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# UNILATERAL NEGLECT IS NOT UNILATERAL: EVIDENCE FOR ADDITIONAL NEGLECT OF EXTREME RIGHT SPACE

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ABSTRACT

Six patients with visuospatial neglect following right hemisphere lesions were given three tasks that assessed performance in areas of space ranging from extreme left to extreme right. A line bisection task required the patients to detect and bisect lines of four different lengths at seven left-right spatial locations, a number report task required the patients to name 11 two-digit numbers in a left-right array, and a tiling task required patients to place small black tiles over the black squares of a grid that stretched from 65° left to 65° right. Performance was compared with that of 20 age-matched controls. The patients showed the characteristic signs of left-side neglect in left space, extending to the central midline. Performance was relatively normal in centre-right space but all 6 patients showed signs of neglect of extreme right space (60° to the right of the midline and beyond). We propose that neglect is best characterised as a bilateral, asymmetrical compression of experienced space in which the constriction extends further from the left than from the right but nevertheless affects both sides of space.

Key words: visuospatial, neglect, line bisection, cancellation

## INTRODUCTION

Heilman et al. (1993) defined neglect as "the failure to report, respond, or orient to novel or meaningful stimuli presented to the side opposite a brain lesion, when this failure cannot be attributed to either sensory or motor defects" (p. 279). For Vallar (1993) neglect is "a behavioural disorder whereby a patient fails to explore the half-space contralateral to the cerebral lesion" (p. 27). Countless similar definitions could be adduced. The implication of all of them is that neglect, as characteristically seen in patients with right hemisphere lesions, is most severe in extreme left space and becomes progressively less severe as one moves through the centre and out into extreme right space, displaying what Kinsbourne (1970, 1993) termed an "attentional gradient".

Several studies have, however, reported that the performance of neglect patients in right space may not be fully normal. Gainotti et al. (1990) noted errors in the right (ipsilateral) sides of stimuli in a drawing completion task, while Halligan et al. (1992) and Small et al. (1994) observed right-side errors in cancellation tasks. Robertson (1989) reported right-side omissions in a target detection task that increased when patients were cued to the left before the stimuli were presented. The indication arising from these studies is that neglect patients may show a general decrement in visuospatial attention that increases in severity towards the left but nevertheless affects right space too when patient performance is compared against that of healthy controls. That is different from the claim we want to make here, as is the suggestion that neglect patients show additional, non-lateralised attentional deficits affecting, for example, sustained attention or the tendency to make perseverative cancellation errors (Robertson, 2001; Rusconi et al., 2002; Samuelson et al., 1998). Our assertion is that typical visuospatial neglect is most severe in extreme left space, improves as one moves through the centre and into near right space, but then becomes more severe again, so that performance in extreme right space (beyond about 60° right of the midline) is worse than in centre-right space.

One hint that patients with supposedly left-side neglect may show additional problems in extreme right space comes from a study by Mennemeier et al. (1997; see also Mennemeier et al., 2001). They asked patients with right- or left-sided brain injuries and healthy controls to bisect horizontal lines which varied in length (250, 300 or 340 mm) and which were presented centrally or displaced 400 mm to left or right. In an uncued condition, participants simply bisected the lines, while in cued conditions they located and identified letters or digits positioned at the left end, the right end, or both ends of lines before bisecting them. Previous studies had reported that bisecting lines in left space leads to a greater rightward displacement that is seen at the centre, while line bisection in right space is closer to the true midpoint and hence closer to normal (Cubelli et al., 1994; Heilman and Valenstein, 1979). Those studies did not, however, displace their lines as far to the left or right of centre as Mennemeier et al. (1997) did. Of interest

