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DISTURBANCES IN CONCEPTUAL SPACE INVOLVING LANGUAGE AND SPEECH

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SUMMARY

We report on a patient, with a CT-verified low density lesion in the right parietal area, who exhibited not only deficits in left conceptual space, but also in reading, writing, and the production of speech. He presented with a left homonymous hemianopia, tactile inattention, and dysphasia that quickly resolved, leaving a left-sided inattention and less marked dysphasia. Several language tasks and language-based imagery tasks revealed poor language processing of the left portion of words which could be remedied if the patient was instructed to do things like spell the word backwards. The overall results were consistent with the idea that some aspects of language processing involve spatial mechanisms.

INTRODUCTION

Unilateral neglect has traditionally and commonly referred to the failure to respond to information from the hemispace contralateral to a parietal lobe lesion, although other lesions can also produce the phenomenon. Such patients also fail to incorporate into actions information that normally falls into the neglected field. Thus patients with right hemisphere disease affecting visual processes ignore the left side of a printed page while attempting to read. When trying to draw they typically draw only one half of an object, such as a clock, but nonetheless claim to have drawn it completely. Although the neglect phenomenon most frequently involves visual processes, it is also seen with tactile and auditory stimuli.

The classical picture of neglect phenomena has undergone several interesting modifications. Kinsbourne and Warrington (1962) reported 6 cases with right parietal disease who failed to read the left side of words, no matter where they appeared in their visual field. This was true even when the words were presented tachistoscopically all within the intact right visual field. These results were consistent with the view that neglect involved the left half of information no matter where it appeared, and for the first time suggested that the dysfunction involved a deficit in left conceptual space as opposed to left retinotopic space. This idea was

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confirmed and extended by Bisiach and Luzzatti (1978) who reported 2 cases with left hemispatial neglect who failed to report the shops on the left half of the Piazza del Duomo in Milan when imagining that they were standing in front of the Cathedral looking across the Piazza. Conversely, when imagining they were across the Piazza looking at the front of the Cathedral, they were able to report the shops ignored in the first condition but now failed to mention the shops previously described. This ingenious study further supported the idea that the parietal lobe was active in organizing information in conceptual space.

In the present study we report a patient who demonstrated not only deficits in conceptual space of the type already described, but also deficits in the production of speech and in writing that relate in a systematic way to a left hemispatial neglect. This case is remarkably similar to one reported by Baxter and Warrington (1983). In the early phases of testing, the overall picture was clouded by a confounding dysphasia as the patient was left handed. This condition largely cleared, however, and the pattern of the patient's mistakes was found to be more consistent with a deficit in spatial abilities. In short, through careful examination, we were able to determine crucial dissociations of function at a cognitive level of activity.

CASE REPORT

J. L. is a 71-year-old retired lawyer, admitted to New York Hospital a few hours after the acute onset of speech difficulty. He was left handed for most activities except writing, having been forced to use his right hand as a child. There was a family history of sinistrality.

At 1.00 a.m. on the day of admission, he noticed he was talking gibberish. On trying to read, he reported seeing only the right side of a printed page and was equally incomprehensible when trying to read aloud to his son. He was aware of his abnormality.

He was first examined 8 h later. He had a left homonymous hemianopia and tactile inattention. He was clearly dysphasic. The dysphasia was fluent with moderate anomia, literal paraphasic errors and difficulty with repetition. He was also markedly dysgraphic and alexic. He bisected a line to the right of the midline and described only the right side of a picture. CT scan of the brain showed a low density lesion in the right parietal area.

Within 24 h after onset, the visual field defect had resolved, leaving left-sided extinction under conditions of double simultaneous stimulation. At this time, visual evoked potentials were performed. Thus at a time when the patient clearly showed extinction of information in the left visual field, the latencies of visual evoked (P100) potentials were symmetric and normal. The dysphasia was much less marked, with few paraphasic errors. Some reading and writing was now possible. On the second day, the Boston Diagnostic Aphasia Examination was administered, confirming the general clinical picture.

