

Spelling Dyslexia: A Form of Cross-Cuing

LYNN J. SPEEDIE, LESLIE J. ROTH, AND KENNETH M. HEILMAN

University of Florida College of Medicine and Veterans Administration Medical Center

A patient with spelling dyslexia maintained the ability to write, spell, and pronounce spelled nonsense words and words that require knowledge of orthographic rules of language. He was unable to perform grapheme-phoneme conversions except after naming the letter involved. We propose that he uses a letter-naming strategy to circumvent the disconnection of visual areas from the area of visual word images and that his letter-naming strategy represents a compensatory cross-cuing strategy.

INTRODUCTION

Dejerine (1891) described a patient who was unable to read or write (alexia with agraphia) and had a left-side angular gyrus lesion. Dejerine thought that the angular gyrus contained visual word images (engrams) and that destruction of these engrams induced the alexia with agraphia. Dejerine (1892) and others (see review by Benson and Geschwind, 1969) also described patients who could not read but could write. This has been termed "alexia without agraphia" (Benson & Geschwind, 1969). These patients usually have a left occipital lesion which may include the splenium of the corpus callosum. One of the postulated mechanisms underlying alexia without agraphia is a disconnection between the functioning visual areas and the intact left-hemisphere language areas, including the area of visual word images. A disconnection of the visual word images from primary visual areas would produce alexia because visual stimuli could not gain access to the left-hemisphere language area. However, because the area of visual word images was intact, the patient could write.

Hécaen and Albert (1978) described several types of alexia without agraphia. In one of these, verbal alexia, the patient reads by letter-

This work was supported by National Institutes of Health Grant NS 15229 and by the Medical Research Service of the Veterans Administration. Reprint requests should be addressed to Kenneth M. Heilman, M.D., Department of Neurology, Box J-236, College of Medicine, University of Florida, Gainesville, FL 32610. Presented at the annual meeting of the International Neuropsychological Society, Atlanta, Georgia, February 1981.

naming. Reading letter by letter has also been termed "spelling dyslexia" by Kinsbourne and Warrington (1962).

At least three mechanisms have been proposed to account for spelling dyslexia. Wolpert (1924) first described a syndrome he termed "simultanagnosia." In this syndrome he included an alexia in which the patient could read words only by spelling them letter by letter. Wolpert felt that the letter-by-letter phenomenon was another manifestation of the patient's inability to appreciate the totality of a visual composition in the face of spared ability to identify its discrete elements.

Kinsbourne and Warrington (1962) in a series of investigations demonstrated that the deficits in simultanagnosia were not a consequence of general intellectual deficit and that recognition of discrete visual entities, regardless of linguistic or symbolic import, was qualitatively similar to that of normals. Simultaneous and sequential presentation of stimuli suggested a deficit in which elements are perceived only one at a time and that a time interval is required before the patient can process another entity.

Subsequently, Warrington and Rabin (1971) studied visual span of apprehension and visual short-term memory in another group of patients with simultanagnosia. Many of these patients were as impaired as those in the 1962 study in terms of visual span of apprehension and short-term memory, but they did not exhibit spelling dyslexia. These observations suggest that a defect in the visual span of apprehension or visual short-term memory is insufficient to account for the letter-by-letter reading characteristic of spelling dyslexia.

In an additional study, Warrington and Shallice (1980) further demonstrate that in two spelling dyslexic patients, visual short-term memory and letter span were equivalent to those of the patients in 1971 who did not have spelling dyslexia. Warrington and Shallice also reject the disconnection hypothesis and instead propose that the letter-by-letter reading of the spelling dyslexic arises from damage to the system through which a visual word-form is attained. The visual word-form system is defined as that which parses letter strings into ordered and familiar units and categorizes these units visually. They suggest that formation of a whole word unit or word-form is necessary before phonological or semantic analysis.

Warrington and Shallice also noted that in their patients, concrete words were no less vulnerable to disruption than any other type of word and suggested, therefore, that the right hemisphere's capacity to contribute to the residual reading process is negligible, at least in the spelling dyslexic.

