Unilateral Neglect: The Effect of Competing Stimuli on Estimated Line Length

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Normal subjects and patients with right hemisphere lesions with or without signs of left unilateral neglect judged the length of a horizontal line presented on the left or on the right side of space. In half of the trials, the line was presented with a centrally located square or diamond, and subjects had to identify the central stimulus before performing the judgment of length. The presence of the central stimulus improved accuracy of performance in controls and in patients without neglect; neglect patients, however, produced more overestimations of left-sided lines when these was presented with a central stimulus than when the lines occurred in isolation. This finding underlines the importance of attentional factors in length estimates performed by neglect patients in their neglected space.

Introduction

Patients with right hemisphere lesions often neglect information coming from the left side of space. Accounts of this pattern of spatial bias, called unilateral neglect, have often postulated a dysfunction of a mental map of space, such as ''a representational map reduced to one half'' (Bisiach, Capitani, Luzzatti, & Perani, 1981, p. 549). More recently, it has been proposed that in neglect the defective part of the mental map of space is not destroyed, but distorted. Milner and Harvey (1995) reasoned that a ''shrinkage'' in object size perception in the left hemispace could explain neglect patients' rightward error in line bisection. They asked 15 right-brain-damaged (RBD) patients (of whom 3 had left neglect) to compare pairs of horizontally arranged shapes (horizontal rectangles, vertical rectangles, or nonsense shapes). Neglect patients consistently underestimated items presented on the left side (consistent with previous similar results obtained by Gainotti & Tiacci, 1971), with the exception of the vertical rectangles, for which patients were accurate. Milner and Harvey (1995) concluded that horizontal size is miscomputed in the left parts of the visual array. Bisiach et al. (1996) had neglect patients mark the left and right endpoints of a virtual horizontal line on the basis of a given midpoint. Patients misplaced the left endpoint leftward, as if mimicking their biased performance in line bisection. Bisiach et al. (1996) concluded that space representation in neglect is characterized by a horizontal anisometry, with spatial coordinates progressively relaxing from the right to the left side. When placing the endpoints of a virtual line, patients should travel further leftward than rightward to equalize the amount of perceived spatial extent. It has also been shown, however, that only patients with an association of neglect and complete left hemianopia seem to show this peculiar behavior, whereas neglect patients without visual field defect do not demonstrate consistent asymmetries in placing the endpoints (Doricchi & Angelelli, 1999); this finding limits the generality of the anisometry account.

More generally, attentional factors could contribute to the bias of size estimation observed in neglect patients. For example, drawing on the evidence that normal individuals overvalue the dimensions of those items on which their gaze is mostly fixed (Piaget, 1961), Gainotti and Tiacci (1971) attributed the perceptual bias of neglect patients to an asymmetrical exploration of space favoring ipsilesional over contralesional objects. This interpretation could also explain the rightward deviation observed in line bisection, because neglect patients tend to fixate their gaze on the point in the right half of the line which they will later mark as the subjective midpoint, without exploring the remaining portions of the stimulus (Ishiai, Furukawa, & Tsukagoshi, 1989).

Despite the claim that that attentional accounts of neglect are not distinguishable, on logical grounds, from representational accounts (Bisiach, 1993), we feel that some properties of attention are less immediately discernible in a purely representational framework or at least in their current implementations. The concept of competition for selection among potentially relevant objects is among these properties. In a purely representational account of neglect, distractors presented in the nonneglected field should not affect the processing of targets presented in the neglected field, because the left part of the representation should be impaired irrespective of what happens in the other half. According to some attentional accounts of neglect (e.g., Gainotti, D'Erme, & Bartolomeo, 1991), on the contrary, nonneglected items are likely to attract patients' attention; hence, the more objects are presented on the ''unaffected'' side, the worse the neglect. In the present study, we aim at exploring the effect of the presence or absence of competing stimuli on a task of estimation of horizontal line length performed by normal subjects and by patients with right hemisphere lesions with or without signs of left unilateral neglect.

Method

Eighteen patients with right hemisphere lesions (7 of whom had left neglect) and 10 age-matched controls (mean age 60 years, range 30–82) participated in the experiment (see Table 1). No patient had visual field defects on clinical examination.

Training session. Subjects were trained to estimate two different line lengths. A 1-mm-thick horizontal line was presented at the center of a horizontal A4 sheet. Lines could be either 61 mm (''short'') or 67 mm (''long'') in length. For the first eight test sheets (four short and four long, presented in alternation), the examiner indicated to the subject whether the line was short or long. Afterward, the same stimulus set was presented in a random order, and the subject had to estimate whether the line was short or long. The set were presented until the subject was 75% correct (i.e., six

TABLE 1
Demographical and Clinical Characteristics of Patients

Group	Sex	Age	Years of schooling	Onset of illness (days)	Etiology	Locus of lesion
RBD N−	M	57	19	210	Hemorragic	IC
	F	41	12	40	Ischemic	FP
	M	53	6	52	Hemorragic	IC
	M	52	17	120	Hemorragic	IC
	F	66	6	68	Ischemic	THAL
	M	58	17	46	Hemorragic	IC, BG
	M	57	8	42	Hemorragic	IC, BG
	F	70	0	56	Hemorragic	IC, THAL
	F	52	8	59	Hemorragic	IC, BG
	F	63	8	75	Ischemic	FP
	M	56	17	51	Hemorragic	IC
RBD N+	M	77	11	112	Hemorragic	IC, BG
	M	59	8	120	Iscemic	FTP
	M	52	0	230	Hemorragic	P
	F	44	14	170	Hemorragic	FP
	M	58	14	137	Ischemic	FTP
	M	64	8	120	Ischemic	FTP
	F	73	8	9	Hemorragic	FP

Note. CTR, control subjects; RBD N−, RBD patients without signs of neglect; RBD N+, RBD patients with signs of left neglect. F, frontal; P, parietal; T, temporal; IC, internal capsule; THAL, thalamus; BG, basal ganglia.

correct responses), up to a maximum of five times. Subjects that were not able to comply with the criterion at the fifth training exposure were discarded.