OBSERVATIONS

Throughout all tests, there was an evolving course evident for most of the phenomena reported. In what follows we describe this course for each set of observations. We begin by reporting the capacity of the patient to process written information presented in free view and with no time constraints on his rate of reporting. Next, we report on the patient's executive skills with detailed descriptions

of his ability to speak, spell and write. Finally, we report on an American attempt to reproduce the Piazza effect and show an inability to access internally-represented visual information in the left visual hemispace.

Reading

On day 1, the patient was admitted, but not seen or examined by us. On day 2, he was alexic, although he could decipher individual letters. On day 3, he was asked to read 68 words presented individually. The words varied in length and frequency of use. He could manage 2 and 3-letter words with little difficulty; however, he made a total of 16 errors (23%) on words longer than 3 letters. Mistakes occurred mostly at the beginning of words (*see* Table), consisting of omissions and sub-

TABLE. READING ERRORS ON DAY 3

Stimulus	*Response*	*Stimulus*	*Response*
1. Nasty	Masty	9. Bequeath	Queath
2. Hastily	Gastily	10. Surround	Sround
3. Very	Neverly	11. Tractor	Doctor
4. Rattle	Mattle	12. Importance	Portance
5. Variety	Charity	13. Fled	Sped
6. Astonish	Tonish	14. Heath	Eath
7. Flambouyant	Ambouyant	15. Dining	Nining
8. Deserve	Observe	16. Know	Now

stitutions, in the latter instance sometimes forming other real words. On the fourth day only 10 words, 9–12 letters in length, were tested individually and errors were made on half of them. On days 5 to 7, the test consisted of reading a text that varied each day. By this time the error rate had dropped considerably: day 5, 7/291; day 6, 21/308; day 7, 9/167. Still, all errors occurred in words of longer than 3 letters, and occurred in the leftmost letters.

Oral spelling

Spelling was tested on day 3. In this test the subject was read a word aloud such as 'cat'. The task was to spell out each of 15 spoken words (10 three letter and 5 four letter). The words were presented one at a time and response was made after each spoken word. The results are plotted in fig. 1. The graded increase in error rates towards the beginning of words, and the added effect of increasing word length can be seen. As with writing, mistakes consisted of omissions or substitutions.

Spontaneous speech

Consistent with the foregoing picture of a failure to process the most leftward letters in a word in both reading and spelling tests, some limited observations were made on spontaneous speech. It was brought to our attention by the patient's son that his father seemed to be omitting the beginning of words. He had said '—bulance' instead of 'ambulance' and '—portant' instead of 'important'. Over the

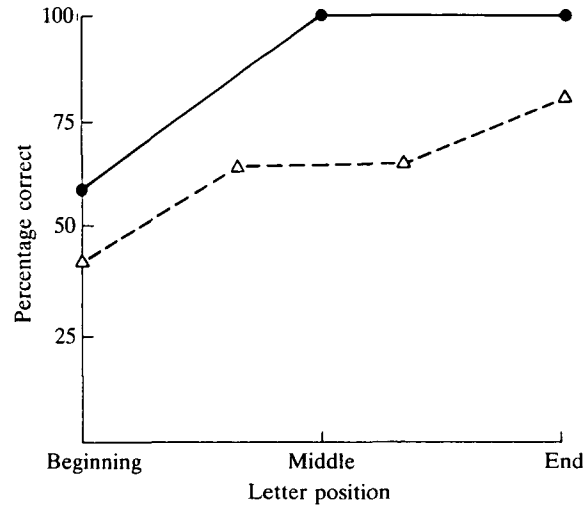

FIG. 1. Percentage error frequency in oral spelling of words. More errors were made at the beginning of 3 and 4-letter words. Solid circles and line = 3-letter words. Triangles and broken line = 4-letter words.

