The influence of limb crossing on left tactile extinction

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Background: Previous research on patients with left tactile extinction has shown that crossing of hands, so that each hand is on the opposite side of the body midline relative to the other, improves detection of stimuli given to the left hand.

Objectives: To study the influence of the spatial position of limbs on left tactile extinction, and its relations with left visual neglect.

Methods: Normal participants and patients with right cerebral hemisphere damage and left tactile extinction were asked to detect single or double light touch stimuli applied to their cheeks, hands, or knees with their arm and legs either in anatomical or in crossed position, increasing the attentional load of the task.

Results: In patients with left extinction, limb crossing caused a deterioration in performance for stimuli applied to right body parts, with only a tendency to an improvement in detection for left body parts (only two of 24 patients showed substantial (>20%) improvement in left extinction after limb crossing). After crossing, left limb detections of double stimuli decreased with increasing degrees of visual neglect.

Conclusions: In conditions of high attentional load, limb crossing may impair tactile detection in most patients with left extinction, and particularly in those showing signs of left visual neglect. These results underline the importance of general attentional capacity in determining tactile extinction. Attentional and somatotopic mechanisms of extinction may assume different weights in different patients.

Brain damaged patients may report only the stimulus ipsilateral to their lesion when stimulated on both sides, despite being able to report a single stimulus wherever applied. This disorder, called extinction or sensory inattention, is clinically defined as the “recognition only on the intact side of bilaterally and simultaneously presented stimuli,” and can occur in different sensory modes: visual, somatosensory, acoustic, olfactory, and even cross modally. Accounts of extinction typically emphasise either a sensory problem not severe enough to impair perception of single stimuli, or an attentional disorder favouring ipsilateral over contralateral stimuli, or both. The sensory and attentional mechanisms may reflect damage to different neural structures: the ascending pathways in the subcortical white matter for the sensory mechanism, and frontal or parietal cortical regions for the attentional mechanism.

Concerning extinction in the somatosensory mode, or tactile extinction, several findings suggest that it is not exclusively determined by sensory mechanisms. First, left extinction may appear or be enhanced when patients look towards the right side. On the other hand, contralateral awareness may be improved by looking at or intentionally moving to tactile stimuli rather than receiving them passively. Second, there is the possibility of observing cross modal, visual-tactile extinction, in which a visual stimulus can extinguish a tactile one. Third, there is the fact that tactile extinction seems to be more frequent after right than after left brain damage, thus paralleling the pattern of occurrence of unilateral neglect. Finally, Moscovitch and Behrmann showed that extinction in patients with unilateral neglect may have a directional component. When the wrist of one hand was touched simultaneously on its left and right side, patients extinguished the stimulus contralateral to the brain lesion, independent of the hand that was stimulated (left or right), and of its position (palm up or palm down).

Aglioti and coworkers recently confirmed that tactile extinction does not depend solely on sensory factors. Smania and Aglioti examined the detection of light tactile stimuli applied on one or both hands of normal individuals and 16 right brain damaged patients. Participants were tested with their hands either in anatomical position, or crossed so that the left hand was placed to the right of patient’s midline and vice versa. They found that crossing the hands improved the patients’ performance by 32.3% for the left hand and left detections for the right hand substantially unchanged. In contrast, crossing impaired the controls’ performance by around 5% for either hand.

The investigators proposed that the subjects’ performance relied upon two different representations: a somatotopic and an extrapersonal spatial representation. Right brain damage would impair the left part of both representations, and cause the right part of the hemispace to be overrepresented. Accuracy of detection for the left hand would thereby improve when the left hand is placed in the right hemispace. However, this account would have predicted an impairment of right hand detection in the crossed condition, that is, when the right hand is situated on the left, impaired side, but Smania and Aglioti found no substantial change in that condition.

In a second study, Aglioti et al employed a similar experimental paradigm in a larger patient sample (36 right brain damaged patients), but this time the hands (in a crossed or uncrossed position) were either across the body midline or both in the right or in the left hemispace. Results showed an improvement in left hand detection by 30% in the crossed position, which occurred independently of the location of the hands (central or lateral); thus the source of the effect seemed to be the position of the hands with respect to each other, without reference to the body midline. On the other hand, crossing impaired performance for the right hand by 3%, but only in the most severely impaired patients—those omitting at least 70% of left sided stimuli under double stimulation and at least 50% of single left sided stimuli.

