Visuospatial Judgment

A Clinical Test

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• **We constructed and developed a brief test assessing capacity for discriminating the direction of lines. Application of the test to patients with unilateral brain disease disclosed a remarkably high frequency of defective performance in those with right hemisphere lesions. The performance of patients with left hemisphere lesions was comparable to that of control patients. Brevity and ease of administration make the test convenient for clinical use.**

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In a recent report,[1] we described the findings of a study of the capacity of right-handed patients with unilateral brain disease to identify the slope of lines presented tachistoscopically for 300 msec to central vision. A remarkable high frequency of defective performance was found in patients with disease of the right hemisphere, while the performances of patients with left hemisphere disease were comparable to those of control patients without evidence or history of brain disease. The results were in line with expectations, in that previous studies have shown the dependence of performance level in directional tasks in both the visual and tactile modalities on the intactness of the right cerebral hemisphere.[2-4]

In addition, studies on normal right-handed subjects have found a left field superiority in the visual perception of direction and a left-hand superiority in the tactile perception of direction, both sets of results pointing to the importance of the right hemisphere in mediating spatial performances.[5-7]

The striking difference in level of performance on this particular visuospatial task by the two groups of patients suggested that it might be fruitful to try to devise a similar procedure that would be more convenient for clinical use, ie, one that would not require the use of a tachistoscope. The development and application of such a procedure is described below.

METHOD

Our aim was to develop a procedure that could be used conveniently in the examining room or at the bedside and yet present a task of the same nature and level of difficulty as that associated with the brief tachistoscopic presentations utilized in the earlier experimental study. In that study, the stimulus lines were of the same length (3.8 cm) as the lines on the response card with which they were to be matched. When this task was presented to patients under a condition of unlimited exposure time, it proved to be too easy, a majority of patients making perfect or near-perfect scores. However, it was found that if the stimulus lines were reduced to one half the length of the lines on the response card, the difficulty of this matching test was augmented to a level comparable to that of the original tachistoscopic test. Therefore, a procedure requiring the matching of "partial" lines (1.9 cm) to "full-length" lines (3.8 cm) was developed and given to large samples of control and brain-diseased patients.

Materials

The response-choice display consisted of an array of lines numbered 1 through 11, each separated by an angle of 18°. Each stimulus consisted of two lines that represented either the proximal, middle, or distal one half (1.9 cm) of a response-choice line (3.8 cm). Five practice items employing the full-length lines preceded the test items. Subjects were informed whether or not their responses were correct on the practice items but not on the test items. The task was to indicate, by naming or pointing, the two lines in the response-choice display that had the same angles ("pointed in the same direction") and occupied the same location as the two stimulus lines. No time limit was imposed.

The materials were assembled in booklet form so that, when opened, the stimuli appeared on the top page and the response-choice display on the bottom of the booklet. The Figure shows two of the test items. Responses were scored as correct if both stimulus lines were accurately identified.

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Test Development

Preliminary data, using a 44-item test, were collected on a pilot group of 66 control patients. The stimuli consisted of 11 pairs each of proximal, middle, distal, or mixed line segments. Several subsets of items were examined for reliability and validity. Finally, a 30-item task (administration time, six to ten minutes) was selected for the subsequent standardization and validity studies. The stimuli were assembled in two different orders in order to provide two forms (form H and form V) of the test.