A summary of the view of Warrington and colleagues is that: (1) reading is a unitary process in which the visual word-form system may process letters, letter strings, and words and does so before further

phonological or semantic analysis; (2) letter-naming is a direct result of a breakdown of the visual word-form system; and (3) the right hemisphere contributes negligibly to whatever residual reading may occur in the spelling dyslexic.

Alternatively, Rothi and Heilman (1981) proposed that patients may use a spelling strategy to cross-cue. In comparison with Warrington and colleagues, Rothi and Heilman believe that (1) reading is a complex process in which graphic information is acted on by multiple and discrete mechanisms, (2) letter-naming is not a direct result of the breakdown in the processing systems *per se* but rather a compensatory cross-cuing strategy that allows entry to phonologic processing; and (3) the right hemisphere is capable of treating letters as objects and naming them accordingly. According to this view, the area of visual word images contains the orthographic rules that allow graphemic stimuli to gain access to phonological, graphomotor, and semantic systems. As postulated by Dejerine (1892), in alexia without agraphia these systems are intact but disconnected from visual input. Thus the typical procedure of grapheme-phoneme transcoding cannot take place. However, this model allows for inclusion of alternative or compensatory strategies, the need for which has been emphasized by Gibson and Levin (1975); and in the case of spelling dyslexia, object-naming is the proposed compensatory mechanism.

A letter or set of letters may be viewed as graphemic symbols of a phoneme or phonemic sequence. Alternatively, a letter may also be viewed as an object and named as such. As an example, in the Public Broadcasting System's program "Sesame Street," "B" becomes Mr. B and is described as an object with a certain shape. When asked to name objects, patients with alexia without agraphia usually show only mild defects (Albert, 1979). These patients are also able to spell, write, and understand words spelled to them. When words are presented visually, by naming the letters, the patients may be spelling to themselves, thereby cross-cuing and gaining access to the intact phonological, graphomotor, and semantic systems of the left hemisphere.

We recently had the opportunity to examine a patient who had spelling dyslexia, and we performed some tests that support the cross-cuing hypothesis of spelling dyslexia.

CASE REPORT

An 84-year-old right-handed man was admitted to the hospital with the chief complaint of sudden onset of vertical diplopia 3 days before admission. The patient was a retired farmer and had 1 year of high-school education.

His past medical history and family history were unremarkable. Examination of mental status revealed that the patient did not know the

current year. He showed some reduction of remote memory. (He did not know the president during World War II but could remember the date and place of his own birth.) Recent memory was minimally impaired. (He recalled two of three objects in 5 min.) He could repeat six digits forward and four in reverse order. Spontaneous speech, comprehension, naming, and repetition were all normal. Calculations, mapping, praxis, right-left orientation, and finger-naming were all within normal limits. The patient could recognize and sing familiar tunes. He could write spontaneously and to dictation but could not read what he had written after a brief delay.

Examination of cranial nerves was significant for a right homonymous hemianopia with relative sparing of the paracentral right superior quadrant. The patient also had mild anisocoria, the left pupil being larger than the right. His hearing was somewhat decreased bilaterally.

Motor examination revealed normal strength except for mild weakness of the left hamstring and a mild intentional tremor in both hands. Sensory examination revealed some diminished sensation to vibration distally in the lower extremities. The remainder of his neurological examination was unremarkable.

Computer tomography disclosed a hypodense area consistent with a left occipital infarction (Fig. 1), which did not appear to include the splenium of the corpus callosum. An electroencephalogram showed decreased alpha activity and decreased driving to photic stimulation in the left occipital area, compatible with a destructive lesion in the occipital region.

During 10 days of evaluation, he showed the constellation of problems typically present in patients with verbal alexia or spelling dyslexia, including intact writing, spelling, and comprehension of spelled words with impaired letter-by-letter reading. On a short form of the Boston Naming Test (Goodglass & Kaplan, 1972) he made 7/20 errors of a circumlocution type (e.g., "Eskimo house" for "igloo"), which indicated a mild naming disturbance. Prompting, regardless of type, did not improve his naming ability. The patient also had marked difficulty in naming colors and in supplying the color of common objects like bananas, but he could match colored chips and place them in order according to hue.

