SHORT REPORT

The selective inability to draw horizontal lines: a peculiar constructional disorder

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Abstract

A patient is described who was affected by degenerative dementia and who developed severe constructional apraxia. She showed a dissociation between the construction of horizontal lines (impaired) and oblique or vertical lines (spared) which has never been reported previously. A battery of tests disclosed that this phenomenon was consistent across a range of experimental conditions and that a similar dissociation was evident in perceptual and representational domains. This peculiar clinical finding suggests that mental representations of horizontal and vertical spatial relations in an egocentric coordinate system are functionally dissociated.

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Disorders of constructional abilities are very common in the course of degenerative dementia.¹ Patients become unable to reproduce (by drawing or assembling) two or three dimensional models and their attempts to do so may contain gross spatial distortions. During diffuse progressive cognitive decline, constructional apraxia and related visuospatial impairments may also be the first prominent symptoms.² Such cases may provide an interesting contribution to the development of the cognitive models of visuospatial processing. A recent study on a patient with progressive visuospatial impairments has showed that the ability to represent visual information in a body centred reference frame may be selectively disrupted in the absence of any defect of visual exploration.³

In the present paper we describe a striking, previously unreported dissociation in a patient with prominent constructional and visuospatial impairment in the context of a dementing illness. Our patient could draw oblique or vertical lines but was selectively unable to draw horizontal lines. As we could also show this dissociation in perceptual and representational domains, we argue that mental representations of horizontal and vertical spatial relations in an egocentric coordinate system may be functionally dissociated.

Case report

A 60 year old right handed woman began having problems with household duties in August 1994. Within one year, she was no longer independent in her daily life activities and had developed memory impairments. She first came to our notice in October 1995. On clinical examination, she was well oriented in time and space and could cope with verbal commands. She could identify objects visually, and had normal ocular movements in horizontal and vertical planes both to visual targets and to command. However, she was unable to use tools or to imitate or execute gestures on verbal command with her left hand (ideomotor apraxia), could not dress herself (dressing apraxia), and had mild bilateral extrapyramidal hypertonia in her upper limbs. Brain MRI showed diffuse cerebral atrophy and SPECT disclosed a reduced blood supply bilaterally in the parietal regions (although more so on the right side). Such findings are compatible with a diagnosis of "probable" Alzheimer's dementia.⁴

Formal neuropsychological testing disclosed mild anomia as the only language impairment, and severe apraxic agraphia. The patient did not show neglect in spatial exploration tasks (line and letter cancellation, sentence reading),⁵ although her reading and cancellation procedures were erratic (for instance, she skipped some words or parts of words during the sentence reading task). When asked to bisect horizontal lines the patient tended to mark one or the other extreme, or points very close to them, without any consistent bias toward left or right. She achieved pathological scores on standardised tests⁶ assessing short term and long term visuospatial memory (span and supraspan learning on the Corsi block tapping task), and abstract reasoning both in the visuospatial (Raven's matrices) and verbal domain (proverb interpretations, analogy and difference detections, concept classifications, numerical judgments, verbal fluency). Her score on the mini mental state examination⁷ was below the normal range (20/30).

Her outstanding impairment was a gross inability to draw (constructional apraxia). In copying the geometrical figures (for example, a cube) of a standardised test⁸ the patient produced severely distorted drawings, obtaining very poor raw scores, well below the age and education adjusted normal range. The

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Examples of graphomotor performance. (A) From left to right copying a circle, a triangle, and a cross; (B) joining pairs of dots, (B1) vertically, or horizontally aligned, at different distances, (B2) 20, 5, and 2 cm trials from top to bottom; (C) from left to right, attempts at drawing a trapezium, a triangle, and a cross by joining three or more dots.

emergence of a striking dissociation between the reproduction of horizontal (impaired) and oblique or vertical (spared) lines warranted a detailed examination of her performance.

Methods

Our examination was aimed firstly at verifying whether the dissociation between drawing horizontal and vertical lines was consistent across different experimental conditions. Then we tried to ascertain whether such a phenomenon was replicable in other, non-graphical, executive tasks. Lastly we assessed visuoperceptual and representational abilities to verify whether the patient had selective difficulties in dealing with horizontally aligned stimuli.

Because testing was always (except on one occasion) conducted in the horizontal plane with stimuli situated at reaching distance below eye level, oblique and vertical lines pointed in a radial direction away from the subject. However, for simplicity's sake we will use the terms oblique and vertical throughout the paper. The patient used her right hand to carry out execu-

tive tests, as motor control of her left hand was impaired.

GRAPHOMOTOR TESTS

The patient was asked to: (1) copy and draw to command 10 simple geometrical figures (for example, square, triangle, cross); (2) copy 20 vertical lines, 20 horizontal lines from left to right, and 20 horizontal lines from right to left; (3) join 20 pairs of dots arranged vertically (10 cm apart), 20 pairs of dots arranged obliquely (10 cm apart), and 80 pairs of dots arranged horizontally (placed 2, 5, 10, or 20 cm apart); (4) construct 10 simple geometrical drawings joining three or more points; (5) track 10 vertical and 10 horizontal lines (trace stimuli with a pen).

Results

The figure shows examples of the patient's graphomotor performance. She was always unable to complete the horizontal segments of geometrical figures in copying and drawing tasks; for instance, in copying a cross she first drew the vertical arm and then was unable to complete the horizontal one. She could copy vertical and oblique lines correctly but was unable to copy any horizontal line, even when the task required drawing from right to left. In "join the dots" tasks the patient's performance was spared when vertical or oblique movements were required, but was unable to join dots arranged horizontally, regardless of their distance (20, 5, or 2 cm); she could point out the dots and start drawing correctly but then seemed to get lost and deflected from the horizontal direction erratically, without completing any horizontal line. In the last task the patient could keep track of all vertical lines, but was never able to trace the horizontal lines from one end to the other.