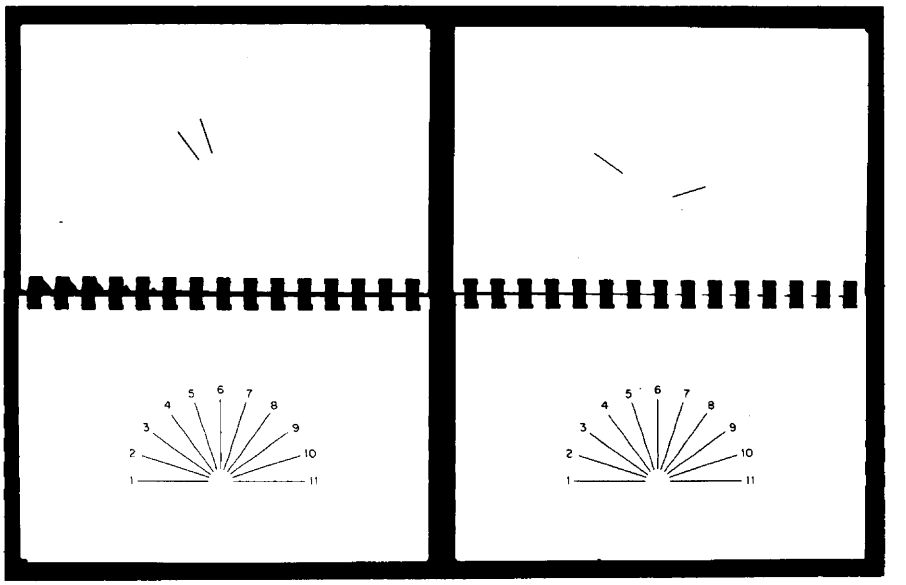
Subjects

The control group consisted of 144 patients (71 males, 73 females) from the general medical services of University of Iowa Hospitals without evidence or history of brain disease; seven patients in this group were left-handed or ambidextrous. Ages ranged from 16 to 78 years. Mean educational level was 11.3 years (SD, 2.9). Modal educational level was 12 years. Six percent had not completed grade school (third to seventh grade).

The clinical groups consisted of 91 right-handed patients with either left or right hemispheric disease from the neurological and neurosurgical services of the University of Iowa Hospitals and the Iowa City Veterans Administration Hospital. Patients with evidence of bilateral or diffuse cerebral disease were excluded from the study. The diagnosis of unilateral cerebral disease was based on the neurologist's final diagnosis and confirming radiologic data (brain scan, angiography, computerized tomography) or the neurosurgeon's operative report. Radiologic studies had not been performed in nine cases in which definite localizing signs were present, eg, homonymous hemianopsia, hemiplegia, aphasia.

There were 48 patients with left hemisphere disease. Vascular disease was the most frequent diagnosis (63%), the next most frequent category being neoplasms and space-occupying lesions (25%). Their ages ranged from 20 to 74 years, with a mean age of 51.8 (SD, 13.3). Educational level ranged from sixth grade through college, with a mean level of 11.8 years (SD, 2.4). Thirty-eight patients (79%) of this group showed aphasic disorder.

There were 43 patients with right hemisphere disease. The most frequent diagnosis was vascular disease (51%), the next most frequent diagnosis being neoplasms and space-occupying lesions (47%). The ages of these patients ranged from 22 to 69 years, the mean being 52.8 years (SD, 15.5). Educational level ranged from eighth grade through college, the mean level being 10.8 years (SD, 2.7). The small differences between the left and right brain disease groups with respect to mean age and education or variance in these characteristics were not significant. However, the proportion of space-occupying lesion cases was significantly higher in the right hemisphere group than in the left hemisphere group ($P < .03$).



Two items of "partial lines" test. Patient identifies slope of lines on display of 11 lines.

RESULTS

Performances of Control Patients

Analyses of the performances of the 144 control patients indicated that performance level was significantly associated with both age and sex. The mean scores of men within the age ranges of 16 to 49 years, 50 to 59 years, 60 to 69 years, and 70 to 79 years were 25.8, 24.3, 23.3, and 22.2, respectively. The mean scores of women within the same age ranges were 23.6, 22.1, 21.1, and 21.6, respectively.

Score corrections taking account of the influence of age and sex were introduced in order to facilitate interpretation of a patient's performance in relation to control subjects of his sex and age. The corrections consisted in adding one point to the obtained scores of subjects in the 50 to 59-year age bracket, two points to the obtained scores of subjects who were 60 years or older, and two points to the obtained scores of female subjects. This resulted in a fairly even level of mean scores across age brackets and sex, the maximal discrepancy being 1.6 points (as compared to 4.7 points for the uncorrected scores).