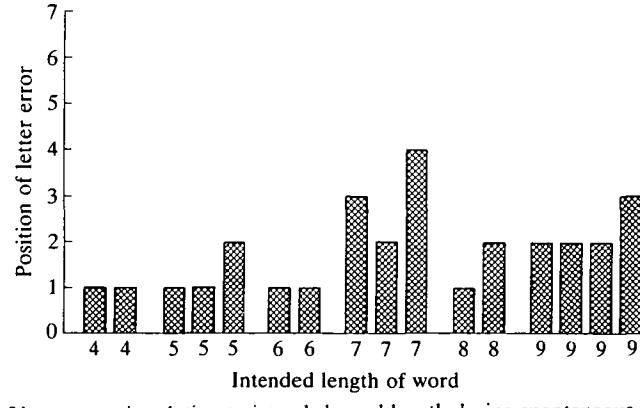

FIG. 2. Position of letter error in relation to intended word length during spontaneous speech. Over a 10-day period several examples were noted where the patient omitted the beginnings of letters for words of a variety of lengths.

next ten days we observed 16 such mistakes, mostly of omission, but also substitutions often forming semantically unrelated words (fig. 2).

Writing tests

At the time of testing for writing ability on day 2, the patient could reproduce the alphabet without any errors. However, on attempting to write words to dictation (26 words), he would start at the end of a word and work backwards, managing only the last few letters without any mistakes and often leaving out the beginnings of words. He was perfectly aware of the deficit in all cases and was able to tell how many letters were missing (or wrong) at the beginning of words. On attempting to

write 'come', for example, he wrote 'ome' and said 'I know there is one letter over here but I can't get it'.

On the third day after admission, he was tested on a total of 13 words. He managed most 3-letter words, although still backwards. As in the case of 'dog', it frequently took several attempts to produce all the letters correctly, working one letter at a time from the end backwards. His span improved daily, proceeding in a right to left direction so that by the end of the first week, he could manage words of virtually any length, although errors remained higher at the beginning of words. Fig. 3 shows the percentage correct for each letter position on days 2 to 4. On day

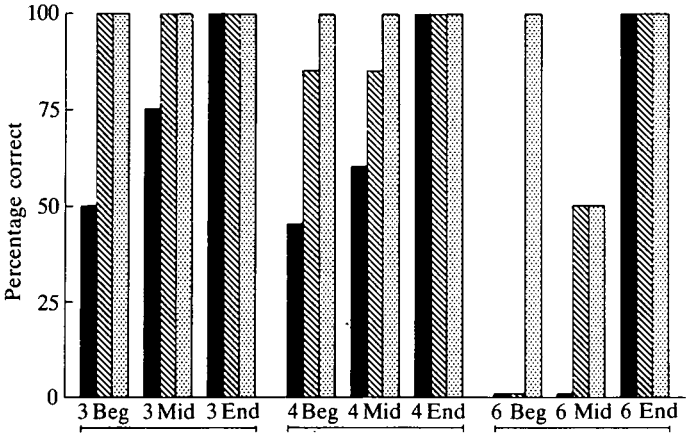

FIG. 3. Response of patient to writing to dictation 3, 4 and 6-letter words showing position in word where most errors were made. Improvement is seen with time. Solid area = day 2; cross-hatched area = day 3; speckled area = day 4.

4 only a few words were tested as he was clearly no longer impaired on the test. The gradation of error rates and the effect of word length is demonstrated, with higher error rates at the beginning of longer words. Error rate increased with distance from the last letter.

For the word 'blue', as the patient had written 'b–ue' and could not 'see' the l, he was asked to write it in reverse, starting with B on the right. As seen in fig. 4,

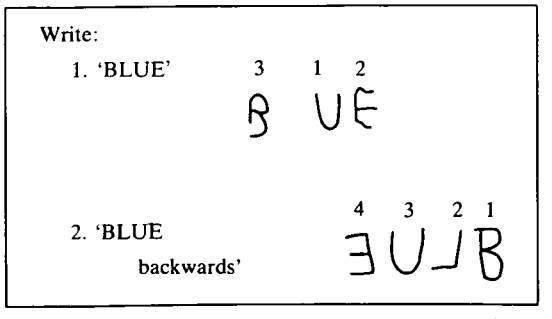

FIG. 4. Examples of writing to command. There was a tendency to omit the first letter of a word or to write it last. If asked to write the word backwards, the first letter was written first.

the missing letter became 'visible' and the whole word was written without hesitation. Two other examples were tried in this manner and, interestingly, the mistakes were again made at the beginning of the word, on the right side of the paper. This result was consistent with the view that writing involved imaging processes that were affected by his disorder such that the left half of imaginal space was not functioning normally. This idea prompted the final observation described below.