On informal inquiry, the patient seemed unable to judge whether her attempts at drawing horizontal lines were accurate.

OTHER EXECUTIVE TESTS

The patient was then asked: (1) to position a stick horizontally or vertically on a table (10 trials for each task); (2) to point to pairs of dots arranged horizontally or vertically on a blackboard on the wall in front of her and to trace an imaginary line joining them (10 trials for each task; only in this case, were the stimuli located beyond reaching distance and with the vertical axis corresponding to a sagittal plane).

Results

The patient proved unable to position the stick horizontally, placing it at varying angles inconsistently while she set the stick in the correct vertical position on eight of 10 trials. Analogously, the patient was never correct in performing horizontal movements to join dots on the blackboard, while she performed well on nine of 10 vertical trials.

VISUOPERCEPTUAL TASKS

We tried to assess the patient on a simple, two choice line orientation test, but she became confused and was reluctant even to report

Correct responses for visuoperceptual matching tasks with horizontally or vertically placed stimuli

	Vertical display	Horizontal display
Line length matching task	16/30	6/30
Nonsense shape matching	22/30	12/30
Token array matching	24/30	10/30

whether a single line was set horizontally; on the other hand, she identified vertical lines promptly.

The patient was then given three simple matching tasks with horizontally or vertically placed stimuli. (1) In a line length matching task the patient had to point out the segment with the same length as the stimulus (a segment 5 to 20 cm long) from among four alternatives; in 30 trials the four alternative choice display was placed either on the left or right of the stimulus, and in 30 trials the display either was placed above or below the stimulus. (2) The patient was asked to make same or different judgements for pairs of complex nonsense shapes; in 30 trials the two shapes were aligned horizontally, in 30 trials they were placed one above the other. (3) The patient was asked to make same or different judgements for pairs of five token (square or circle) linear arrays; in 30 trials the two stimuli were aligned horizontally, in 30 trials they were placed one above the other.

Results

The table shows the number of correct responses on visuoperceptual tasks. She performed at a chance level in the line length matching task when the choice display was placed to the left or the right of the stimulus, but she performed significantly better when it was positioned below the stimulus (χ^2 7.2, df 1, $p=0.007$).

In the two choice visuoperceptual matching tasks, the patient performed at a chance level in the horizontal condition but performed far better in the vertical condition (for shapes, χ^2 6.7, $p=0.009$; for tokens, χ^2 13.6, $p=0.003$).

Discussion

Our patient presented with a very unusual clinical picture. To summarise, she showed a selective inability to draw horizontal segments, independent of line length and the direction of hand movements, and analogous difficulties in non-graphical executive tasks. A similar detrimental effect of horizontality was seen in matching tasks tapping visuoperceptual and representational abilities.

Taken together, these findings exclude any interpretation of the phenomenon based on purely motor or intentional impairments. To account for both constructional and perceptual representational deficits more than one cognitive impairment ought to be hypothesised, but we suggest that a more parsimonious interpretation based on a single defect could explain the present findings.

Animal and human information processing models of spatial cognition postulate that elementary sensory data are transformed into a body centred framework to guide behaviour.⁸⁻¹⁰

The representation of the external world with respect to an egocentric reference frame could be likened to a mental spatial map. As mentioned above, it has been shown that the ability to build such a cognitive spatial map may be selectively disrupted in the absence of any defect of the exploratory activity.³

The possible functional dissociation of spatial representations along horizontal, vertical, and radial dimensions is postulated by a cognitive model, according to which the mental representation along each of the three axes is derived from the integration of different modality dependent information.¹¹

Our interpretation of the clinical behaviour in the present case combines both theoretical positions. We argue that within the cognitive system devoted to building an egocentric spatial representation of the external world, the representation of relations along horizontal, vertical, or radial axes are based on dissociable cognitive processes.

One of the main properties of the spatial representation system is to build a coherent organisation (a continuum) of points in space, and to generate reciprocal relations between the subject and external objects. Stimuli localised at different points in the visual field can be thus perceived as coexistent, because they occupy different locations within the same continuous mental representation of space—that is, they are embedded in the same cognitive map.

Our patient could be considered as having a selective impairment of the ability to mentally encode spatial relations along the horizontal axis. She showed good performance on exploratory tasks and pointed correctly to single stimuli without hesitation, showing that she had spared spatial attentional abilities and was able to localise stimuli with respect to her egocentric reference system. Her difficulty was evident when she had to create an ideal contiguity between two points along a horizontal axis. We suggest that the patient could not internally represent both points together, but did so as if they were lying in different “spaces”, so that she could not join them with a line. This severe difficulty in coding horizontal spatial relations probably generated her peculiar drawing pattern.

Our data could be also explained by hypothesising that the impairment lies in a single system devoted to the representation of spatial coordinates, affecting relations in the horizontal rather than in the vertical dimension. However, this interpretation would not readily account for the greater vulnerability of the horizontal dimension in the present patient. Moreover, such an explanation would have been more plausible if the patient had showed a consistent pattern of errors in graphical and executive tasks and if her performance had not shown a clear cut dissociation between horizontal and vertical axes in the graphical tests. We therefore maintain that the present case could be considered as the first instance of the selective impairment in the encoding of spatial relations along the horizontal axis.

As this representational and constructional disorder does not involve the vertical dimension, it is possible to argue that the cortical neural circuits devoted to representing the horizontal dimension are functionally and anatomically separate from those representing the vertical axis, as has been suggested for the attentional domain on the basis of similar dissociations between horizontal and vertical axes.^{12 13}

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