Corrected split-half reliability of form H in a sample of 40 subjects was found to be 0.94. The same statistic for form V in a sample of 124 subjects was 0.89. In the combined sample of 164 subjects, the corrected split-half reliability was 0.91, the standard error of measurement being 1.7. A sample of 37 patients was given both forms of the test, the interval between test and retest ranging from six hours to 21 days. The mean scores for the first and second administrations were almost identical (23.1 and 23.5), indicating the absence of a systematic practice effect. The test-retest reliability coefficient was 0.90, with a standard error of measurement of 1.8 points.

The distribution of the corrected scores of the control patients is given in Table 1. One hundred thirty-seven of the 144 patients (95%) made scores of 19 or higher, and 140 patients (97%) made scores of 17 or higher. On this basis, a score of 17 to 18 was interpreted as a mildly defective performance and a score of 15 to 16 as a moderately defective performance. Scores below 15, representing a per-

Table 1.—Distributions of Test Scores

Score	Controls (N = 144)	Patients With Left Lesions (N = 48)	Patients With Right Lesions (N = 43)
29-30	38	6	2
27-28	24	11	5
25-26	24	8	2
23-24	26	7	3
21-22	16	9	8
19-20	9	4	6
17-18	3	3	3
15-16	3	0	1
< 15	1	0	13

Table 2.—Performance Level and Locus of Lesion in Patients With Right Hemisphere Disease

Locus		Pass	Fail
Prefrontal	VFP +	0	0
	VFD—	4	0
Perirolandic	VFD +	3	0
	VFD—	10	0
Posterior	VFD +	1	7
	VFD—	1	1
Indeterminate	VFD +	2	4
	VFD—	5	5

formance level exceeded by 99.3% of the controls, was interpreted as indicating severely defective performance.

Performances of Patients With Unilateral Brain Disease

The distributions of scores of the patients with unilateral disease are also given in Table 1. The scores of most of the patients with left hemisphere lesions were in the normal range, only 6% of them making mildly defective performances and none of them performing at a moderately or severely defective level. In sharp contrast, 40% of the patients with right hemisphere lesions performed defectively, 30% showing severe defect and 10% showing moderate or mild defect.

Performance Level and Type of Lesion

Since there was a higher proportion of cases with space-occupying lesions in the right hemisphere group than in the left, the performances of the space-occupying and vascular cases were compared to determine the degree to which the obtained between-hemispheres difference in scores might be ascribable to a difference in type of lesion. In the right hemisphere group, the mean score of the 22 vascular cases was 19.2 and the mean score of the 20 cases with space-occupying lesions was 16.7, the difference between the means being nonsignificant. Thirty-two percent of the vascular patients performed defectively as compared to 45% of the space-occupying lesion patients, the difference between these percentages being nonsignificant. In the left hemisphere group, the mean score of the 30 vascular cases was 24.1 and the mean score of the 12 space-occupying lesion cases was 25.6, the difference between the means being nonsignificant. Thus the analyses disclosed a slight, nonsignificant trend toward more defective performance by the patients with space-occupying lesions in the right hemisphere group, but not the left hemisphere group.

Performance Level and Locus of Lesion

Lesions were classified in respect to site as "prefrontal" (anterior to precentral gyrus), "perirolandic" (frontal involving area 4, frontoparietal, frontotemporal, anterior parietal, anterior temporal), or "posterior" (parietal sparing areas 1, 2, and 3, parietooccipital, parietotemporal, occipital). It was possible to make this classification confidently on the basis of operative reports and radiographic findings in 27 of the 43 patients with right hemisphere disease. The remaining 16 cases were classified as "indeterminate" in locus because of radiologic evidence of more than one lesion or uncertainty about the limits of a lesion.