However, Vaishnavi et al also explored the effect of limb crossing on extinction and found that crossing induced an...
average 5% deterioration in performance for left hand
detections in a group of 10 right brain damaged patients.15
Only two patients showed some improvement (8%) after
crossing (see their table 3, patients LAB and GS). Performance
for the right hand remained at ceiling both in anatomical
and crossed positions.

Perhaps these discrepancies resulted from different impair-
ments being at work in different patients. For example, in
Aglioti's 1999 study,16 crossing may have impaired stimulus
detection on the right hand only for patients with a severe asymmetry in attentional orienting, as suggested by their
tendency to omit even single left sided stimuli. If so, then
increasing the possible loci of stimulation in a tactile
extinction paradigm, and thereby taxing the already biased
processing capacities of right brain damaged patients, should
allow one to observe a more systematic detrimental effect of
extinction paradigm, and thereby taxing the already biased
processing capacities of right brain damaged patients, should
increase the possibility of observing individual differences in
anatomical and crossed positions.

A further question of interest concerns the relations
between tactile extinction and signs of visual neglect in the
extrapersonal space. There is functional and anatomical
segregation of the brain mechanisms which process personal
and extrapersonal space, as shown by neurophysiological
studies in the monkey20 and by human lesion studies.21 In
support of this distinction, tactile extinction has been found
to correlate poorly with tests of extrapersonal visual neglect.22
If, however, the effect of limb crossing involves a recoding of
personal space into extrapersonal coordinates,18 then this
effect might be found to correlate with neglect signs on paper
and pencil tests.

To explore these issues, we examined right brain damaged
patients with left tactile extinction and normal individuals,
using a task involving the presentation of tactile stimuli on
their cheeks, hands, and knees, both in anatomical position
and after crossing of arms and legs. Double stimuli were
given either to homologous or to non-homologous body parts
(for example, left hand and right knee). Thus patients had to
monitor six possible loci of stimulation at any given time. The
number of patients studied (n = 24) was relatively larger
than in most previous studies involving limb crossing, to
increase the possibility of observing individual differences in
performance. The relation of crossing induced changes with
the presence and degree of visual neglect was explored by
correlating these changes with patients' performance on a
neglect battery, including tests of target cancellation, line
bisection, drawing copy, and identification of overlapping
figures.

METHODS
Participants
Twenty four patients with unilateral lesions in the right
hemisphere and left tactile extinction and 10 subjects
without neurological impairment participated in the study
after giving their informed consent. The study was carried out
in accordance with the guidelines of the Declaration of
Helsinki. Patients and controls did not differ in age or
educational level (both t values <1). All patients underwent a
preliminary examination of tactile extinction following a
standard clinical procedure22 consisting of six single uni-

lateral stimuli (left or right hand, left or right knee, left or
right cheek) and six double simultaneous stimuli (both
hands, both knees, or both cheeks, each repeated twice),
delivered to the blindfolded patient according to a previously
derandomised sequence. Patients were included in the study if
they detected at least one single left stimulus per body part
and extinguished at least one left stimulus under double
stimulation. Table 1 shows the participants' demographic and
clinical characteristics.

Procedure
Tactile detection task
Participants were seated blindfolded in a comfortable chair.
The examiner gave light touch stimuli with the index
fingertips. In the “anatomical” condition participants seated
with hands on their lap. In the “crossed” condition, participants
crossed their legs and arms, with the right limbs positioned
over their left homologues. Stimuli were given to participants' cheeks, hands (dorsum), and knees. For each
condition (anatomical or crossed), there was a basic sequence
of 12 single stimuli (two for each body part and side of
space), 24 double stimuli on homologous sites (two for each
cheek, five for each hand, and five for each knee), and 12
double stimuli on non-homologous sites (two for each body
part and side of space). Double stimuli were always given to
body parts on the opposite sides of the body. To avoid
ambiguities in the interpretation of responses, participants
were asked to respond both by verbally localising the
stimulated body part and by moving or touching it. The
basic sequence was repeated four times, following an ABBA
design, with A = anatomical and B = crossed for half of the
participants, and the reverse assignment for the other half.
Results of the two repetitions of each condition (anatomical
or crossed) were pooled together.