Reading and Writing Tests

We asked the patient to perform several tasks of reading, writing, and spelling. When one reads with a letter-naming strategy, long words are typically more taxing to memory systems. If the letter-naming strategy were the sole method by which our patient was able to read, we would expect that he should have greater difficulty with long words than with short words. In reading aloud, words varying from 3 to 11 letters long,

he could read the shorter words, albeit laboriously, with 97% accuracy (Table 1). Typically he named each letter aloud, sometimes repeatedly, before saying the word (e.g., for the word "cup" he said "c, u, p—cup"). He had more difficulty with the longer words (17% correct), which suggested that his letter-naming strategy was less effective for the longer word that taxed immediate memory.

To determine whether he might have some other reading strategy available (ideographic or grapheme-to-phoneme conversion), we limited the time of presentation. When time of presentation was limited to less than 3 sec, the patient was able to read very few 3- to 4-letter highly familiar words (15% correct). Typically, he guessed what the word might be, based on the initial letter or letters (e.g., for fish he said "f, i," and then guessed "fist"), or he complained that he did not have enough time. His inability to read rapidly suggests that these other more rapid strategies may not have been available to him.

For patients who must rely on a letter-naming strategy, transcoding from script to print should be more difficult than transcoding from print to script because the letters themselves are less visually distinct in script than in print and thus more difficult to treat as an object to be named. Our patient was able to transcode four words and three brief sentences from print to script in 7 min and 23 sec but required 15 min and 33 sec to transcode script of the same material presented in counterbalanced fashion over multiple days. In both situations, he used the letter-naming strategy. That he was slow on both tasks but required twice as long to transcode from script to print as from print to script and required the letter-naming approach in both tasks is consistent with the cross-cuing hypothesis.

The ability to transcode a single grapheme to a phoneme or vice versa, should not be affected by either simultanagnosia or a breakdown of the visual word form because no word form is involved. We asked the patient to transcode grapheme to phoneme and vice versa. When asked to select a grapheme from an array of graphemes when its phoneme was pronounced, he did so with 63% accuracy. When asked to provide the phoneme for a particular grapheme, he did so with 11% accuracy. In neither case did he select a response without first saying the name of the letter involved. These results not only are incompatible with the simultanagnosia and word-form hypotheses of spelling dyslexia but also demonstrate that the patient could not perform grapheme-to-phoneme conversion without first naming letters. These results again suggest that the letter-naming may reflect cross-cuing.

According to the cross-cuing hypothesis, the patient's morphophonological conversion rules should be intact. To demonstrate this, we asked him to discriminate words for which correct pronunciation and meaning