Spatial representation

An effort was made to determine whether or not the patient would show difficulties in accessing information falling into an internal conceptual hemispace. A test of general imagery was given which required the patient to describe from memory the spatial location of certain elements when viewed from a particular vantage point. The test was given on day 3 and again before his discharge from hospital. In this test the patient was asked to imagine that he was standing in New York with his back to the ocean, facing California, and to name the states which lay in between. The results are shown in fig. 5. On day 3, 10 states were named, all

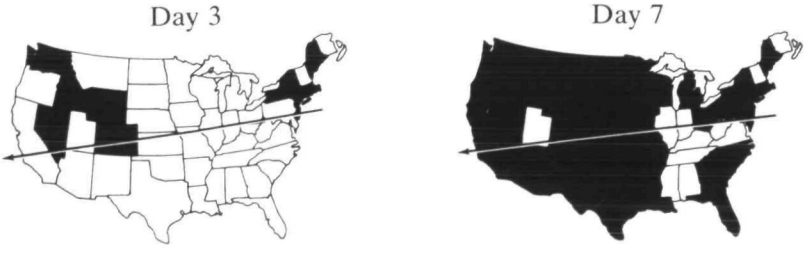

FIG. 5. The patient was tested on his capacity to recall American states when he adopted a vantage point looking west from the George Washington Bridge in New York City to California. His initial report, occurring during the period of severe inattention, showed a failure to recall states falling into left conceptual space. Some days later he reported almost all states.

to the right of the line representing the imaginary direction of gaze. Unfortunately the patient then became tired and it was not possible to run the converse test using an eastwardly looking vantage point. Before discharge, however, and with the same original instructions, he managed to name most states, leaving out 6 to the left of the line and 3 to the right. At this time, he was making only occasional paralexic mistakes and there was no tactile inattention.

DISCUSSION

The foregoing observations appear to support the general view that right-sided parietal lesions can cause disturbances in left conceptual space. Consistent with earlier observations (Kinsbourne and Warrington, 1962; Bisiach and Luzatti, 1978), the patient produced results suggesting that visual information falling into the left part of a conceptual space was inaccessible to conscious report. In addition, the

present observations suggest that this deficiency in accessing information in left conceptual space can extend into the executive functions of language including oral spelling and spontaneous speech. The case as described is remarkably similar to the patient reported by Baxter and Warrington (1983). Both were left handed and experienced insults to their right parietal cortex. Both were dysphasic at onset. Their observations were also made acutely as well as after a nine-month interval. Their patient also showed the letter effect on spelling and this persisted when attempting to spell backwards. Interestingly, their patient also tended to write the last letters first when trying to spell forwards. In the following we argue this constellation of deficits, which impairs both perceptual and language processes in left conceptual space, reflects damage to two separate spatial systems, a disturbance that becomes uniquely observable in damage to left handers with right hemisphere dominance.

It has recently been determined that in right handers, language-related processing may be relatively impervious to the influence of neglect due to right hemisphere damage. This is evidenced by the finding of Tzeng and Hung (1987) that in Chinese, there is a left neglect of pseudoideograms but not of genuine Chinese characters in spite of the similar visuospatial attributes of the two figure types. M. Sieroff and M. I. Posner (personal communication, 1986) have found a similar lack of vulnerability in words relative to nonwords in English speaking subjects with left neglect. In a related observation, it has been shown that deaf patients with right parietal lesions who communicate with American Sign Language are impaired in their left conceptual space for perceptual space but not for language expression (Bellugi and Klima, 1987). Taken together, these studies have been interpreted as suggesting that some kind of 'top-down' process in the language system can override the attentional deficits produced by the right parietal lesion.