Neglect battery
In the cancellation tests, a horizontal A4 sheet was presented
to the patient, who was asked to cancel targets of various
kind that were scattered on it: lines23 or “A’s among other
letters.24 In the overlapping figures task,25 patients were
requested to identify five patterns of overlapping linear
drawings of common objects. Each pattern included a central
object (for example, a basket) with a pair of objects depicted
over each of its sides (such as a lamp and a watch on the left
side, a pipe and a key on the right side). The line bisection
test was originally described by D'Erme et al.26 It consists of
eight lines horizontally disposed in a vertical A4 sheet, in a
fixed random order. There are three 62 mm samples at 38, 81,
and 124 mm from the left margin of the sheet, three 100 mm
samples at 17, 62, and 90 mm from the margin, and two 180
mm samples at 14 mm from the margin. Finally, patients
copied a linear drawing representing a landscape consisting
of a house and four trees,27 presented on a horizontal A4
sheet.

Data analysis
To obtain a quantitative measure of spatial bias in each
component test of the visuospatial battery, laterality scores
were computed for each of the neglect tests using the
following procedure. For the line bisection test, the score was
the cumulated percentage of deviation from the true centre
for all the lines. Rightward deviation assumed a positive sign,
whereas leftward deviations carried a negative sign. For the
overlapping figures test and each of the cancellation tests, we
estimated the bias toward the right side by using a laterality
score, defined as: (x1-x2)/(x1+x2). Values for x1 were given
by the number of items identified on the right side for the
overlapping figures test, or the number of items cancelled on
the right half of the page for the cancellation tests. Values for
x2 were computed in an analogous fashion—that is, by using
the number of left sided identified overlapping figures and
the number of left sided cancelled items. One advantage of this
laterality score is that it provides a quantitative estimate
of spatial bias which is independent of the overall level of performance (for example, of the total number of cancelled targets). Its possible range is from $-1$ (all the items reported or cancelled on the left side, none on the right side) to $+1$ (the opposite situation). A correction was needed for cancellation tasks undertaken by patients with severe neglect, who cancelled only the rightmost items, without crossing the midline. In order not to underestimate their neglect, the laterality score obtained by these patients was augmented by the proportion of the number of neglected items on the right side (maximum $+1.97$, corresponding to a single item cancelled on the right). The landscape copy was scored by subtracting from 6 one point for each tree completely copied to 5.5 (only the right half of a single tree copied).

The proportions of correct detections in the tactile detection task for each participant and condition were arcsin transformed and entered into separate repeated measures analyses of variance (ANOVA) for normal participants and for right brain damaged patients. The stimulated body part (cheek*, hand, or knee), its anatomical side (left or right body parts), the type of stimulus (single, double on homologous body parts, or double on non-homologous body parts), and the limb position (anatomical or crossed) were entered as factors. Theoretically relevant results were followed up by Tukey HSD tests.

**RESULTS**

Normal participants performed at or near ceiling in all conditions (fig 1A), but were more accurate in the anatomical position (99.7% accuracy) than in the crossed position (99.1%), F(1,9) = 8.65, p<0.05. This effect interacted with the type of stimulus, F(2,18) = 5.28, p<0.05, because crossing decreased performance for double homologous stimuli (Tukey test, p<0.01), but not for the other types of stimuli. No other effects or interactions reached significance.

Right brain damaged patients’ performance (fig 1B) was affected by the stimulated body part, F(2,46) = 65.86, p<0.0001, because patients detected a touch on cheeks better (87.8%) than on limbs on their left side (left hand: 43.8%, left knee: 46.9%) (Tukey test, all p values <0.0005). Patients detected more stimuli on the right side (93.7%) than on the left side (55.8%), F(1,23) = 151.26, p<0.0001. These effects interacted (F(2,46) = 19.43, p<0.0001) because performance was worse for the left hand (43.8%) and knee (46.9%) than for the left cheek (76.7%) (all p values <0.0005). Accuracy decreased from single stimulation (94.5%) to double homologous stimulation (69.0%) and to double non-homologous stimulation (60.6%), F(2,46) = 139.63, p<0.0001. As expected in patients with left extinction, these effects interacted (F(2,46) = 37.75, p<0.0001) because patients detected fewer stimuli on their left body parts with double stimulation than in the other conditions (all p values <0.0005). The body part interacted with the type of stimulus (F(4,92) = 8.57, p<0.0001) because the fall in accuracy from single to double stimulation was more substantial for limbs than for cheeks. The limb position (anatomical or crossed) had no effect on overall performance (F(1,23) = 1.35) but interacted with the side (F(1,23) = 10.40, p<0.005), because crossing non-significantly improved performance for left body parts by 2.6%.

