**Effect of Posture on the Perception of Verticality in Neglect Patients**

Arnaud Saj, PhD; Jacques Honoré, PhD; Jessy Davroux, PhD; Yann Coello, PhD; Marc Rousseaux, MD, PhD

**Background and Purpose**—The anticlockwise (ACW) deviation of the visual and visuohaptic subjective verticals (SVs), known to occur in patients with right hemisphere lesion, is amplified by spatial neglect (N). These patients have only been assessed when sitting. We investigated the hypothesis that postural changes modulate visuohaptic SV deviation.

**Methods**—Eight patients presenting with a right hemisphere lesion and spatial N were compared with 6 matched control subjects (C). In the dark, they had to rotate a luminous rod to put it at the vertical in 4 conditions: (1) sitting with plantar sole support; (2) sitting without plantar sole support; (3) sitting with legs extended on a support; and (4) supine position.

**Results**—N patients showed a significant ACW deviation (−4.5°) of the SV compared with C subjects (+0.01°). The effect of body position depended on the group (P=0.022) because changes had definite effects in the N but not in the C group. In fact, the former showed a reduction of the ACW deviation, from the first to the fourth condition.

**Conclusions**—Although the possible role of plantar and leg somaesthetic inputs remains to be thoroughly investigated, the modulation of gravitational inputs at trunk or vestibular level influences the SV deviation in N patients. This has to be put in relation with the modulation of N signs reported by other authors when passing from the sitting to the supine position. *(Stroke. 2005;36:2203-2205.)*

**Key Words:** hemispatial ■ neglect ■ posture ■ stroke ■ visual vertical

The perception of body orientation relative to earth gravity requires integration of information provided by vestibular, visual, proprioceptive, and tactile signals. Continuous exposure to these covariant signals during static and dynamic postures provides multimodal configurations of indices corresponding to a great variety of body orientations.

The subjective vertical (SV) seems liable to interaction with body orientation. When assessed in the visual modality, SV corresponds to the orientation of a visual stimulus perceived as earth vertical (in the absence of relevant visual cues). This SV is known to depend on actual body orientation according to well-established effects. Although it is precise and accurate in upright healthy subjects, the visual SV is biased in roll-tilted subjects. In patients with right hemisphere injury, the visual SV was evaluated only when sitting, head upright, with methods providing or not providing additional tactilo-kinesthetic cues. An anticlockwise (ACW) deviation occurred, which was amplified when the lesion causes a spatial neglect (N) syndrome.

In the present experiment, we investigated whether the modulation of gravitational inputs conveyed by the otolithic and somatosensory systems affects the deviation of the visual SV in N. In fact, we compared 4 body configurations, from sitting to supine conditions. Thus, the perception of SV of right brain–damaged patients with spatial N was assessed with a visuohaptic method when: (1) sitting with plantar sole support (SS); (2) sitting without plantar sole support (SNS); (3) sitting with legs extended (SLE); and (4) lying in supine position. In the second condition, the plantar input was suppressed; in the third, the proprioceptive input from legs was also suppressed; and in the last only, otolithic influence was changed.

**Subjects and Methods**

**Subjects**

Patients were recruited in the neurological rehabilitation department of Le Centre Hospitalier Universitaire de Lille. They were informed of the protocol and signed an informed consent form before inclusion. All had experienced a relatively recent right hemispheric hemorrhagic or ischemic stroke, demonstrated by MRI or computed tomography scan.

Patients with bilateral lesions, previous neurological or psychiatric disorders, impairment in primary visual perception, behavioral disorders, motor difficulties in the right upper limb, or psychotropic treatment and pusher syndrome were not included in the study. The pusher syndrome (ie, severe contralateral trunk deviation with active resistance to any attempt of external correction) was evaluated with the Scale for Contraversive Pushing and patients’ self-report of instability in a correct sitting position. They were regarded as pusher if they scored $>3$ on this scale and reported a feeling of rightward
imbalance in vertical position, with and without perception of the visual environment.

Spatial N was assessed using bell cancellation, line bisection, and scene copy tests. Patients were considered N when performance was pathological in ≥2 of the 3 tests.

Eight N patients (mean age 61.0 years) were compared with 6 right-handed healthy control subjects (C; 51.0 years). Hemianopia was observed in 5 of 8 cases and somatosensory disorders in 8 of 8 cases (Table). Two of these patients (D and F) participated in a previous study that compared SV in pitch and in roll after a right hemispheric stroke.

