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# Different spatial processing for stimulus-centered and body-centered representations

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**Abstract**—The authors describe a patient who experienced two successive strokes in the right hemisphere. After the first stroke, she showed stimulus-centered left neglect confined to right space on a circle discrimination task, which resolved. After the second stroke, she showed body-centered left neglect on the same task. These observations of two types of left neglect in the same patient suggest there are at least two distinct spatial attentional systems in the brain: global and focal attentional systems.

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Unilateral spatial neglect (USN) is characterized by a failure to notice stimuli presented in the contralateral space.<sup>1,2</sup> According to the reference frame theory, left USN can be divided into body-centered left neglect (BCLN)<sup>3,4</sup> and stimulus-centered left neglect (SCLN).<sup>5,6</sup> BCLN is defined as less response toward the left space of the trunk's midsagittal plane compared with the right. SCLN is defined as failure to notice the left side of a stimulus, irrespective of its spatial location in relation to the body. Recently, we confirmed the double dissociation of these two symptoms with one task,<sup>7</sup> which suggests that spatial attention mechanisms operating with respect to the body and with respect to a particular stimulus are independent of each other. We herein report on a patient who showed different manifestations of USN after two successive strokes.

**Case report.** An 82-year-old, right-handed woman developed a right cerebral infarction on January 11, 1999. Sensation of touch was intact, but sensation of pain was mildly disturbed on the left side. She showed a left homonymous hemianopia and left USN on a line bisection task but not on a circle cancellation task.<sup>8</sup> On a double daisy copying task<sup>9</sup> (daisy task), she failed to copy the left side petals of both flowers, and more petals were omitted on the right flower than on the left. On double simultaneous stimulation, she showed extinction on the left to auditory and tactile stimuli. A prosopagnosia was also present. An MRI revealed an infarction in the right posterior cerebral artery (PCA) region (figure 1).

Five months after the first stroke, she again developed a right cerebral infarction. She showed a left facial palsy and moderate sensory disturbance of touch and pain on her left side, in addition to the left homonymous hemianopia. She showed left USN on the line bisection test and on the circle cancellation task. On the daisy task, she neglected the left flower completely and copied the right flower omitting petals on the left side. An MRI obtained 5 months after the second stroke showed an infarction in the right middle cerebral artery (MCA) region adjacent to the old lesion (figure 2).

**Materials and methods.** We used a circle discrimination task<sup>7</sup> (CDT) to qualify and quantify the types and degree of USN. Stimuli were composed of three types of circles (15 mm in diameter): left side missing circle, complete circle, and right side missing circle. Twenty circles of each type were arranged in a pseudo-random manner on a sheet of paper (29.7 × 42 cm). Six trials were given for one evaluation. Evaluations were performed during month 3 and month 4 after the first stroke and month 2 after the second stroke. The patient was seated at a desk and instructed to circle every complete circle and to cross out every incomplete circle. The stimulus sheet was placed on the desk at midsagittal plane of the patient's body. No restriction was imposed on movement of the head or eyes. When she finished a task, she was encouraged to reconfirm that all the items were satisfactorily checked. There was no time limit.

Failure to circle or cross out figures on the left side of a paper was regarded as BCLN. Circling of a left side missing figure was regarded as SCLN. To evaluate BCLN and SCLN, the number of figures correctly circled or crossed out was calculated for space and types of circle. We analyzed the data using two-way analysis of variance (ANOVA) with the body-centered frame (left and right space) and stimulus-centered frame (left side missing, complete, and right side missing circle).

