Cerebral Commissurotomy in Man

Minor Hemisphere Dominance for Certain Visuospatial Functions

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Hughlings Jackson[22] wrote in 1864, "If, then, it should be proved by wider evidence that the faculty of expression resides in one hemisphere, there is no absurdity in raising the question as to whether perception—its corresponding opposite—may not be seated in the other." Nielsen[27] showed in 1937 the dominance of one occipital lobe over the other; and more recently Critchley[8] discussed asymmetry in parietal lobe functions. Recent experiments by Sperry[33,34] have drawn new attention to the functions of the corpus callosum, among them the possible integration of dissimilar or complementary capacities of the two hemispheres. Dide[12] in 1938 considered the complementary functions of the two hemispheres to be symbolic versus gnosokinesthetic. However, an increasing accumulation of clinical data suggests that complementary functions in man may be verbal v. visuospatial.

Brain[7] reported a series of patients with right cerebral tumors whose visual disorientation disabilities were greater than their other defects. Heimburger and Reitan[21] suggested that tumors might be lateralized to the left or to the right depending on whether the patient had more difficulty with writing or drawing. Although localization studies on tumor patients are notorious for pressure and other secondary symptoms, support has come from studies of patients with circumscribed injuries or infarction. For example, Olsen's[29] patient with a right parietal thrombosis had visual agnosia but had excellent visual acuity, played the piano and conversed well. Especially notable are studies by modern neuropsychologists: Paterson and Zangwill[31] emphasized the importance of the right hemisphere in constructional apraxia, a conclusion supported by Piercy and Smyth[5] in their recent review of this subject. Hécaen and Angelergues[20] found that of 18 unilateral lesions with agnosia for faces, 16 were on the right side; of the remaining 2 patients, one was known to be left-handed. Teuber[37] found visual seizures in 15 patients, the injury being predominantly right-sided in 13 cases. Delimitation of the lesions is perhaps more exact with surgical removals such as temporal lobectomy: Milner[24] found verbal deficits following left-sided ablations and visuospatial deficits on the right.‡

It was suggested by Bard and Brooks[1] that acceptance of the localization of a particular function to a particular area requires affirmative as well as negative evidence. That is, not only must there be loss of the function with injury to the specific area, but there should also be preservation of the function when the specific area remains intact in the event of widespread surrounding loss. Such a criterion is particularly relevant here since Denny-Brown[10,11] has pointed out that certain visuospatial (which he terms morphosynthetic) processes in the left hemisphere may suffer losses difficult to demonstrate because of the more important losses in certain language (propositional) processes.

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‡ It should be pointed out that the difference is one of degree, just as the left hemisphere is dominant rather than exclusive in language function. See Nielsen,[27] Subirana,[35] Zangwill,[38] Critchley,[9] on the role of the minor hemisphere in language and the more general question of relative dominance.

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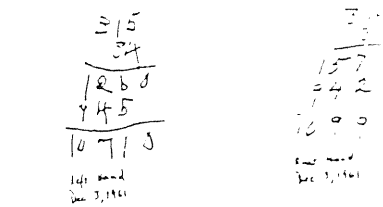

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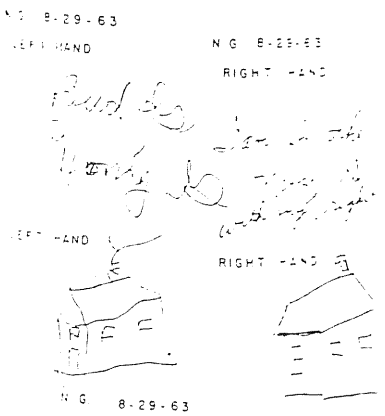

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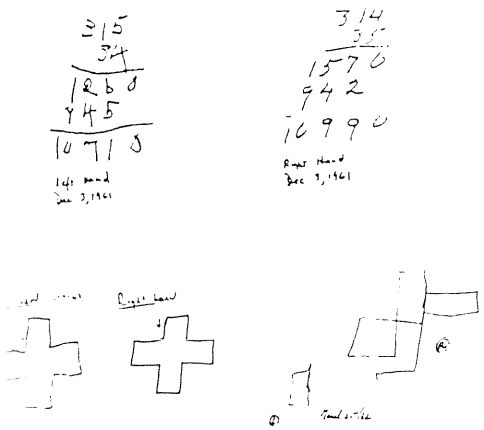

FIG. 1. (*Upper left*) Two months before operation, J. uses the left hand fairly well for writing although is right handed. (*Upper right*) The right hand writes better than the left. (*Lower left*) Two months before operation both hands copy a Greek cross correctly; right shows better motor coordination. (*Lower right*) Two months after operation the left hand is apraxic and cannot effectively copy the Greek cross. The right hand is well coordinated but the design is misplaced.

