

NOTE

LATERALITY OF MOTOR RESPONSE IN VISUO-SPATIAL NEGLECT: A CASE STUDY*

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Abstract—We report a case of severe visuo-spatial neglect consequent upon right hemisphere stroke. At time of testing, the patient had a left visual field deficit and a very mild left hemiparesis. Star cancellation and line bisection performed with the right hand revealed profound left neglect; tested with the left hand, performance was only slightly impaired. The results are compatible with recent accounts of differential hemispheric activation provoked by lateralized pre-motor programming.

INTRODUCTION

SEVERE LEFT visuo-spatial neglect is usually consequent upon large lesions of the right hemisphere; most patients accordingly have both left visual field deficits and left hemiparesis [8]. The motor loss thus results in the patient only being tested on traditional neglect tasks with his or her ipsilesional (right) hand. Because the anatomic relationship between cerebral hemispheres and limb control is primarily contralateral, a possible conclusion from most studies of neglect is that much of the observed symptomatology is programmed from the left hemisphere. Interesting issues of attentional control thereby arise. How, for example, do the (damaged) right hemisphere and the (intact) left hemisphere interact to produce the classical “neglect” patterns of impaired and preserved performance as a function of spatial position?

We are aware of only one study, that by JOANETTE *et al.* [4], in which patients with manifest left neglect have been systematically tested with both the ipsilesional and the contralesional hand. Three right-handed patients were diagnosed as showing neglect by virtue of their performance (with the right hand) on a modified version of Albert's line cancellation task [1]; left hand performance on this test was not reported.

However, all the patients were capable of pointing with either hand. In the experimental task, six light-emitting diodes were situated 50 cm in front of the subject and 10 cm below eye level; stimulus eccentricities were 20°, 40° and 55° in the left and right fields, respectively. Patients were required to “touch as quickly as possible, with the index finger of a given hand” the diode that lit up on that trial; the order in which the diodes were illuminated was random. In the primary experiment, the patients (two of whom did not have visual field deficits) fixated a central diode; detection, as assessed by manual pointing, was significantly better when the patients used the left (contralesional) hand than when the right was used. In a follow-up study (with one of the patients), the same result was obtained in a “free gaze” condition.

These findings suggest that it may be informative to study performance on more traditional neglect tasks in a patient who is able, like those of JOANETTE *et al.* [4] to use both the right and left arm and hand. The results of such testing should throw light on the two hemispheres' respective contributions to overt performance in neglect tasks.

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METHOD

Subject

C.M., a 54-year-old, right-handed, laboratory technician was admitted to Wexham Park Hospital on 23 June 1988. His presumptive diagnosis was right hemisphere stroke. CT scan, performed at Charing Cross Hospital on 27.6.1988, showed an extensive lesion of the right parietal and upper temporal regions, consistent with a recent middle cerebral artery infarct. Lacunar infarcts in the right lentiform nucleus and internal capsule were also

Table 1. Transection displacements on the line bisection task (Patient C.M.). + = rightward displacement, - = leftward displacement.

Line length		Signed displacement (SD)	Absolute displacement (SD)	Range
279 mm (11 in.)	Left hand	-7.0 (11.92)	9.6 (9.69)	-33 → +8
	Right hand	+21.5 (9.3)	21.5 (9.3)	+9 → +33
254 mm (10 in.)	Left hand	+4.3 (10.7)	8.3 (7.7)	-12 → +26
	Right hand	+16.7 (10.9)	16.7 (10.9)	+6 → +37
228 mm (9 in.)	Left hand	+1.3 (13.6)	9.9 (9.9)	-32 → +20
	Right hand	+17.9 (11.3)	17.9 (11.3)	+3 → +44
203 mm (8 in.)	Left hand	-6.2 (10.6)	10.6 (5.6)	-17 → +12
	Right hand	+9.3 (5.6)	9.3 (5.6)	+1 → +20
178 mm (7 in.)	Left hand	+4.8 (15.8)	11.0 (11.9)	-21 → +40
	Right hand	+14.9 (12.4)	16.9 (9.14)	-10 → +36
152 mm (6 in.)	Left hand	-1.1 (9.4)	6.7 (6.3)	-10 → +22
	Right hand	+7.2 (9.04)	9.8 (5.7)	-10 → +20
127 mm (5 in.)	Left hand	-5.3 (8.4)	8.7 (4.3)	-15 → +2
	Right hand	-0.4 (8.41)	7.0 (4.1)	-12 → +12
102 mm (4 in.)	Left hand	-9.5 (5.8)	9.5 (5.8)	-18 → -2
	Right hand	-10.0 (2.0)	10.0 (2.0)	-13 → -6
77 mm (3 in.)	Left hand	-10.2 (4.7)	10.2 (4.7)	-17 → -3
	Right hand	-7.6 (3.78)	7.6 (3.78)	-15 → -2
51 mm (2 in.)	Left hand	-8.6 (4.6)	8.6 (4.6)	-16 → -2
	Right hand	-10.5 (3.03)	10.5 (3.03)	-14 → -5
25 mm (1 in.)	Left hand	-3.5 (1.27)	3.5 (1.3)	-5 → -1
	Right hand	-5.4 (0.84)	5.4 (0.84)	-7 → -4