here is the fact that while the right hemisphere lesioned group showed the standard pattern of bisecting lines in left and centre space to the right of centre (c.f., Schenkenberg et al., 1980; Monaghan and Shillcock, 1998), lines in right space tended to be bisected to the *left* of centre, though the lines used in this study were some 10 times longer than those for which 'crossover' effects have previously been observed with central presentations (Halligan and Marshall, 1988; Tegnér and Levander, 1991; Anderson, 1997; Monaghan and Shillcock, 1998). Mennemeier et al. (1997) commented that "the consistent, reversed error direction (in right hemispace) is not easily explained by current theories of visual neglect (p. 712)". If rightward bisection of lines in left or centre space is to be interpreted as the consequence of a failure to adequately process the left ends of lines, then the same logic would require that leftward bisection of lines in right space should be interpreted as the result of a failure to adequately process the *right* ends of those lines. Mennemeier et al. (1997) proposed that patients with chronic right hemisphere lesions may have compromised attentional processing in peripheral space on the right as well as in left space.

The present study sought further evidence of compromised attentional processing in extreme right space in patients with conventional visuospatial neglect. The study included a line bisection task in which lines were presented at locations further to the left and right than has been the case in previous studies. The task therefore incorporated an element of line detection as well as line bisection. The lines varied in length from 160 mm down to 20 mm. Two other tasks assessed processing of stimuli extending from extreme left to extreme right. A number report task required participants to identify two-digit numbers extending in a row from 60° left of the midline to 60° right, while a tiling task required participants to place small black tiles over the black squares of a grid that extended from 65° left of the midline to 65° right. This last task was based on a report from an occupational therapist who had employed a similar task in her work with neglect patients and had noticed that as well as showing the more obvious problem positioning tiles on the left, they often failed to position tiles correctly in extreme right positions.

## Materials and Methods

### *Subjects*

Six right-handed patients aged 67 to 86 years (3 male, 3 female) with right hemisphere brain lesions confirmed by computed tomography (CT) scans participated in the study. All the patients showed clear evidence of neglect on line bisection and star cancellation tasks from the Behavioural Inattention Test (Wilson et al., 1987). The patients were assessed by an Occupational Therapist who confirmed that performance on the tasks was not limited by issues of mobility.

### *Tests*

#### *Tiling Task*

A long, thin board, 150 cm wide and 20 cm deep, was used to present the stimuli for this task. On the board was drawn a grid pattern of alternating black and white squares that was 2 squares deep by 21 squares across. The squares were 70 mm by 70 mm. The grid was centered on the participant's midline, approximately 300 mm in front of the participant. It therefore extended 735 mm to the left and right of the midline (half the width of the central squares plus 2 rows of 10 squares left and right). In terms of angles subtended, the grid pattern extended from approximately – 68° left of the participant's midline to + 68° right of the midline. Participants were given a set of black 70 × 70 mm tiles and asked to place the tiles over the black squares of the grid pattern using their right hand. They performed the task four times, twice working from left to right and twice from right to left. This does not mean that they were forced to start at the extreme left or extreme right; rather that they started at the leftmost or rightmost position they were aware of and then moved right or left. Scanning order was counterbalanced.

#### *Number Report Task*

Eleven two-digit numbers were presented in a single horizontal row 300 mm in front of the patient. There was one central number plus five numbers extending to the left of centre and five to the right. The numbers were 10 mm wide and separated by 90 mm gaps. The row therefore extended from 500 mm left of the participant's midline to 500 mm right. From left to right, the 11 positions will be referred to as L5, L4, L3, L2, L1, C, R1, R2, R3, R4 and R5. The angles subtended by the numbers were – 60°, – 53°, – 45°, – 34°, – 18°, 0°, + 18°, + 34°, + 45°, + 53° and + 60°, where – denotes an angle to the left of centre and + an angle to the right of centre. Participants were instructed to name all the numbers they could see. They performed the task twice, once working from left to right and once from right to left. Scanning order was counterbalanced.

#### *Line Bisection Task*

In the line bisection task, seven horizontal lines of length of length 160 mm, 80 mm, 40 mm or 20 mm were drawn on a sheet of paper measuring 150 cm wide by 13 cm deep. The seven lines were