Affirmative evidence for lateralization of visuospatial function was found by Mullan and Penfield:[25] in 217 patients with temporal lobe epilepsy, 12 had visual illusions, arising in 11 cases from the hemisphere minor for speech.

Affirmative evidence of visuospatial dominance in the minor hemisphere has recently become available from 2 of our patients who had complete section of the corpus callosum and anterior commissure for the treatment of seizures.§ The first patient's clinical history and surgery have been discussed before in detail.[5,6,15,16] Our second patient was operated upon in September 1963, and has had a smooth postoperative course with complete relief of convulsions to date: a more detailed report is in preparation.[4] Both of these patients, W. J., a 48-year-old man, and N. G., a 30-year-old woman, were always right-handed and right-footed and without left-handed near-relatives except N. G.'s maternal uncle.

§ Part of the relevant data has been presented as part of an extended discussion of visual perception following commissurotomy (Gazzaniga *et al.*[14]).

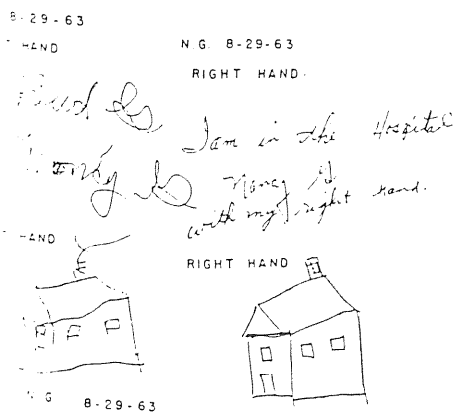

FIG. 2. (*Upper left*) Before operation, N. G. writes with the left hand. (*Upper right*) The right writes better than the left. (*Lower left*) The left draws well from a model (the wisp of smoke was the model). (*Lower right*) The right hand draws, model, with slightly more assurance than the

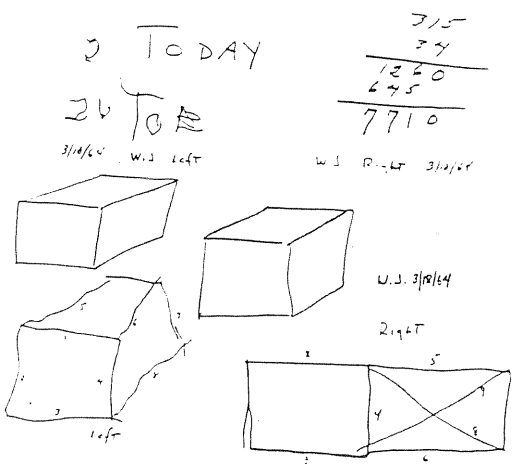

FIG. 3. (*Upper left*) Two years after operation, a pencil was placed in W. S.'s left hand and he was asked to write a simple arithmetic problem (14×5). He managed a few scrawls, scowled, and said "argh." The word "TODAY" was printed on the same sheet of paper and he was asked to copy it. He succeeded at first, slowed down, growled again, and threw down the pencil. (*Upper right*) The pencil was placed in his right hand and he was asked to multiply 315 by 34. He completed the writing as shown and then shook his head saying, "I have trouble seeing the numbers." (*Lower left*) The pencil was then used to draw a model cube. It was placed in his left hand and he was asked to copy the model on the same sheet of paper. When he finished the eighth line, the hand moved to one side and rested. (*Lower right*) With a new sheet of paper, the pencil was used to draw a second model and then placed in his right hand. He drew seven lines and stopped. He was asked, "Should there be some more lines?"; he then drew the last two lines and stopped, again shaking his head.