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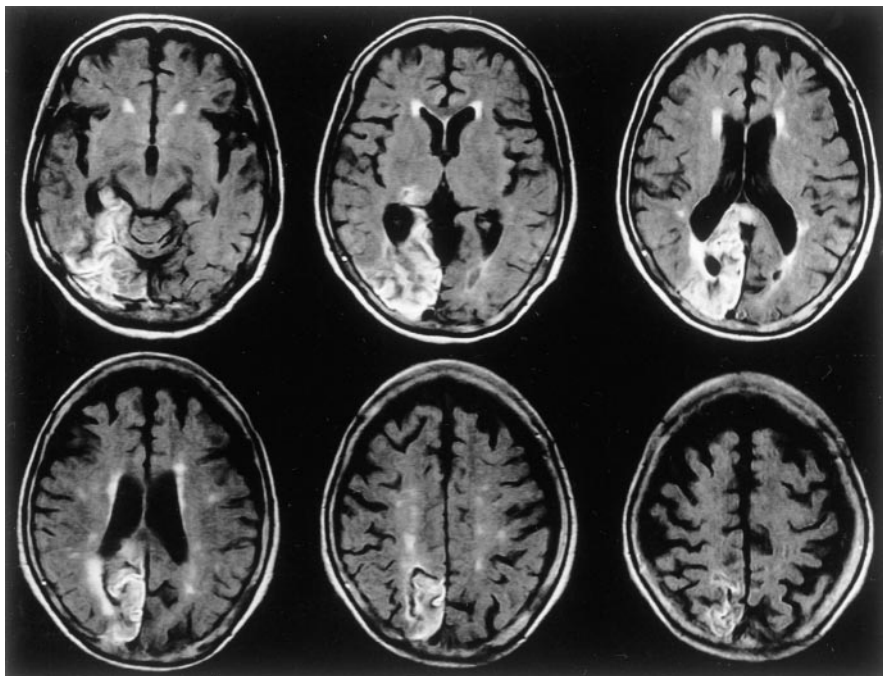


Figure 1. Brain MRI (FLAIR) performed 1 month after the first stroke. The lesion was located mainly in the right cuneus, precuneus, lingual gyrus, parahippocampal gyrus, lateral occipital gyri, and the pulvinar. The left sides of the images depict the right side of the brain.

**Results.** In the first evaluation, ANOVA revealed a main effect of stimulus-centered frame [ $F(2,30) = 4.93$ ;  $p < 0.05$ ]. Post hoc analysis using Fisher's protected least significant difference (PLSD) revealed that the number of correct responses for left side missing circles ( $17.50 \pm 2.88$ ) was fewer than for complete circles ( $19.33 \pm 1.03$ ;  $p < 0.05$ ) and right side missing circles ( $19.67 \pm 0.52$ ;  $p < 0.01$ ). Furthermore, there was an interaction between these two factors [ $F(2,30) = 8.69$ ;  $p < 0.005$ ], indicating that there was an effect for stimulus-centered frame on the right space [ $F(2,15) = 9.42$ ;  $p < 0.005$ ]. Post hoc analysis using PLSD revealed the number of correct responses for left side missing circles ( $7.67 \pm 1.86$ ) was fewer than for complete circles ( $10.00 \pm 0.00$ ;  $p < 0.005$ ) and right side missing circles ( $10.00 \pm 0.00$ ;  $p < 0.005$ ) on the right space. In the second evaluation, the response for each target was almost correct, and there was no significant difference. In the third evaluation, ANOVA revealed a main effect for the body-centered frame [ $F(1,30) = 1095.20$ ;  $p < 0.001$ ] but not for the

stimulus-centered frame. There were fewer responses for the left space ( $1.17 \pm 1.60$ ) than for the right space ( $25.83 \pm 2.14$ ; figure 3).

**Discussion.** The patient experienced two cerebral infarctions in 5 months, first in the right PCA region and second in the right MCA region. After the first stroke, our patient showed SCLN only in the right space, but no BCLN was apparent on the CDT. This symptom soon resolved itself. After the second stroke, she developed BCLN, but no sign of SCLN was apparent on the CDT. This interesting course of events in terms of two types of left USN in the same patient suggests there are at least two different spa-