### Experimental Setup

The subject was installed on a chair or a medical device that enabled testing in sitting or supine positions. In fact, there were 4 conditions: (1) SS; (2) SNS; (3) SLE; and (4) supine position. The head, aligned with the trunk, was fixed by a headrest with lateral stabilizers; it was slightly raised when lying. The left arm was placed along the left thigh and maintained by a scarf in patients with severe hemiplegia. An abdominal strap helped to maintain a vertical position when sitting.

A metal rod (25-cm long, 1.5-cm wide, 1.5-cm thick) that could rotate in roll plane (relative to the participant) was placed before a vertical black panel. A fixed metal disk (25 cm in diameter), centered on the rotation axis and inserted between the rod and the panel, avoided tactilo-kinesthetic cues that could be given by the panel. A precision potentiometer, mounted in the rotation axis, was connected on the rotation axis and inserted between the rod and the panel, avoided tactilo-kinesthetic cues that could be given by the panel. A precision potentiometer, mounted in the rotation axis, was connected to an electronic device that displayed the angle between the rod and the vertical (error in tens of degrees). Positive values corresponded to clockwise deviations, negative values to ACW deviations. Rotation was limited on each side by a stop situated at 110°. Ten red diodes (2-cm long, 0.5-cm wide) were inserted in the rod. All parts of the apparatus (rod included) were centered relative to the midsagittal plane of the participant. The distance between the participant and the middle of the rod was similar in the 4 different conditions.

### Procedure

Participants were tested individually in a quiet, dark room. During the task, only the rod was visible, and the participant had to set it to the vertical, holding it in the middle with the right arm half-extended (visuohaptic method). Time was not limited, but task completion was fast, whatever the group. Three initial tilts of the rod (0°, −45°, and +45°) were used twice. Thus, there were 6 repetitions per body position. The participant had his/her eyes closed during the setting of the initial tilt. No information was given on performance. Trials were separated by ~20 seconds. The order of initial tilt of the rod and the order of positioning were counterbalanced.

### Statistical Analyses

For each participant and each body position, the 6 repetitions recorded were averaged. The ANOVA (Statistica software) performed on the resulting means included the factors group (2 groups) and body position (4 positions). Post hoc analyses used the Newman–Keuls test. The α-risk was fixed at P<0.05.

### Results

The effect of group was significant (F(1,12)=10.91; P<0.001). Healthy participants accurately adjusted the rod to the vertical (mean±SD: 0.01°±0.3°). N patients inclined the rod in the ACW direction (−4.5°±1.6°). The significant group×body positions interaction (F(3,36)=3.07; P=0.022) revealed that the posture effect differed between groups. As the Figure suggests, posture did not affect the SV of C group. On the contrary, the N group presented with a decrease in the ACW deviation, from the SS to the SNS, the SLE, and the supine position; the linear trend was significant (F(1,7)=9.32; P=0.018) and explained 95% of the variance of body position factor. Post hoc analysis showed that the visuohaptic

---

**Clinical and Demographic Data of the Patients**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Years of Schooling</th>
<th>Days Since Stroke</th>
<th>Aetiology</th>
<th>Lesion Site</th>
<th>Scene Copy</th>
<th>Bell Cancellation L</th>
<th>Bell Cancellation C</th>
<th>Bell Cancellation R</th>
<th>Bisection Line %</th>
<th>Neglect</th>
<th>Hemianopia</th>
<th>Sensory Disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>77</td>
<td>M</td>
<td>8</td>
<td>95</td>
<td>I</td>
<td>F, P, T, R, Co, Cl, S</td>
<td>4</td>
<td>10 3 9 61.5 Yes Yes No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>61</td>
<td>M</td>
<td>7</td>
<td>180</td>
<td>I</td>
<td>F, P, T, R, O, CO, IC, S</td>
<td>4</td>
<td>15 5 7 92.0 Yes No Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>54</td>
<td>M</td>
<td>8</td>
<td>150</td>
<td>I</td>
<td>F, P, T, R, Co, Cl, S</td>
<td>4</td>
<td>15 2 1 44.9 Yes No Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>48</td>
<td>M</td>
<td>10</td>
<td>95</td>
<td>H</td>
<td>T, CO, IC, S</td>
<td>4</td>
<td>15 5 4 60.0 Yes Yes Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>51</td>
<td>M</td>
<td>22</td>
<td>60</td>
<td>H</td>
<td>P, R, CO</td>
<td>4</td>
<td>15 5 9 49.2 Yes Yes Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>66</td>
<td>F</td>
<td>7</td>
<td>32</td>
<td>I</td>
<td>F, CO, IC, S</td>
<td>4</td>
<td>15 5 5 67.0 Yes Yes Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>79</td>
<td>F</td>
<td>20</td>
<td>45</td>
<td>I</td>
<td>F, P, T, R, O, Co</td>
<td>4</td>
<td>5 3 0 83.1 Yes Yes Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>54</td>
<td>M</td>
<td>10</td>
<td>90</td>
<td>H</td>
<td>P, T, R, O, Co</td>
<td>4</td>
<td>8 1 0 30.1 Yes Yes Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Years of schooling since the age of 6.

