Bilateral vestibular stimulation does not improve visual hemineglect

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Received 16 March 2001; accepted 5 September 2001

Abstract
This work compared the effect of unilateral (right and left) and bilateral vestibular stimulation in a right-brain-damaged patient with neglect. Neglect was improved following left caloric vestibular stimulation, and worsened following right vestibular stimulation. On the other hand, no modification of neglect was observed after bilateral vestibular stimulation. These results support the idea that caloric vestibular stimulation may improve neglect through a specific effect; bilateral stimulation making the putative activation bilateral and symmetrical does not affect the lateral bias of neglect. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Neglect; Vestibular stimulation; Vestibular cortex

1. Introduction

Hemineglect may be temporarily alleviated by unilateral vestibular stimulation [6]. Improvement not only concerns extrapersonal and personal neglect, but also the somatosensory and motor deficits often seen in association with the syndrome [9]. Furthermore, other components of the neglect syndrome, such as neglect of representational space, anosognosia and somatoparaphrenic delusions may temporarily be reduced by vestibular stimulation. These results suggested that vestibular stimulation may have selective cognitive effects in restoring a symmetrical activity in the neural mechanisms updating the internal representation of egocentric and personal space [5,9]. This theory challenges the traditional view that reduction of hemineglect through vestibular stimulation could result from a decrease in hypoactivation of the lesioned right hemisphere [3].

In order to give support to one or the other hypothesis, we compared the effects of a unilateral (right or left) and bilateral vestibular stimulation in a case of visual neglect.

2. Methods

A 71-year-old, right-handed man (J.S.) was admitted to hospital in November 1998 for acute left hemiparesis. Clinical examination revealed a left homonymous hemianopia, a left-sided visual hemineglect and anosognosia. Head and gaze were deviated to the right, but the patient could move the eyes towards the left on both verbal command and during visual pursuit. A CT-scan performed 2 months post onset showed a hypodensity in the right parieto-occipital region, consistent with an infarct in the territory of the posterior cerebral artery.

Neuropsychological examination was performed 1 month after the onset and revealed a persistent left-sided visual hemineglect. J.S. showed evidence for a left hemineglect and anosognosia. Head and gaze were deviated to the right, but the patient could move the eyes towards the left on both verbal command and during visual pursuit. A CT-scan performed 2 months post onset showed a hypodensity in the right parieto-occipital region, consistent with an infarct in the territory of the posterior cerebral artery.

Neuropsychological examination was performed 1 month after the onset and revealed a persistent left-sided visual hemineglect. J.S. showed evidence for an impairment on all assessment tests. The patient omitted most of the left side when asked to draw a daisy. He failed to complete the clock-face on the same side. On a line-cancellation test, the patient omitted to cross the left and middle section of the test sheet. Requested to bisect horizontal lines, he placed his transections significantly to the right. However, the patient did not show a left-sided neglect for personal space. Mental evocation of the map of France from memory did not show neglect of representational space [5]. At the time of examination, the patient was quite alert, well oriented in time and cooperative. He had mild hemiparesis and anosognosia for the motor deficit and the visual deficit had disappeared.
Table 1

Results of the three assessment tests in a case of left visual hemineglect before and after a bilateral vestibular stimulation (pre- and post-test 1), a left stimulation (pre- and post-test 2) and a right stimulation (pre- and post-test 3).

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Pre-test 1</th>
<th>Post-test 1</th>
<th>Pre-test 2</th>
<th>Post-test 2</th>
<th>Pre-test 3</th>
<th>Post-test 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line-cancellation</td>
<td>11</td>
<td>7</td>
<td>10</td>
<td>31</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>Line-bisection</td>
<td>87.2</td>
<td>93.2</td>
<td>89.6</td>
<td>62.8</td>
<td>73</td>
<td>97.5</td>
</tr>
<tr>
<td>Copying test</td>
<td>4</td>
<td>4.5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Vestibular stimulation was performed by using a cold ear caloric stimulation. The patient was lying in his bed and his head was pitched approximately 30° forward. He was blindfolded. During stimulation, the room illumination was decreased. The external ear canal was irrigated with 60 cm³ of cold (20°C) water for 30 s. Three caloric stimulations were performed with a 24 h delay between each stimulation. A simultaneous right and left external canal irrigation was performed at day 1 (test 1), a left irrigation at day 2 (test 2) and a right irrigation at day 3 (test 3). For each session, visual neglect was assessed by the same procedure as before (pre-test 1, 2 and 3). Three different assessment tests were used: a line-cancellation test [1], a line-bisection test [7] and a copying test [4]. For the line-cancellation test, we measured the number of canceled lines; for the line-bisection test, we used the score calculation proposed by Schenckenberg et al. [7], expressing the mean percentage of horizontal deviation to the right (signed positive) or to the left (signed negative). This score reflects the bias in bisecting the 20 horizontal lines of the testing sheet. A value close to 100% corresponds to a shift of the deviation to the end of the right side. For the copying test, the number of items drawn symmetrically by the patient was noted. Each parameter was thus measured in each pre- and post-test and compared between the two conditions using a t-test. In normal subjects, unilateral cold water irrigation produces a horizontal nystagmus lasting about 3 min and directed towards the side of the irrigation. The total duration of testing did not exceed this 3 min delay and was compatible with the experimental procedure.

