, central, and right side of the display, respectively; all words embedded another word in their left-end or were compound words, eg, *poubelle*, *porte-feuille*). The patient made three errors in FS but none in NS; all were omissions of the leftmost letters (eg, "vision" for "television" and "feuille" for "porte-feuille").

In a final task, the patient was presented with a series of squares that could have either four complete sides or a right- or a left-side opening; she had to tell

Fig 2. Deviation errors from the true midline in the bisection task are shown as a percentage of the line length across four conditions: standard (100, 120, and 140 cm) and longer (200, 240, and 280 cm) lines given in the near space and comparable standard lines given in the far space on the first and second testing sessions. Percentages are calculated as the proportion of the bisection error divided by the line length, with positive numbers denoting bisections to the right of the actual midpoint and negative numbers denoting bisections to the left.



for each square if it was complete or not. The only error occurred in FS for a left-open square, which was stated to have four complete sides.

### Discussion

This patient showed unilateral neglect for far but not near space in purely perceptual tasks (eg, square completion, word reading) as well as in visuomotor or manual tasks (eg, cancellation, line bisection). Neglect was, however, more pronounced in the latter, and this might suggest that motor responses are important to show such a dissociation.<sup>8,14</sup> Brain<sup>14</sup> first speculated that the neural representation of extrapersonal space might differ with respect to near and far distances and that this might be related to the independent perceptual and motor systems that mediate responses to external stimuli. He distinguished between "grasping distance" and "walking distance." More recently, studies in monkeys supported a similar division by showing that unilateral ablation of the frontal area 8 leads to contralesional visual inattention that is much more severe for stimuli in far than in near space, whereas unilateral ablation of frontal area 6 or parietal area 7b conversely leads to contralesional inattention for stimuli in near visual and somatosensory space.<sup>5,6</sup>

In humans, the only evidence for such a division in attentional processes has been the patient of Halligan and Marshall,<sup>7</sup> who showed rightward displacements when bisecting lines in near space but no or minimal errors in far space. Yet, because this patient was tested on line bisection only, his defect could have been less partitioned than it appeared. Furthermore, in two small group studies of neglect patients in whom line bisection<sup>9</sup> or lateralized effects in a visual illusion<sup>8</sup> were systematically compared in near and far conditions, no single instance of a similar dissociation was found. Rather, there was a strong correlation<sup>8</sup> or a gradient<sup>9</sup> in the severity of neglect from near to far space. The inverse dissociation in our case provides a clear double dissociation and further evidence that distinct mechanisms are involved in visual attention to near and far space in humans as in monkeys. Moreover, whereas our patient consistently bisected far-distant lines to the right of their objective midpoint, she made opposite leftward deviations for near-distant lines. Such contralesional deviations are not uncommon in patients with hemianopia in the absence of attentional disturbances. "Paradoxical" leftward displacements can also occur in patients with left neglect on very short lines in the peripersonal space,<sup>13</sup> but the line's length appeared otherwise unimportant in our patient.

Unlike most neglect patients who have a large stroke involving the parietal lobe and deep subcortical structures, our patient suffered from temporal lobe damage. Neglect for far peripersonal space was demonstrated in a patient with bilateral temporo-occipital damage on

the bisection of radially presented lines,<sup>15</sup> as opposed to neglect for near peripersonal space in another patient with bilateral parietal damage.<sup>16</sup> It has been suggested that temporo-occipital areas in the ventral visual system might be preferentially implicated in monitoring attention for far space because of their role in the recognition of complex forms and objects in the environment, whereas parieto-occipital areas in the dorsal system might be more involved in attending near space because of their function in reaching and visuomotor manipulatory behavior.<sup>17,18</sup> Albeit complex forms and objects undoubtedly need to be recognized at all distances, neurophysiological findings in monkeys are consistent with the view that directing attention to objects and locations in space is linked to the implicit planning of possible actions,<sup>6,19</sup> and attentional mechanisms solicited for touching, looking, or walking might differ in some critical aspects.<sup>14,20</sup>

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