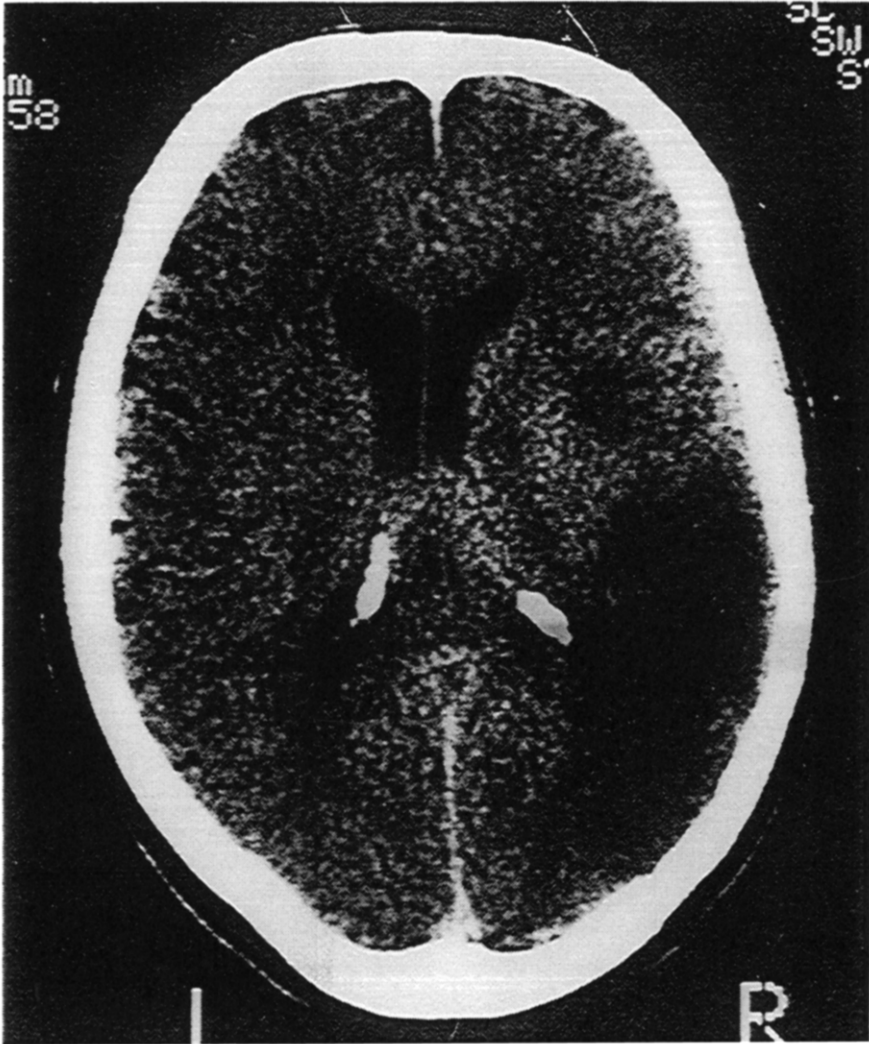


Fig. 1. CT-scan of patient C.M., showing infarction of the right middle cerebral artery territory.

observed. In addition, evidence of diminished density in the left occipital lobe suggested the appearance of old infarcts. The CT scan is shown in Fig. 1.

On admission to Rivermead Rehabilitation Centre (19.9.1988), C.M. was found to have a mild left hemiparesis, left homonymous hemianopia, and left-sided visuo-spatial neglect. Over the next 8 weeks, the motor deficit improved, although visual neglect persisted. At 8 weeks post-admission to Rivermead, perimetric visual field testing revealed a left homonymous inferior quadrantanopia. Examined at this time on the Behavioural Inattention Test [10] C.M. obtained a score of 96/146. This BIT aggregate is based upon performance on: line crossing; letter and star cancellation; figure copying; line bisection; and representational drawing. The cut-off score for normality is 130/146. C.M. also showed neglect on reading, writing, and picture-scanning tasks.

Procedure

Two of the six screening tasks were then employed in further experimental investigations.