Aetiology: H, indicates hemorrhagic; I, ischemic.

Lesion site: F indicates frontal; P, parietal; T, temporal; R, rolandic; CO, centrum ovale; IC, internal capsule; S, striatum; Th, thalamus.

Scene copy: The scene includes 4 distinct elements from the left to the right of the sheet: a fir tree, a barrier, a house, and another tree. Performance is coded as: 0, no omission; 1, omission of element(s) of the house; 2, omissions of the left half of the house or of the tree; 3, omissions of the tree; and 4, omission of the half of another element.

Bell cancellation: No. of omitted bells in the left (L; 15), central (C; 5), and right (R; 15) parts of the test sheet.
SV in the SS, SNS, and SLE positions was significantly different from that observed in the supine position ($P<0.05$).

**Discussion**

The aim of the study was to assess the role of otolithic and somatosensory afferences in the perception of the visuo-haptic SV among N patients. We showed that progressive change in body positioning, from the sitting to the supine position, associated with a reduction of graviceptive inputs, resulted in a progressive reduction of the visuo-haptic SV bias of N patients.

To the best of our knowledge, this effect has never been reported in the literature. In fact, the only available information is about the effect of body position on another clinical aspect of spatial N, ie, the ipsilateral deviation in line bisection. In 8 patients with N, Pizzamiglio et al$^{15}$ investigated the influence of body position on the patients’ ability to bisect lines. This latter was measured when the body was either in an upright body position (sitting) or in a supine position. The rightward directional error found in the upright position ($+6.3$ cm or $5.1^\circ$ of visual angle) was significantly reduced in the supine position ($+2.9$ cm or $2.4^\circ$ of visual angle). A similar tendency, although not significant, was observed in a study by Karnath et al,$^{16}$ with a reduced exploratory bias to the right when patients were pitched $30^\circ$ backward. Data from Pizzamiglio et al$^{15}$ suggest that this tendency could have been more pronounced if patients were placed in a full supine position.

Pizzamiglio et al$^{15}$ interpreted their finding as evidence that the gravitational input from the left and right otolithic system may be processed in a nonsymmetrical fashion by the neural circuits disrupted by a unilateral cerebral lesion. They assumed that the reduction of the otolithic input obtained when placing patients in the supine position reduced the ipsilesional distortion of a higher-order representation of space. In fact, the literature suggested that otolithic input is reduced in a supine position$^{17}$ or when the head is pitched backward with subjects in a standing position.$^{18}$

The outcome of our study is consistent with the view that supine position results in a reduction of the otolitic influence. However, the somatosensory changes occurring when passing from the lying to the sitting position could also play a role. Indeed, an influence of somatosensory inputs was suggested by the effect of limb manipulation and deserves further investigation. The role of somatosensory afferences have been emphasized by other authors for explaining the modulation of the subjective visual vertical resulting from lateral body tilt in patients with bilateral peripheral vestibular lesion.$^{19}$ By analogy with the hypothesis put forward about vestibular input,$^{15}$ one may consider that reducing somato-sensory input could reduce the deficit because of a processing system biased by the lesion.

Concerning rehabilitation, the present study suggests that patients could benefit from performing exercises in supine position at the beginning of care, before they pass to the sitting position.

**References**

Effect of Posture on the Perception of Verticality in Neglect Patients
Arnaud Saj, Jacques Honoré, Jessy Davroux, Yann Coello and Marc Rousseaux

Stroke. 2005;36:2203-2205; originally published online September 15, 2005;
doi: 10.1161/01.STR.0000182236.73502.19
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2005 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://stroke.ahajournals.org/content/36/10/2203

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org//subscriptions/