Alternatively, and more consistent with the present findings, is the view that there are spatial processes specifically associated with language use which are typically spared in neglect patients. These processes, which are most probably associated with language systems in the left hemisphere, are spared with right parietal lesions when the language system is in the left hemisphere. In the present left-handed case and in the patient of Baxter and Warrington, the right hemisphere is doing double duty by necessarily managing both language and perceptual processes. Damage to these patients creates disturbances in both spatial systems.

Further support for this view comes from observations on split-brain patients. These patients have never revealed the type of errors seen here. In the split-brain patient the left hemisphere is cortically disconnected from the right hemisphere. This might lead to the proposal that the left hemisphere should behave as if it processed information without the advantages of the right parietal systems and the right without the advantages of the left parietal system. However, when it comes to writing, spelling, and speaking from the left hemisphere, deficits of this type are not seen. This would be predicted if special spatial systems associated with language processes were managed by the left hemisphere. Additionally, the disconnection

model does hold for some aspects of spatial attention. In a series of studies examining how hemisphere disconnection affects gravitational coordinates in attentional processes, it has been demonstrated that the left disconnected hemisphere behaves as if the right hemisphere were lesioned and in the same patient the right hemisphere behaves as if the left hemisphere were lesioned (Gazzaniga and Ladavas, 1986). Taken together, this suggests that the attentional systems active in the imaging processes of a hemiconceptual space are distinct from those associated with directing attention to points in physical space.

It is also of interest to consider these deficits in conceptual space in light of more traditional studies on mental imagery. The experimental investigation of imaging systems has been extensive in recent years and several ideas have emerged as to how mental imagery is accomplished. Some have argued imaging systems have an identity with perceptual systems and that they share the same brain processes (Shepard, 1982). Others have maintained that imagery is the product of propositional features of language systems and is not a distinct aspect of the cognitive system (Pylyshyn, 1981). Yet the dominant view is that mental imagery is a distinct mental system and that mental images are generated by the interaction of several identifiable component processes such as image generation, image rotation, and image scanning, to mention but a few (*see* Kosslyn *et al.*, 1979).

The present results, as well as others, raise problems for the perceptual hypothesis. Patients who have difficulty accessing imaged information are not impaired in simple measures that examine the integrity of the perceptual systems. For stored information, if they change their vantage point for inspecting an image, once-neglected information is accessed. Other studies have shown that information that falls into an extinguished field is processed in a perceptual task, albeit outside the realm of consciousness (Volpe *et al.*, 1979). Finally, patients who have undergone partial commissurotomy that interrupts interhemispheric transfer of tactile but not visual information, reveal a pattern of results on imagery tests that suggest imagery systems are not connected to visual cortical processes (Gazzaniga, 1985). In these studies, patients presented with an object in, say, the right hand, could not find its match with the left hand. However, if a picture of the object was presented to either hemifield, they could find the matching stimulus with the left hand. This shows that when the object appeared in the right visual field, the remaining intact callosal fibres transmitted information about the visual stimulus over to the right hemisphere for use by the somatosensory system. These same patients, however, failed to use these intact visual fibres when the instructions to the patient were to make 'an image' of the object placed in their right hand before trying to find the match with their left. While the patients claimed to have made an image and while tests of their overall capacity to make images were positive, this strategy did not promote integration of information over their remaining and clearly functional neuronal pathways.

The view that imagined processes are epiphenomenal to propositional language is also not supported by the present results as well as other studies. The propositional

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language system is wholly intact in such cases, where clear deficits exist in imaged space. Additionally, results of imagery studies on split-brain patients are not consistent with this view (Farah *et al.*, 1985; Kosslyn *et al.*, 1985). The most extensively studied patient examined in these studies, Case J. W., possessed propositional language in only the left hemisphere. The right hemisphere possessed a rich lexical system but little or no syntax or the capacity to make simple inferences. Results to date on this patient suggest that some features of the imaging process are normally carried out in the left hemisphere, such as the ability to assess details of a globally generated image. At the same time, both hemispheres seem capable of generating images of the type needed to draw objects and localize points in imaged space (personal unpublished observations). Taken together, it would appear that each half brain can have imaging processes related to perceptual processes.

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