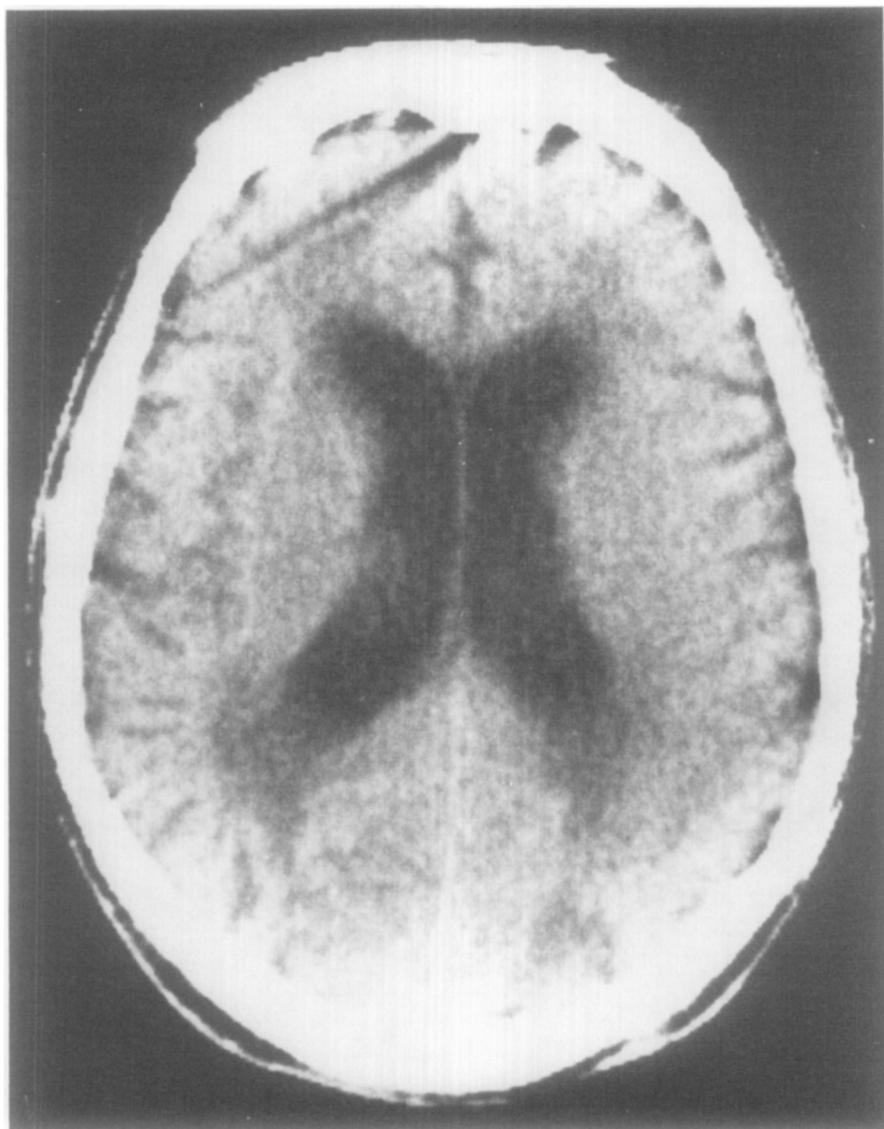


FIG. 1. Computer tomograms illustrating the patient's left occipital infarction.