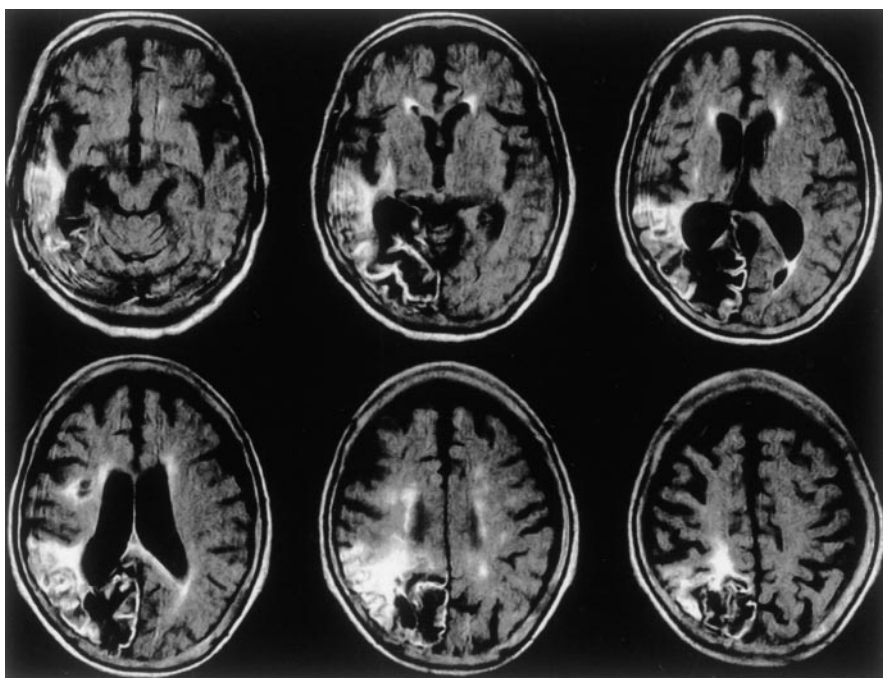


Figure 2. Brain MRI (FLAIR) performed 5 months after the second stroke. In addition to the old lesion, the new lesion was located mainly in the inferior parietal lobule, middle to the posterior part of the superior and middle temporal lobe.

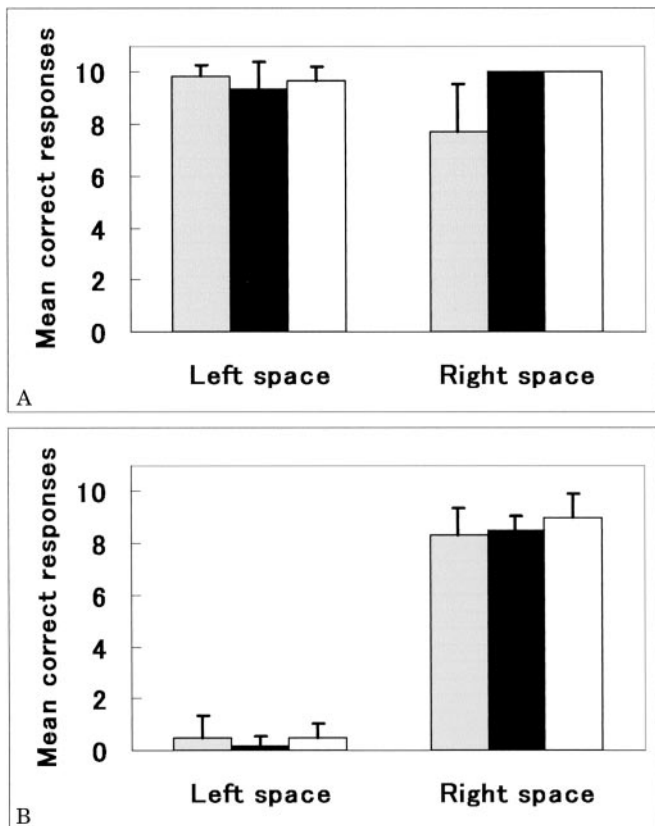


Figure 3. Mean number of correct responses for three types of stimuli in the left and right hemispaces: the first evaluation (A) and the third evaluation (B). Gray columns represent mean number of correct responses for circles that had a missing portion on their left side; black columns are for complete circles; and white columns are for circles that had a missing portion on their right side. The lines above each column represent the SD of the mean.

tial attentional systems in the brain, i.e., global and focal attentional systems.<sup>1</sup>

In the first evaluation, the patient's SCLN was confined to the right hemisphere. If we hypothesize that the focal attentional system of the right hemisphere lost part of its ability bilaterally but more toward the left, its distribution would be weakened but become symmetric to both sides. Because the focal attentional distribution of the left hemisphere remains biased toward the right, attention toward a

specific object would show rightward predilection only in the right hemisphere. A case report, which showed left USN after a stroke in the PCA region, manifested a similar set of symptoms to those of our patient.<sup>10</sup> This case and ours suggest that the focal attentional function in the PCA region is different from that in the MCA region. The disappearance of the symptom after the first episode may have been accomplished either by compensational decrease of the stronger rightward attention of the left hemisphere or by increase of the weakened leftward attention of the right hemisphere.

In the second stroke, the lesion extended laterally from the old lesion into the MCA region. This lesion may have destroyed the global attention system in the right hemisphere. Thus, our patient showed BCLN on the daisy task and the CDT. Because of the functional compensation of the focal attentional system after the first stroke, she may have been able to judge each stimulus in the right hemisphere on the CDT. More clinical data are required to confirm our hypothesis.

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