Prism adaptation can improve contralesional tactile perception in neglect

Abstract—The authors show that prismatic adaptation can reduce tactile inattention in stroke patients with unilateral neglect. Four patients with visuospatial neglect and tactile extinction underwent 10-minute application of 20° right-shifting prismatic lenses during pointing. This improved contralesional tactile perception in all patients, even for a task requiring no exploration or spatial motor responses. This finding suggests a potential role for prismatic adaptation in the rehabilitation of multiple sensory modalities in patients with neglect.

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Unilateral neglect is common after right hemisphere lesions. Neglect patients ignore stimuli on the contralesional (usually left) side of space and body.1 Some patients may show extinction, whereby single stimuli can be perceived on each side, but contralesional stimuli go undetected during bilateral stimulation.2 Rehabilitation of visuospatial neglect has proved challenging, but recent work suggests striking effects from prism adaptation (PA).3 Prismatic lenses induce an optical deviation toward the ipsilesional side for several minutes, while patients perform pointing movements with the ipsilesional hand toward visual targets. To correct for the visual shift induced by the lenses, patients must make motor corrections toward the contralesional side during each pointing movement. At the same time, they receive visual feedback on any inaccuracy further to the ipsilesional side than usual. Once prisms are removed, patients show a directional pointing error toward the contralesional side (prism aftereffect).3 This aftereffect can be particularly long-lasting for neglect patients3–6 as compared with PA in subjects, and critically is accompanied by improvements in visuospatial neglect lasting several hours or days.5

Prism adaptation has been shown to improve several visuospatial neglect symptoms, including visual search or drawing,3 neglect dyslexia,4 personal neglect, and haptic7 and visuomotor tasks.5 However, it remains unknown whether the beneficial effect of PA can directly affect perception in neglect patients or rather modulates primarily active exploration strategies (which may even affect visual imagery).8 It also remains unknown whether PA can modulate the somatosensory deficits associated with neglect.8 To address these issues, we tested whether PA can ameliorate tactile extinction.

Methods. Four patients with right hemisphere damage (figure) and tactile extinction were studied after giving written consent. The Ethics Committee of the Homerton Hospital in London (UK) previously approved the study. All patients showed some degree of neglect on standard tests (table 1). Tactile perception was assessed experimentally using electromagnetic solenoids (Trans Dimension, USA) to deliver single unseen 100-ms taps on the index finger pad of either hand. Patients placed their hands in their lap while fixating a cross centered on a monitor in front of them. Tactile stimuli could be delivered unilaterally to either the right or left hand (18 per side for Patients 2 and 4, 12 for Patients 1 and 3) or to both hands simultaneously (18 for Patient 2 and 4, 24 for Patients 1 and 3) in an intermingled sequence. Six “catch” trials

See also pages 1734 and 1826

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(no stimulation) were also intermingled. Patients verbally re-
ported their perception on each trial (i.e., “left,” “right,” “both,” or
“none”). All patients showed substantial misses of the left con-
tralesional stimulus during bilateral stimulation (table 2). Percep-
tion of unilateral left stimuli was good in three patients (Patient
1 = 83% correct; Patient 2 = 89%; Patient 3 = 100%) but impaired
in Patient 4 (28%; see table 2). Responses to unilateral right and
catch trials were always accurate (>98% for unilateral; 100% for
catch trials). Patients were tested for visuospatial neglect and
tactile extinction immediately before and after a single 10-minute
application of prismatic lenses producing a 20° rightward shift of
visual input. During PA, patients sat in front of a touch screen 57
cm away. They pointed to successive visual targets appearing
randomly on the monitor at 0° or 10° of visual angle toward the
left or the right (90 targets, 30 per position). Patients pointed to
each visual target as quickly as possible using their right index
finger, starting from their chest. A horizontal occluding board
allowed patients to see only the terminal part of each pointing
movement (which enhances PA).

To assess any aftereffects of PA, two open-loop measures were
also taken, one before PA (pre-PA) and one after PA (post-PA).
During these measures, comprising 10 trials per position, patients
could not see the endpoint of pointing movements because the
occluding board now contacted the screen.