Observations

With the eyes open for all testing, both patients were able to write passably with the left hand before surgery (Figs. 1 and 2); after surgery both lost this ability with the left hand but not with the right. Both patients could copy geometric figures better right-handed before surgery; after surgery, both could copy geometric designs better with the left hand. This is best shown in the copying of designs suggesting a third dimension (Figs. 3 and 4). The phenomenon has persisted in the first patient, W. J., for over two years. The second patient, however, reacquired writing in the left hand and drawing in the right hand by the 8th month after operation (Fig. 5).

The visuospatial superiority of the right hemisphere can be seen in other tests, for example, Kohs' block design test[23] as modified by Wechsler.[37] This is especially true in the first case. (In association with a generally lower IQ, the second patient performed poorly on the block design test both before and after operation.) The left hand does consistently well whereas the right is barely able to do the simplest problems (see Fig. 6). In contrast, verbal instructions for arrangement of the blocks are executed well by the right hand and poorly if at all by the left. Some preliminary tests suggest that although the right hand may be unable to construct an imitation of a design, the right hand can often select the proper design from a collection. Also, the patient can usually indicate verbally whether or not a design is correct.

Discussion

Akelaitis[1,2] studied language functions in 24 patients with varying degrees of section of the corpus callosum. Ability to draw was not reported, but writing and tactile lexia did not suffer from the operation except transiently in 4 cases (Akelaitis' cases #13, 14, 21 and 24). The deficits in our patients may be related to their strong lateralization of language (especially the older man) although Akelaitis pointed out in detail the reasons for assuming

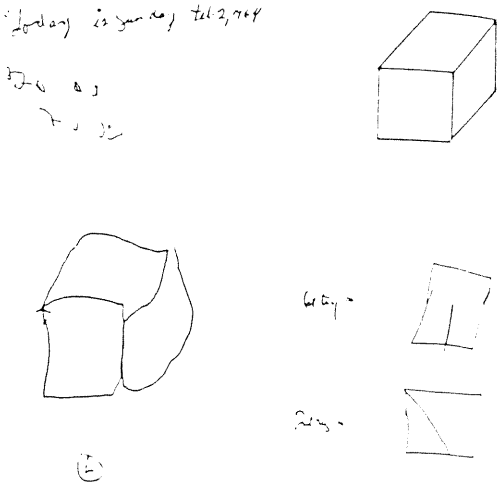

FIG. 4. (*Upper left*) Five months after operation. N. G. was asked to write something on a blank sheet of paper. When she finished she was asked, "Now write something with your left hand." She put the pencil in her left hand and made several unsuccessful attempts as shown. (*Upper right*) The model. (*Lower left*) She was asked to copy the model with her left hand. The hand reached over, picked up the pencil and carefully drew the picture, then stopped and she said, "how's that?" (*Lower right*) She was complimented and asked to repeat with the right hand. After the first try she laughed and said, "can I start again?" She then drew the 2nd figure, laughed again and said, "I give up."

similar lateralization in some of his patients. Variations in damage before or during operation may also be important but are difficult to evaluate in the absence of anatomical follow up. Akelaitis felt his data showed the importance of commissural systems other than the corpus callosum. Unlike all but one of his patients (G.E., case #18 in his paper VII

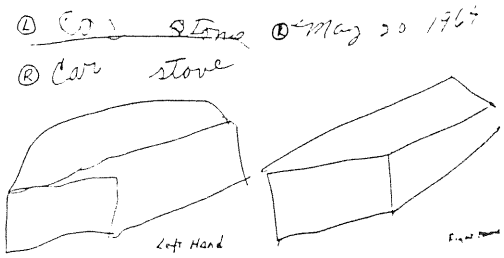

FIG. 5. (*Upper left*) Eight months after operation. N. G. writes legibly to dictation with the left hand. The right hand is better. (*Upper right*) When asked to write the date with the right hand, she does well except for omission of a comma. (*Lower left*) The left hand draws about as well as at 5 months postoperatively. (*Lower right*) The right hand is now able to draw, from a model, better than the left.