(1) The star cancellation test (from the BIT) was performed six times. Over a 3-day period, C.M. undertook the task three times with the right hand and three times with the left in alternate order. The test comprises 56 small stars (the targets), pseudo-randomly interspersed with distractors (large stars, letters, and words). The overall dimensions of the stimulus sheet are 298 × 208 mm (A4). The task is simply to cancel (that is, cross-out) with a fine pen or pencil all the small stars. The two central stars are crossed out by the examiner while explaining the nature of the test to the patient. C.M. was seated at a comfortable distance from the test sheet displayed on the desk top; the stimulus sheet was centred on the sagittal midplane of the patient's head and trunk. Head and eye movements were in no way constrained, but moving the stimulus sheet was not allowed. The distance from the patient's eyes to the midpoint of the stimulus sheet was approx. 400 mm. No knowledge of results was fed-back to the patient and no time pressure was imposed. The patient stopped when satisfied with his performance. Further details of the test, and results from a representative sample of neglect patients can be found in MARSHALL and HALLIGAN [7].

(2) The Line Bisection Test was performed with 11 lines (1 mm in width) that varied in length from 1 in. (25 mm) to 11 in. (279 mm) in steps of 1 in. Each black line was presented individually and centred both horizontally and vertically on a sheet of white A4 (298 × 208 mm); the stimulus sheet was always centred on the midsagittal plane of the subject's head and trunk. All stimulus lengths were presented ten times in one session; order of presentation was pseudo-randomized across lengths. C. M. bisected two sets of 110 lines (11 lengths × 10 trials), one set with the right hand and one with the left. All stimuli were presented in free vision, without restraint on head and eye movements. Knowledge of results was not provided.

RESULTS

For scoring purposes, the star cancellation stimulus sheet was divided into six columns. Reading from left-to-right, the 54 target stars are distributed as follows: columns: 1 (width 51 mm) = 8 stars; 2 (width 40 mm) = 8 stars; 3 (width 50 mm) = 11 stars; 4 (width 48 mm) = 8 stars; 5 (width 48 mm) = 8 stars; and 6 (width 49 mm) = 8 stars. The visual angle subtended in left field (from the midpoint of the array to the far boundary of column 1) was approximately 20°, and likewise approx. 20° in right field. The data are reported in terms of percentage cancellations across the six columns so defined. The results (means of three trials) are shown in Fig. 2, for performance with the right (RH) and left (LH) hands, respectively.

It is clear that left hand performance is dramatically better than right hand performance. With the right hand, targets are never detected in the two left-most columns, and detection then improves from left-to-right until, at the right-most column, performance reaches ceiling. With the left hand, detection is relatively good at all eccentricities, although there is again a discernible, if very slight, improvement from left to right.

Results from the second task, line bisection, are given in Table 1, where we show the mean and absolute displacements (and their respective standard deviations and ranges) for all line lengths.

For 10 out of 11 line lengths, mean left hand performance is closer to true centre than is right hand performance ($P < 0.006$, binomial test). The results are presented graphically in Fig. 3.

The best-fitting regression equation for right hand performance (signed displacement against stimulus length) is $-15.53 + (0.134 \times \text{line length})$. The equation accounts for 86.9% of the variance. The linear correlation between line length and standard deviation of the signed displacements is $r = +0.797$ ($P < 0.01$). For left hand performance, the equivalent regression equation is $-8.38 + (0.031 \times \text{line length})$. Consistent with this much improved bisection accuracy, the equation only accounts for 22.9% of the variance. With the left hand, the correlation between line length and standard deviation of the signed displacements is $r = +0.84$ ($P < 0.01$).

The cross-over from rightward displacements at longer line lengths to leftward displacements at shorter lengths has been previously documented by HALLIGAN and MARSHALL [3].

DISCUSSION

Our results would appear to be fully consistent with the central claim made by JOANETTE *et al.* [4]. They write that, in neglect, "some aspects of the preparation for the motor act may interact with some aspects of signal processing".

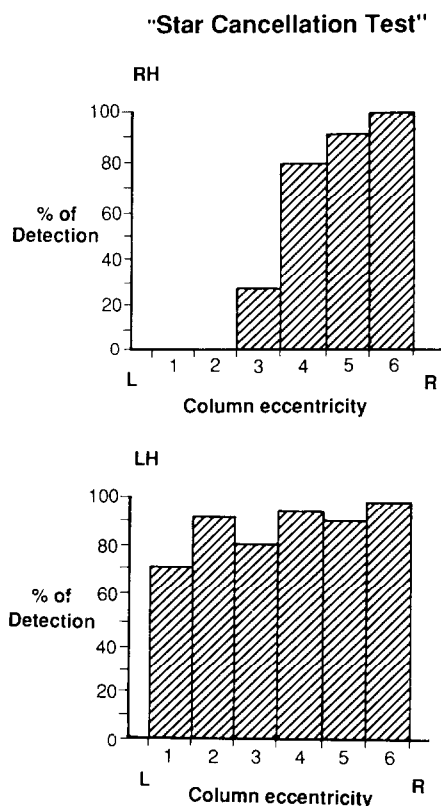


Fig. 2. Detection accuracy as a function of column eccentricity on the star cancellation test. RH = right hand performance; LH = left hand performance. L (left) and R (right) refer to the lateral position of the columns.