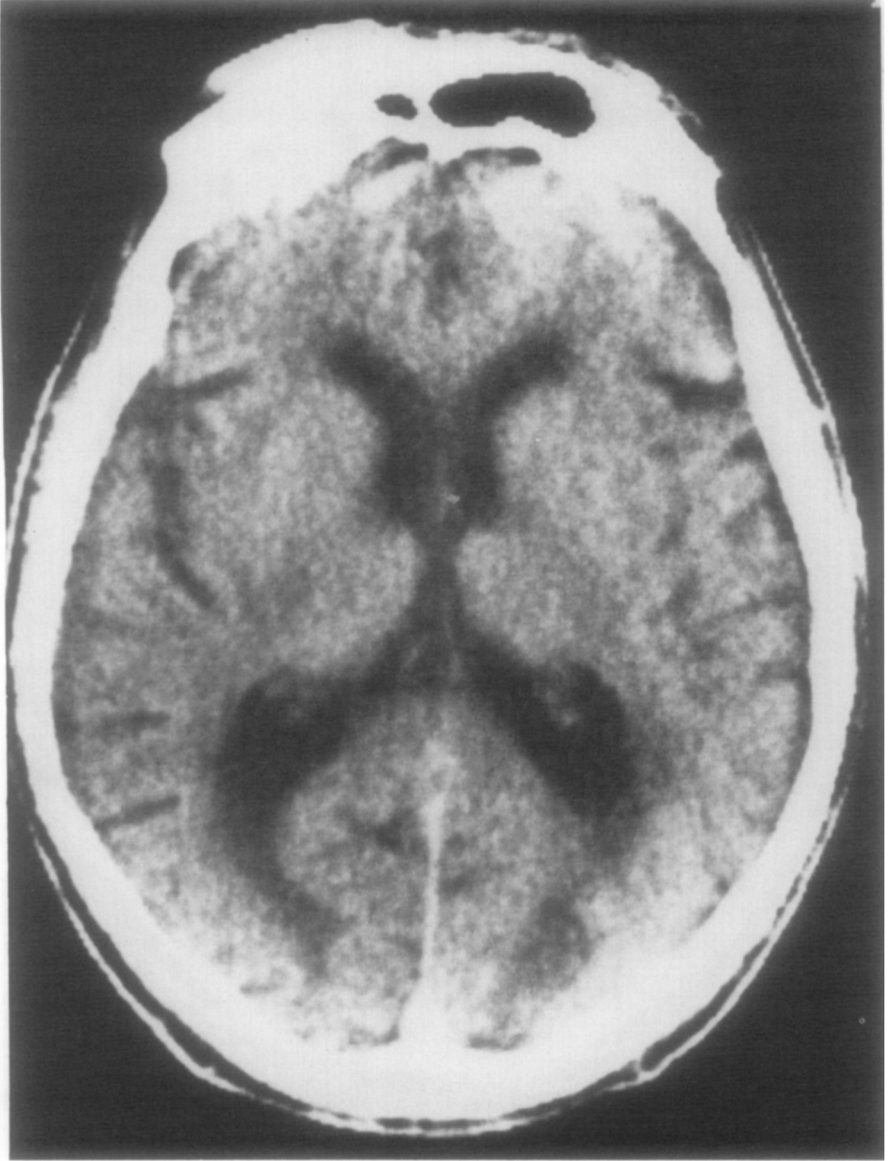


FIG. 1.—*Continued*

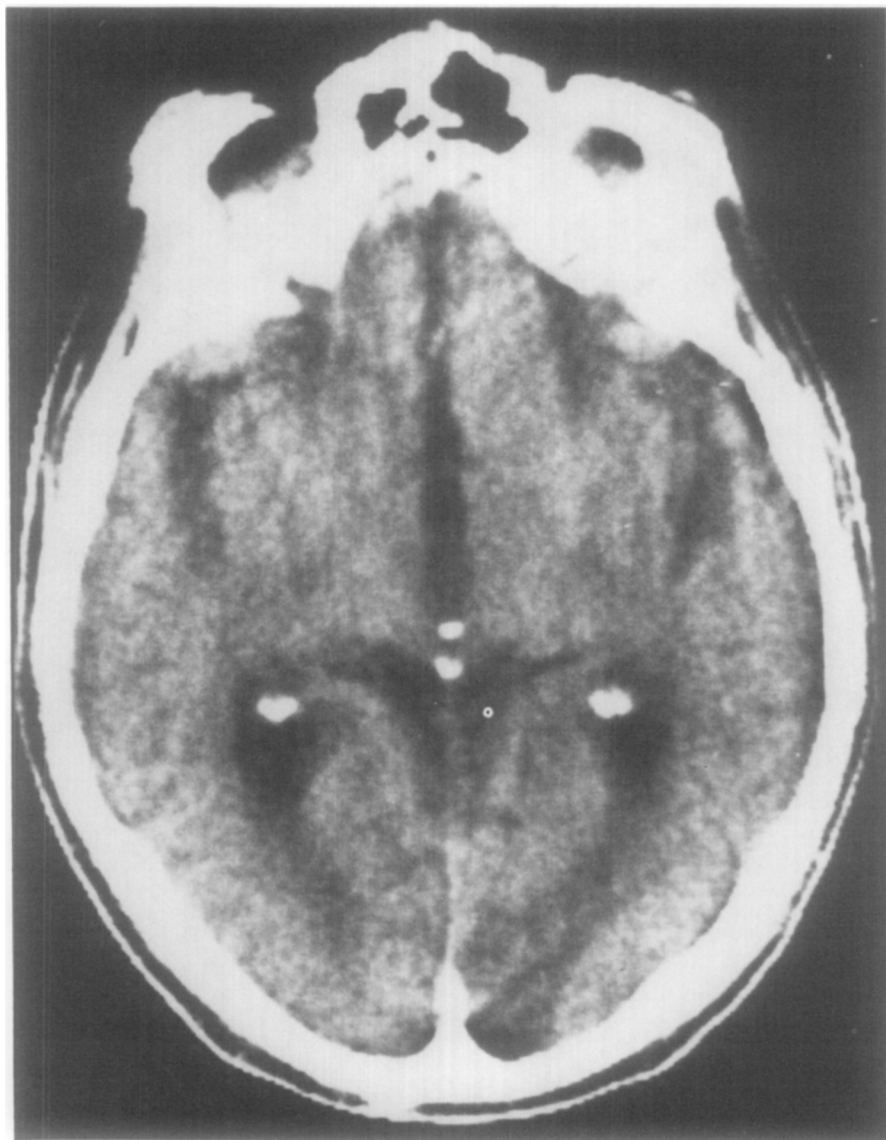


FIG. 1.—*Continued.*



FIG. 1—*Continued.*

TABLE 1
SUBJECT'S PERFORMANCE ON GRAPHIC TESTS

Task	Correct/items	Correct (%)
Read short words (3-6 letters)	29/30	97
Read long words (7-11 letters)	1/6	17
Read short words with limited time	3/20	15
Transcribe phoneme to grapheme	10/16	63
Transcribe grapheme to phoneme	2/18	11
Pronounce rule-governed words	24/30	80
Pronounce nonsense words	10/12	83
Spell nonsense words	9/10	90