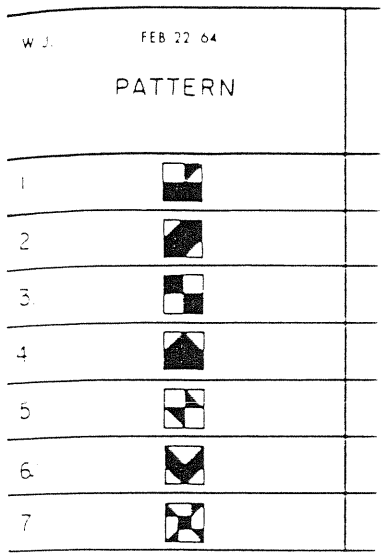

FIG. 6. Two years after operation, the right hand eventually succeeded on two of was arbitrarily ended.

and case #1 in his 1944 paper[2]) tients had division of the anterior sure as well as complete section of callosum including all fibers of the Further data is needed to clarify Kohs' block design test was given Akelaitis' patients by Parsons[30] but plete results were not published.

The results reported here might ized on the grounds that they clude the possibility that the pa been deluding the examiners f either conscious or unconscious. also arose with respect to a recent of Geschwind and Kaplan[17] "Classical hysterical manifesta totally absent; the pattern of abil ability was too complex, especiall ing the patient's limited intellectu many features showed an affin above-mentioned classical clinic which could hardly have been kn patient; and prolonged careful of his behavior militated against pretation." This excellent obs even more applicable when there tients that differ one from anoth as ours.

The return of function in N.

W.J. FEB 22 64 PATTERN	BLOCK DESIGN TEST TIME IN SECONDS LEFT HAND	RIGHT HAND
1	50	> 180
2	49	> 180
3	20	19
4	19	51
5	110	> 300
6	26	> 150
7	190	> 300

FIG. 6. Two years after operation, the block design test was done fairly well by W.J. with the left hand. The right hand eventually succeeded on two of the patterns, but fumbled ineffectually on the remainder until the trial was arbitrarily ended.

and case #1 in his 1944 paper[2]) our two patients had division of the anterior commissure as well as complete section of the corpus callosum including all fibers of the splenium. Further data is needed to clarify this issue. Kohs' block design test was given to some of Akelaitis' patients by Parsons[30] but the complete results were not published.

The results reported here might be criticized on the grounds that they do not exclude the possibility that the patients have been deluding the examiners for reasons either conscious or unconscious. This issue also arose with respect to a recent tumor case of Geschwind and Kaplan[17] who wrote "Classical hysterical manifestations were totally absent; the pattern of ability and disability was too complex, especially considering the patient's limited intellectual abilities; many features showed an affinity to the above-mentioned classical clinical pictures which could hardly have been known to the patient; and prolonged careful observation of his behavior militated against this interpretation." This excellent observation is even more applicable when there are two patients that differ one from another as much as ours.

The return of function in N. G. after 8 months may reflect the emergence of latent conceptual capacities in each hemisphere, or more probably an increased capacity for each hemisphere to direct the behavior of the ipsilateral hand. Recent experiments in the split-brain monkey by Myers *et al.*,[26] by Glickstein and Sperry[15] and by Gazzaniga[13] have shown the remarkable extent to which this may be true. Akelaitis[1] considered the possibility of ipsilateral control but felt "it is hardly possible to explain the complex motor and sensory aspects of language on this basis."

It is of particular interest that a hand incapable of constructing the correct design could nevertheless choose it correctly from several offered. Such a choice, of course, requires only positive or negative reactions to each of the several offered; and this may mean that affective responses within the right hemisphere readily transfer or otherwise guide the expressive function of the left hemisphere. Or it may show the presence of a visuoperceptive capacity within the left hemisphere adequate for yes or no answers but insufficient to direct a complex voluntary act. If the latter explanation is correct, it could have its parallel in the inability of verbal processes in the right hemisphere to direct propositional speech.[14]

Summary

Evidence is presented that the disability of the disconnected right hemisphere in responding appropriately to language is paralleled by a left hemisphere incapacity to respond appropriately to a visuoconstructive problem. These studies provide affirmative evidence of dominance in the minor hemisphere for certain visuospatial functions. Furthermore, they illustrate the probable role of the corpus callosum in the simultaneous use of verbal and visuospatial thought.

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