Our patient, C.M. (with multiple lesions), clearly shows a major interaction between perception and lateralized motor programming. On two traditional neglect tasks, C.M. manifests severe left neglect when tested with the right hand, and very mild neglect when tested with the left. On star cancellation, the cut-off for normal performance is 52/54 [10]; with the right hand, C.M. obtains a mean score of 27/54, and with the left, a mean of 49/54. Likewise, C.M.'s left hand transections on line bisection are far more accurate than those made with the right hand when the stimulus lines are longer than 5 in. (127 mm). A similar phenomenon has been reported by KASHIWAGI *et al.* [5]. Their patient, a 56-year-old right-handed man, had sustained callosal lesions due to cerebral infarction. CT and MRI scans indicated lesions "in the genu and the whole truncus of the corpus callosum, as well as in the left medial frontal and temporo-occipital lobes". Tested with the right hand, the patient showed left neglect when bisecting lines and copying line drawings. With the left hand, however, there was no neglect "other than mild right-sided inattention in copying multiple digit numbers".

Our findings are also consistent with the theoretical position outlined in KINSBOURNE [6]. In Kinsbourne's account of attentional processes, use of the right hand activates preferentially the left hemisphere, which is attentionally-biased towards processing stimuli in right hemisphere. C.M.'s right hand performance accordingly deviates to the right (left space is "neglected") and cannot be compensated by the contralateral bias of the (damaged) right hemisphere. Yet if the (damaged) right hemisphere is significantly activated (by left hand responding), neglect decreases very substantially.

A similar account of differential hemispheric activation (in normal subjects) provoked by lateralized eye movements has been proposed by TRESSOLDI [9]. In Tressoldi's experiments, stimuli were presented foveally but nonetheless in right or left hemisphere, a manipulation made possible by varying the side of gaze deviation. The results showed that "directing attention to one side of the extrapersonal space renders the contralateral hemisphere ready to react to stimuli presented within that hemisphere". Such a unilateral activation hypothesis has also been conjectured to underlie the transitory remission of hemineglect consequent upon caloric vestibular stimulation [2].

Kinsbourne's hypothesis that neglect should be interpreted in terms of "attentional bias" rather than "attentional deficit" is a promising approach to a still-mysterious clinical phenomenon [6].

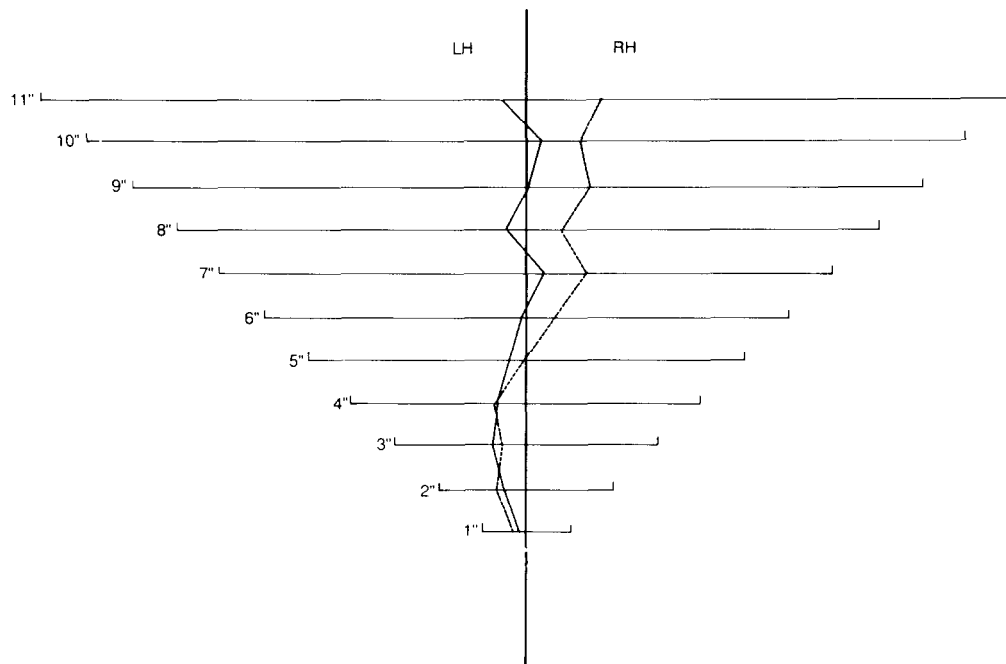


Fig. 3. Transection displacements as a function of line length for right hand (RH) and left hand (LH) performance.

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