Results. Prism adaptation was measured by comparing the av-
erage pointing error, as recorded by the touch screen, between the
first and last five trials of the PA session for each target position.
Pointing errors were always larger in the first than the last five

Table 1 Patients’ clinical and demographic data

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Lesion</th>
<th>Visual field</th>
<th>Strength</th>
<th>Letter cancellation</th>
<th>Star cancellation</th>
<th>Mesulam cancellation</th>
<th>Line bisection</th>
<th>Visual extinction</th>
<th>Tactile extinction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>69</td>
<td>T I Th BG Infarct</td>
<td>LHH</td>
<td>4</td>
<td>6/4</td>
<td>–</td>
<td>19/11</td>
<td>7/0</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>F T P W Craniotomy</td>
<td>LHH</td>
<td>1</td>
<td>–</td>
<td>0/0</td>
<td>14/4</td>
<td>26/18</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>64</td>
<td>W Ic Infarct</td>
<td>LIQ</td>
<td>2</td>
<td>–</td>
<td>5/4</td>
<td>20/16</td>
<td>6/4</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>57</td>
<td>F T P Infarct</td>
<td>LIQ</td>
<td>4</td>
<td>–</td>
<td>22/5</td>
<td>17/16</td>
<td>1/–5</td>
<td>–</td>
<td>+</td>
</tr>
</tbody>
</table>

All lesions were in the right hemisphere and occurred 4 to 24 months previous to testing.

T = temporal; P = parietal; T = temporal; O = occipital; I = insula; Th = thalamus; IC = internal capsule; BG = basal ganglia; W = subcortical white matter; LHH = left homonimous hemianopia; LIQ = left inferior quadrantanopia.

Strength scores are reported according to the MRC scale for Grading Muscle Strength (score 5 = no deficit). Neglect assessment was performed by means of three standard tests: either Star cancellation or Letter cancellation, line bisection, and Mesulam random shape cancellation. Values represent the number of items omitted on the left side (for cancellation tasks), or the average percentage of right-
ward (positive values) or leftward (negative values) deviation from the objective midline (for line bisection); values are given for before
and after prism adaptation (PA), separated by a forward-slash (i.e., pre-PA/post-PA).
tactile perception should improve only after rightward but not rightward corrections and aftereffects in subjects, whereas in the sessions we now used a leftward optical prismatic shift (inducing dure and numbers of trials as described previously. Critically, to able to implement a more extended PA protocol in Patient 4, crease rather than decrease over successive trials. Third, we were extinction testing before PA, any trend was for extinction to in- over multiple tests performed before the PA protocol in all pa-

Finally, we also assessed visual extinction within Patient 4 be-fore and after each PA session. The computerized task consisted of detecting 15-ms color changes of target squares (1° visual angle) at 10° eccentricity. Visual extinction showed a similar improve-
to that found for tactile extinction after rightward (both sessions at p < 0.05) but not leftward prismatic shift.

**Discussion.** Our results show that PA (specifically to a rightward optical shift) can significantly improve perception of contralesional tactile stimuli in neglect patients with right hemisphere strokes. Im-

The results also show that the beneficial effects of PA are not restricted merely to visuomotor tasks but can also affect perception in nonvisual modalities in tasks not requiring spatial exploration. PA may have benefited our patients by influencing the high-level, multimodal representations associated with spatial attention, possibly in the parietal lobe, which can be activated by PA. Its beneficial influences on somatosensory and visuomotor deficits suggest a potential role for PA in rehabilitation of patients with multiple aspects of neglect.

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### References

6. Rode G, Rossetti Y, Boissin D. Prism adaptation improves representa-

<table>
<thead>
<tr>
<th>Patient (session)</th>
<th>Bilateral (unilateral)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before PA</td>
<td>After PA</td>
</tr>
<tr>
<td>1 (rightward shift)</td>
<td>25</td>
</tr>
<tr>
<td>2 (rightward shift)</td>
<td>11</td>
</tr>
<tr>
<td>3 (rightward shift)</td>
<td>54</td>
</tr>
<tr>
<td>4 (rightward shift 1)</td>
<td>22 (28)</td>
</tr>
<tr>
<td>4 (leftward shift 1)</td>
<td>22 (33)</td>
</tr>
<tr>
<td>4 (rightward shift 2)</td>
<td>11 (33)</td>
</tr>
<tr>
<td>4 (leftward shift 2)</td>
<td>16 (39)</td>
</tr>
</tbody>
</table>

Values represent the percentage of correctly reported left tactile stimuli on bilateral (or unilateral; in parentheses, only for pa-
tient 4) presentations, before and after PA. Top four rows show results of PA with rightward optical displacement for each pa-
tient. Bottom three rows show results for each successive session of PA in Patient 4, one with leftward and two with rightward optical prismatic shift (each session separated by a week). Perfor-

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