cannot be gained from strict letter-to-sound transcoding without the knowledge of morphophonological conversion rules (such as the difference in pronunciation between "tap" and "tape").

He correctly pronounced 80% of the items. He also reasonably approximated the pronunciation of 83% of printed nonsense words such as "arpistan." Finally, we asked him to spell aloud nonsense words such as "mishapool." He offered reasonable spelling on 90% of these items. His ability to pronounce and to spell aloud nonsense words and to discriminate between words that require knowledge of morphophonological conversion rules suggests that his orthographic code or area of visual word images was intact.

DISCUSSION

This patient suddenly developed visual difficulties and was found to have a lesion in the left occipital region and resultant characteristics of alexia without agraphia. Like previously described patients, such as one in a report by Denkla and Bowen (1973), our patient could, however, read some words using a letter-naming strategy (verbal or spelling dyslexia). We explored his reading behaviors in the hope of clarifying the nature of the underlying mechanisms.

We propose that this patient's alexic difficulties arose because visual input of graphic information was isolated from an intact area of visual word images containing the morphophonological rules of spoken language. He was unable to approach any of our tasks without verbalizing the letter names that constituted the grapheme sequences, and his ability to perform in any fashion declined drastically when presentation time was limited. Consequently, we believe that verbalization of letters may substitute for visual input into the area of visual word images. His reliance on letter-naming, both in grapheme-phoneme conversion and in print-script transcoding provides further evidence that the patient used object-naming of letters as a compensatory cross-cuing strategy. He performed very

slowly in transcoding script to print and print to script, but required twice as long to transcode script to print. This fact may reflect the relative difficulty in treating script letters as independent objects, since they are less visually discrete than printed letters.

For the naming to succeed, the verbalizations must gain access to an intact left-hemisphere orthographic code (area of word images). That the left-hemisphere word images were indeed intact was reflected in the patient's ability to spell aloud nonsense words and pronounce written nonsense words as well as words that required knowledge of morpho-phonological rules of conversion in order to be spoken or understood.

Two issues need to be addressed. As Hécaen and Kremin (1977) noted, how can objects be named at all in patients whose functioning visual areas are disconnected from the left hemisphere? What role may the right hemisphere play in such a naming process?

Oxbury, Oxbury, and Humphrey (1969) suggested that degraded visual information traverses the corpus callosum sufficiently to allow gross visual recognition for objects but not the fine visual recognition required for reading. In contrast, Geschwind (1965) suggested that visual input within the right hemisphere may invoke sensory associations other than visual ones and that derived information may cross the corpus callosum anteriorly and thus be recognized, named, or in some fashion used.

However, the right hemisphere itself may also have the capacity for naming objects. Findings from patients with split-brain syndrome suggest that the right hemisphere is capable of certain linguistic processing usually conducted to better advantage by the left hemisphere, even in the split-brain populace. Specifically, Levy and Trevarthen (1977) demonstrated that the right hemisphere can match visually presented words and can select an appropriate picture for simple words. This confirmed a similar finding of Gazzaniga and Sperry (1967), that the right hemisphere is capable of reading simple words. Zaidel (1976) reported that, given sufficient time, the right hemisphere of certain patients can process words of all grammatical classes. Furthermore, the right hemisphere may initiate articulations characterized by single syllables or highly habitual phrases (Levy & Trevarthen, 1977). Thus, letter-naming in certain patients may reflect the capacity of the right hemisphere to treat the graphemes as objects and to name them.

Further evidence for right-hemisphere contributions to language processing arises from residual skills of aphasic patients as well. Heilman, Roth, Campanella, and Wolfson (1979) described a patient with global aphasia who selected entrees from a cookbook to indicate his preferences for dinner and who also learned Amerind, an ideographic gestural system. After a subsequent right-hemisphere stroke, the patient lost both skills.