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**Table 1** Demographical and clinical characteristics of right brain damaged patients (P01–24) and normal controls (C01–10)

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex/age/years of schooling</th>
<th>Locus of lesion</th>
<th>Weeks since symptom onset</th>
</tr>
</thead>
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<tr>
<td>P01</td>
<td>M/67/5</td>
<td>Frontal, parietal</td>
<td>2</td>
</tr>
<tr>
<td>P02</td>
<td>M/46/13</td>
<td>Occipital, temporal</td>
<td>4</td>
</tr>
<tr>
<td>P03</td>
<td>F/50/5</td>
<td>Frontal</td>
<td>2</td>
</tr>
<tr>
<td>P04</td>
<td>M/68/8</td>
<td>Frontal, parietal</td>
<td>12</td>
</tr>
<tr>
<td>P05</td>
<td>M/71/14</td>
<td>Basal ganglia</td>
<td>1</td>
</tr>
<tr>
<td>P06</td>
<td>M/52/9</td>
<td>Internal capsule, thalamus</td>
<td>22</td>
</tr>
<tr>
<td>P07</td>
<td>M/62/5</td>
<td>Parietal, occipital</td>
<td>2</td>
</tr>
<tr>
<td>P08</td>
<td>F/72/6</td>
<td>Temporal, parietal</td>
<td>4</td>
</tr>
<tr>
<td>P09</td>
<td>M/50/17</td>
<td>Frontal, parietal, temporal</td>
<td>28</td>
</tr>
<tr>
<td>P10</td>
<td>F/80/12</td>
<td>Temporal, parietal</td>
<td>2</td>
</tr>
<tr>
<td>P11</td>
<td>M/81/5</td>
<td>Temporal, parietal</td>
<td>1</td>
</tr>
<tr>
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<td>M/74/15</td>
<td>Temporal, parietal</td>
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<td>3</td>
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<td>M/71/5</td>
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<td>Frontal, parietal, temporal</td>
<td>6</td>
</tr>
<tr>
<td>P18</td>
<td>M/60/8</td>
<td>Internal capsule, thalamus</td>
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<td>F/70/4</td>
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<td>P20</td>
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<td>Thalamus</td>
<td>2</td>
</tr>
<tr>
<td>P21</td>
<td>M/76/5</td>
<td>Parietal</td>
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<tr>
<td>P22</td>
<td>M/60/8</td>
<td>Frontal, parietal</td>
<td>2</td>
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<tr>
<td>P23</td>
<td>F/73/5</td>
<td>Temporal, parietal</td>
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</tr>
<tr>
<td>P24</td>
<td>M/74/5</td>
<td>Temporal, parietal</td>
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</tbody>
</table>

* C, control; F, female; M, male; P, patient.
(p = 0.51) but decreased performance for right body parts by 5.4% (p<0.05). Limb position also interacted with side and stimulus type (F(2,46) = 6.29, p<0.005), because crossing resulted in deterioration of performance for right body parts, especially with double non-homologous stimulation (8.7% decrease, p<0.05). No other effect or interaction reached significance.

A potential concern in the interpretation of these results comes from the fact that crossing decreased normal participants’ accuracy on double stimulus detection. Thus the crossing-induced deterioration we found for right limb stimulation in extinction patients might simply result from intrinsic differences between task conditions. To address this possibility, we conducted a mixed design ANOVA with participants (controls, patients) as between-subjects factor and the same within-subject factors as for the previous analyses. If crossing induced different rates of detection of double stimuli in patients and in controls, then an interaction should occur between participants, limb position, and side of stimulation. This was indeed the case (F(1,32) = 4.70, p<0.05). Planned comparisons showed that the crossing-induced deterioration of detection of double stimuli on the right limbs was much larger in patients (12%) than in controls (1.8%) (F(1,32) = 5.77, p<0.05).