Experimental session. After completing the training session, subjects were presented with lines similar to those of the training session, but drawn either on the right or on the left side of the sheet. Moreover, each line could appear either in isolation or accompanied by a geometrical figure drawn in the center of the sheet. The figure could be either a square or a diamond, both with a 16-mm-long side. Each possible combination of two line lengths (short or long), two line locations (left or right), and presence or absence of a central figure was presented 32 times, for a total of 192 trials, presented in a random order. For each trial, subjects had to identify the line as being short or long. When a central figure was present, they had to identify it as being a diamond or a square before producing the length estimate. Half of the figures were squares and half were diamonds.

Results and Discussion

A preliminary analysis of variance (ANOVA) with group (neglect, nonneglect, controls) as between factor revealed that neglect patients made more errors (36%) than the two other groups (nonneglect, 17%; controls, 12%) ($F = 18.37$; $d.f. = 2, 25$; $p < .0001$). This confirms that neglect patients are specifically impaired in estimating the length of a horizontal line.

Results (Table 2) were analyzed separately for each experimental group using repeated-measures ANOVAs with side (left, right), type of error (over-, underestimation) and presence or absence of a competing stimulus as factors.

Normal subjects. No effect of side or type of error emerged (Fs < 1.32; $d.f. = 1, 9$), but these two factors interacted ($F = 5.95$; $d.f. = 1, 9$; $p < .05$), because more underestimations than overestimations were produced on the right side ($F = 15.15$,

TABLE 2
Mean Percentages of Over- and Underestimations on the Left and Right Side of Space for Controls (CTR) and RBD Patients without (N−) and with Neglect (N+), with or without the Presence of a Central Stimulus

		Left w/o	Left with	Right w/o	Right with
CTR	Over	10	15	5	5
	Under	18	3	30	10
RBD N−	Over	12	15	8	13
	Under	22	18	28	22
RBD N+	Over	22	48	27	32
	Under	45	52	33	31

$d.f. = 1, p < .005$). This finding reproduces in a different experimental set the well-known asymmetry of performance demonstrated by normal left-to-right readers, who deviate leftward when bisecting horizontal lines (pseudoneglect; Bowers & Heilman, 1980; Chokron & Imbert, 1993). This leftward bias could reflect either an underestimation of the right half of the line or an overestimation of the left half-line. Our present findings seem to support the first possibility.

The presence of the central stimulus tended to improve the overall accuracy of performance ($F = 3.73$; $d.f. = 1, 9$; $p = .08$); this effect interacted with the error type ($F = 5.94$; $d.f. = 1, 9$; $p < .05$), because the absence of a central stimulus increased the number of underestimations ($F = 8.71$; $d.f. = 1$; $p < .05$). No interaction was present between side, error and the presence of the central stimulus ($F < 1$).

RBD patients without neglect. Only the effect of the type of error reached significance; patients produced more underestimations than overestimations ($F = 7.44$; $d.f. = 1, 10$; $p < .05$). This was true for the right side of space ($F = 9.39$; $d.f. = 1$; $p < .05$), but not for the left side ($F = 1.68$; $d.f. = 1$; p ns), similarly to normal controls' performance.

RBD patients with left neglect. As expected, neglect patients tended to produce more errors on the left than on the right side ($F = 5.65$; $d.f. = 1, 6$; $p = .05$). Contrary to the pattern of results obtained by controls, the presence of the central stimulus tended to impair neglect patients' performance ($F = 4.34$; $d.f. = 1, 6$; $p = .08$). Specifically, the presence of the central stimulus increased the production of overestimations ($F = 9.59$; $d.f. = 1$; $p < .05$). This effect was significant for the left side ($F = 23.02$; $d.f. = 1, 6$; $p < .005$), but not for the right side of space ($F = 1.51$; $d.f. = 1, 6$). Thus, in neglect patients, the number of errors of length estimation increased with the presentation of a concurrent stimulus, in sharp contrast with the facilitatory effect exerted by this same stimulus on controls' performance. This finding seems to underline the difficulty that these patients meet when dealing with multiple competing stimuli. Furthermore, this detrimental effect appears to affect primarily the lines presented on the left, neglected, side. This pattern of results does not support the prediction of the representational hypotheses reviewed in the Introduction, according to which nonneglected, competing stimuli should not affect the processing of neglected objects. On the contrary, our findings are consistent with attentional hypotheses of left neglect (see, e.g., Bartolomeo, 1997; D'Erme, Robertson, Bartolomeo, Daniele, & Gainotti, 1992; Gainotti et al., 1991) postulating that the presence of right-sided, nonneglected objects attracts patients' attention, thus further worsening their performance on the left, neglected, side.

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