Table 2 shows the frequency of normal and defective performance of patients with and without visual field defects in the four categories. Among the patients with localized lesions, only those with posterior lesions performed defectively. All the patients with prefrontal or perirolandic lesions (including three with visual field defects) performed normally. A trend toward a positive association between the presence of visual field defect and impaired performance is evident. However, it is also evident that some patients with visual field defect performed normally and others without visual field defect performed defectively. Sixteen of the 48 patients in the left hemisphere group had visual field defects. Their mean score of 25.0 was not significantly different from the mean score of 24.5 made by the 32 patients without visual field defects.

COMMENT

Performance on this rather pure measure of visuospatial judgment discriminated fairly sharply between patients with right and left hemisphere disease. In view of previous findings with directional judgment tasks[1-7] and the long-established relationship between visuospatial disability and right hemisphere disease,[8-12] it was anticipated that a significantly higher frequency of defective performance would be found among patients with right hemisphere lesions. However, the extremely low incidence of impairment in those with left hemisphere disease was somewhat unexpected. As noted, the majority of these patients were aphasic and, considering the diverse cognitive defects so often observed in association with aphasic disorder, a somewhat higher frequency of impaired performance on this task might have been anticipated.

Analysis of the relationship of performance level to site of lesion in the patients with right hemisphere disease indicated that failure was characteristic of those with posterior parietal or temporo-occipital lesions. Patients with prefrontal or perirolandic lesions performed on a normal level. The influence of visual field defect on performance is not clear despite the observed trend toward a positive association between the presence of field defect and impairment

on the test. Most of the patients with right posterior lesions had visual field defects and thus it is difficult to separate the influence of the two factors. The finding that practically all the patients with visual field defect in the left hemisphere group performed normally indicates that the visual disability per se is neither a necessary nor sufficient determinant of defective performance.

In the earlier study,[1] which employed tachistoscopic presentations of 300 msec in duration to central vision, it was found that 59% of the patients with right hemisphere lesions performed defectively. The comparable figure in the present study was 40%. To determine whether this difference in the proportions of patients showing failing performance was merely a matter of sampling fluctuation or reflected a greater sensitivity of the tachistoscopic task, both tasks were given to 18 patients with left hemisphere lesions and 18 patients with right hemisphere lesions.

All the patients with left hemisphere lesions performed on a normal level on both tasks, the correlation coefficient between the two test scores being .88. In the patients with right hemisphere lesions, the correlation between the two test scores was .78. Seven patients performed normally and five patients performed defectively on both tasks. The remaining six patients performed normally on the partial lines test, but failed the tachistoscopic task. Thus, the brief exposure task elicited defective performance in 61% of the patients with right hemisphere disease while the partial lines test elicited defective performance in 29%.

These findings indicate that the tachistoscopic task, which includes a speed factor, provides a more sensitive measure of visuoperceptive efficiency. They further suggest that incorporating a time limit in the administration of the partial lines test or taking account of the time taken for each response in scoring performance might enhance its diagnostic significance. These possibilities deserve to be explored.

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The two forms of the test are available for $15.00, which represents current production and mailing costs. Orders should be addressed to the Administrative Assistant, Department of Neurology, University Hospitals, Iowa City, IA 52242.

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International Symposium on Peripheral Neuropathies.—The symposium will be held in Milan, Italy, from Monday, June 26 to Wednesday, June 28, 1978, at the University of Milan (Aula Magna), Via Festa del Perdono 7. For further information contact Secretariat—Symposium on Peripheral Neuropathies Ospedale S. Raffaele, 20090, Segrate, Milan, Italy.

Conference on Hyperbaric Oxygen.—The third annual conference on clinical application of hyperbaric oxygen will take place June 8-10, 1978, at Memorial Hospital Medical Center, Long Beach, Cal. A nursing and technician workshop will be held simultaneously. For further information contact G. B. Hart, MD, Memorial Hospital Medical Center, 2801 Atlantic Ave, Long Beach, CA 90801.