To see whether crossing decreased right body part detections only in patients with the most severe impairment—as reported in a previous study—we conducted a further ANOVA on data from only those patients (n = 14) who detected at least 75% of single stimuli and at least 25% of double stimuli in the anatomical position. The resulting pattern of effects and interactions was similar to that of the ANOVA done on the whole group of patients. In particular, the critical interaction between position and side of stimulus was still present (F(1,13) = 10.03, p<0.01), because crossing caused deterioration in right detections by 6% (p<0.05). Thus in our sample limb crossing impaired tactile detection on right body parts even in patients with milder somatosensory impairment.

Table 2 reports the participants’ detection of double stimuli on limbs for the anatomical and crossed conditions, the size and direction of the modifications induced by crossing, and the patients’ performance on paper and pencil neglect tests. Inspection of table 2 suggests that there was no straightforward relation between crossing-induced modifications and the presence and amount of left visual neglect. Concerning, for example, the two patients who showed the larger improvement in left detections after crossing, patient 03 had no signs of visual neglect and patient 05 showed only a moderate rightward deviation on line bisection. The relation between crossing induced effects and visual neglect was explored more formally by calculating the correlation coefficients between the laterality scores obtained from paper and pencil tests and the effect of crossing on limb tactile extinction. If the effect of crossing involved a recoding of personal coordinates into extrapersonal coordinates, then performance on paper and pencil neglect tests should positively correlate with crossing-induced modifications of tactile extinction. Contrary to this prediction, no significant positive correlation emerged between these measures (table 3). Unexpectedly, instead, negative correlations occurred between neglect tests and crossing induced changes of left limbs detection. This was because patients with severe degrees of left visual neglect were the least likely to improve when their left limbs were positioned on the right, non-neglected side (see, for example, patients 16 and 17 in table 2, who had severe left neglect and whose tactile detection for left limbs decreased by more than 20% after crossing).

**DISCUSSION**

We asked normal participants and right brain damaged patients with left tactile extinction to detect single or double light touch stimuli applied on their cheeks, hands, or knees before and after crossing of hands and legs, so that the left limbs were now on the opposite side relative to their right counterparts. Independently of crossing, patients showed better accuracy for stimuli delivered on their face than for stimuli applied on limbs, confirming previous evidence. This result seems consistent with the view that the cortical sensory representation of the face is organised more bilaterally than that of the limbs, where it is strictly contralateral. Sensation from the face would thus be more resistant to disruption resulting from unilateral brain damage.

Crossing the hands and knees induced changes in accuracy of detection of tactile stimuli. Normal participants showed a slight deterioration of performance in the crossed condition, especially for double simultaneous stimuli, suggesting that these situations are particularly demanding in terms of attention. For right brain damaged patients with tactile extinction, the deterioration of performance on limb crossing was substantial for the right limbs—six times larger than shown by controls. Aglioti et al. using a task similar to ours but with stimuli given only to the hands, found an analogous
Table 2  Accuracy of detection (% of hits) for double stimuli given on limbs in the anatomical and crossed conditions, crossing induced changes (% hits anatomical – % hits crossed), and patients’ performance on the neglect battery

<table>
<thead>
<tr>
<th>Participant</th>
<th>Left anatomical</th>
<th>Left crossed</th>
<th>Change</th>
<th>Right anatomical</th>
<th>Right crossed</th>
<th>Change</th>
<th>Line bisection (% deviation)</th>
<th>Line cancellation (max 30/30)</th>
<th>Letter cancellation (max 30/30)</th>
<th>Overlapping figures (max 10/10)</th>
<th>Landscape drawing</th>
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<td>P01</td>
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<td>94</td>
<td>75</td>
<td>-19</td>
<td>-11.64*</td>
<td>26/30†</td>
<td>21/26</td>
<td>9/8</td>
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<td>+20.48*</td>
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For line bisection, + indicates rightward deviation and – indicates leftward deviation. For cancellation tests, left/right correct responses are reported. Asterisks indicate pathological performance for standardised tests. *Rightward or **leftward deviation greater than 2 SD from the mean performance of 30 normal age matched individuals.††The same group of normal individuals never omitted more than one item on this task.

C, control; P, patient; –, missing data.
deterioration of performance only in extinction patients with severe impairment, who also omitted most single left stimuli. In the present study, by contrast, even patients who detected most left single stimuli showed this pattern of performance. This discrepancy may be explained if one considers that increasing the possible loci of stimulation also increases the attentional demands of the task, which thereby becomes more sensitive to disruption when the usual left–right position of the limbs is reversed.