3. Results

The results are summarized in Table 1. Before stimulation, the patient showed a florid visual hemineglect as shown by numerous omissions in the line-cancellation test and a shift of the mean deviation to the right in the line-bisection test in pre-test 1 and 2. In pre-test 3, the respective values were less important. This may be due to the repetition of the task, for three consecutive days, rather than a sustained effect of left caloric vestibular stimulation from the previous day. In the copying test, J.S. omitted to draw the left half of two

Fig. 1. Copying test before (a) and after (b) a right caloric vestibular stimulation. The patient is required to copy a drawing made of five items. Following the stimulation, the patient omitted to draw the left half of house and the drawings are tilted to the right side.
items out of five in the pre-test 1 and 2. In the pre-test 3, the copy was complete. Following the unilateral caloric vestibular stimulation, there was no significant modification of neglect, as assessed by the three scores. Comparison of mean deviation in the line-cancellation test by a t-test did not reveal a significant difference ($t = -1.29, P > 0.05$). No horizontal or vertical nystagmus was observed.

Following the left caloric vestibular stimulation, neglect improved, as shown in the line-cancellation test (24 additional canceled lines) and in the line-bisection test, with a 26.8% reduction of mean rightward deviation ($t = 4.75, P = 0.0001$). No effect was observed in the copying test. The left unilateral cold water irrigation produced a rightward horizontal nystagmus of about 3 min duration.

Following the right caloric vestibular stimulation, a worsening of neglect was observed in the line-cancellation test (the patient canceled only one line, located to the rightmost part of the sheet) and in the line-bisection test, a 22.5% increase of mean rightward error ($t = 5.53, P = 0.0001$). Moreover, a left object-based hemineglect was induced by the stimulation (Fig. 1). The right unilateral cold water irrigation produced a left beating horizontal nystagmus of about 3 min duration as well as an increase of the head and gaze deviation to the right.

4. Discussion

Our results support the idea that vestibular stimulation may improve hemineglect through a specific effect. As previously reported by Rubens [6], cold water in the left ear improves visual hemineglect, whereas, cold water in the right ear worsens the deficit. In the same patient, we showed that a cold water irrigation simultaneously on the two ears does not modify visual hemineglect. In this case, the reversibility of deficit through vestibular stimulation cannot be simply explained by a better ability to maintain arousal. The effects produced by the left or right ear stimulation are comparable in magnitude, as shown by the comparison of scores in the line-cancellation and -bisection tests, between sessions 2 and 3. So, we suggest that the effectiveness of vestibular stimulation in hemineglect syndrome results from specific activation of subcortical and cortical structures integrating vestibular information. At subcortical level, the differential activation of vestibular nuclei could influence the level of hemineglect by ‘peripheral’ (vestibulo-ocular) effects. The positive and negative effects of vestibular stimulation are indeed related to the direction of the slow phase of nystagmus, rather than to the irrigated side. Therefore, the improvement (or worsening) of visual neglect could depend on the facilitation (or the reduction) of leftward lateral gaze and on past-pointing to the left. At the cortical level, the asymmetrical cerebral hemispheric activation (predominantly contralateral) after unilateral vestibular stimulation could influence the intensity of hemineglect through cognitive effects [2]. We rather suggest that they depend on the removal (or the accentuation) of rightward distortion of the egocentric coordinates (Fig. 1). Left vestibular stimulation may favor the restoration of a symmetrical activity in the neural mechanisms supporting the internal representation of egocentric and personal space [5,9], as suggested by the reversibility of representational hemineglect, the reduction of somatosensory or motor deficit showed by right-brain patients or the partial remission of a right visual hemineglect in a left brain-damaged patient with dysphasia after vestibular stimulation [8]. On the other hand, bilateral vestibular stimulation making the putative activation bilateral and symmetrical does not affect the lateral bias of neglect.

Acknowledgements

The authors wish to thank Jason Mattingley for his comments on an earlier version of this manuscript.

References