Our results only partially confirmed the improvement of left body part detections after limb crossing shown in previous studies, in which the hands alone were stimulated.14 15 We observed only a tendency in this sense for the left knee and cheek, but not for the left hand (see fig 1B). Inspection of individual performances (table 2) shows that about half the patients had some improvement of left limb extinction after crossing, but only for a third of patients was the improvement larger than 10%, and only for two patients was it larger than 20%. Also this discrepancy may underline the increased attentional load of our task as compared with the tasks employed by Aglioti and coworkers.

The possibility that the effect of limb crossing varies with the attentional load of the task (left body part improvement with low load, right body part deterioration with high load) supports the view that an attentional component participates in somatosensory extinction after right brain damage. Requested to monitor six possible anatomical loci for brief tactile stimuli, after crossing, patients made many more omissions when they had to orient their attention leftward to detect stimuli given to their right limbs. Although not statistically significant, the tendency for limb crossing to improve left detections on checks in right brain damaged patients (fig 1B) might also suggest that part of the influence of limb crossing observed in previous studies may simply be an arousal effect. Manoeuvres that increase arousal are known to ameliorate left visual neglect.10

As mentioned in the introduction, Vaishnavi et al found that limb crossing induced an average deterioration of performance for left hand detections.15 They argued that extinction patients may suffer from an attentional bias in personal (somatotopic) space, rather than in extrapersonal space. They also proposed that tactile sensation might be biased towards personal rather than extrapersonal space. The alternate pattern could be true in individual cases. Heldmann et al found that repetitive peripheral magnetic stimulation of the left hand led to a significant reduction in left extinction, but had no effect on ipsilesional errors, whereas attentional cueing had no significant influence on left extinction, but increased right hand extinction errors.12 Our results are not inconsistent with the proposal by Vaishnavi15 that tactile sensation might be biased towards personal rather than extrapersonal space, and are quite consistent with the proposal by Heldmann11 that the high attentional demands of their tactile extinction task may account for the detrimental effect of contralesional cueing on ipsilesional performance.

Table 3  Correlation coefficients between the crossed-induced modifications of double detections on limbs and the laterality scores derived from the neglect tests

<table>
<thead>
<tr>
<th>Crossing: left</th>
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<tr>
<td>Line cancellation</td>
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<td>Letter cancellation</td>
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<tr>
<td>Line bisection</td>
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<td>Landscape drawing</td>
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<td>Overlapping figures</td>
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</table>

*p test, p<0.05

Inspection of tables 2 and 3 and results of the correlational study suggest that there is no clear relation between the results of paper and pencil tests of neglect and the effects of limb crossing on tactile extinction. Contrary to the expectation that neglect patients might particularly benefit from limb crossing when detecting tactile stimuli on their left limbs (now placed on the right, “intact” side of space), the observed tendency was in the opposite sense. Patients with visual neglect tended to omit more left limb stimuli after crossing. If the crossed condition were particularly demanding in terms of attention, then neglect patients might have found this condition especially difficult, in keeping with evidence showing deficits of non-lateralised attentional capacities in these patients.12–14 The present results seem also in line with other evidence showing poor correlations between tactile extinction and visuo-spatial tasks in right brain damaged patients,12 and, more generally, between tasks performed under visual control and tasks carried out without visual control.15–17 This evidence can be interpreted as suggesting that right visual objects exert a powerful “magnetic attraction” on patients’ attention, thus enhancing left neglect, as compared with situations in which no visual stimuli are present.18 19 20 Another possible interpretation of these discrepancies is that an attentional bias can manifest itself either in personal or in extrapersonal space, and that tactile sensation may be biased toward personal rather than extrapersonal space.15 Some patients of the present series showed dissociations in performance between line bisection and target cancellation tasks, consistent with previously reported evidence.20–23 The fact that patients with biased performance in either task are represented in the present sample suggests that our results generalise to both these patient populations.

Conclusions

Our results suggest that both somatotopic and attentional factors contribute to tactile extinction, perhaps with different weights in different patients. A rightward attentional bias for the personal space, with the possible addition of a more general, non-lateralised impairment of attentional capacity,24 25 may affect right brain damaged patients’ tactile detection by causing a dramatic deterioration in the performance of the right limbs when they are displaced leftward.

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