In Japanese alexic and aphasic patients (Sasanuma, 1975; Sasanuma, Itoh, Mori, and Kobayashi, 1976; Yamadori, 1975) their relatively pre-

served capacity to process *Kanji* as compared with *Kana* also lends some credence to possible right hemisphere mechanisms for ideographic processing of linguistic symbols.

Finally, it is not clear why the patient we describe here could treat letters as objects but could not treat words as objects (ideographic reading). Rothi and Heilman (1981) postulated that the alternative strategies available to a patient depend in part on premorbid reading abilities. We suspect that this man before his illness relied on a nonideographic reading strategy such as grapheme-to-phoneme conversion; therefore, after his stroke he was unable to use an ideographic strategy. We suspect that after the left-side lesion he began to use a right hemisphere mechanism for letter-naming and then employed a verbal-auditory letter-naming code to access the area of visual word images, whereupon he applied orthographic morphophonemic rules of conversion.

REFERENCES

- Albert, M. L. 1979. Alexia. In K. M. Heilman & E. Valenstein (Eds.), *Clinical neuropsychology*. New York: Oxford Univ. Press. Pp. 59–91.
- Benson, D. F., & Geschwind, N. 1969. The alexias. In P. J. Vinken & G. W. Bruyn (Eds.), *Handbook of clinical neurology: Disorders of speech, perception, and symbolic behavior*. New York: American Elsevier. Pp. 112–140.
- Dejerine, J. 1891. Sur un cas de cécité verbale avec agraphie suivi d'autopsie. *Comptes Rendus Hebdomadaires des Séances et Memoires de la Société de Biologie*, **3**, 197–201.
- Dejerine, J. 1892. Contribution a l'étude anatomopathologique et clinique des différentes variétés de cécité verbale. *Comptes Rendus Hebdomadaires des Seances et Memoires de la Société de Biologie*, **4**, 61–90.
- Denkla, M. B., & Bowen, F. P. 1973. Dyslexia after left occipitotemporal lobectomy. A case report. *Cortex*, **9**, 321–328.
- Gazzaniga, M. S., & Sperry, R. W. 1967. Language after section of the cerebral commissures. *Brain*, **90**, 131–148.
- Geschwind, N. 1965. Disconnexion syndromes in animals and man. *Brain*, **88**, 237–294, 585–644.
- Gibson, E. J., & Levin, H. 1975. *The psychology of reading*. Cambridge, MA: MIT Press.
- Goodglass, H., & Kaplan, E. 1972. *The assessment of aphasia and related disorders*. Philadelphia: Lea & Febiger.
- Hécaen, H., & Albert, M. L. 1978. Disorders of written language. In *Human neuropsychology*. New York: Wiley. Pp. 54–66.
- Hécaen, H., & Kremin, H. 1977. Reading disorders resulting from left hemisphere lesions: Aphasic and pure alexias. In H. Whitaker & H. Whitaker (Eds.), *Studies in neuro-linguistics*. New York: Academic Press. Vol. 2, pp. 269–329.
- Heilman, K. M., Rothi, L., Campanella, D., & Wolfson, S. 1979. Wernicke's and global aphasia without alexia. *Archives of Neurology*, **36**, 129–133.
- Kinsbourne, M., & Warrington, E. K. 1962. A disorder of simultaneous form perception. *Brain*, **85**, 461–486.
- Levy, J., & Trevarthen, C. 1977. Perceptual, semantic and phonetic aspects of elementary language processes in split-brain patients. *Brain*, **100**, 105–118.
- Oxbury, J. M., Oxbury, S., & Humphrey, N. K. 1969. Varieties of colour anomia. *Brain*, **92**, 847–860.

- Rothi, L. J., & Heilman, K. M. 1981. Alexia and agraphia with spared spelling and letter recognition abilities. *Brain and Language*, **12**, 1-13.
- Sasanuma, S. 1975. Kana and Kanji processing in Japanese aphasics. *Brain and Language*, **2**, 369-383.
- Sasanuma, S., Itoh, M., Mori, K., & Kobayashi, Y. 1976. Tachistosopic recognition of Kana and Kanji words. *Neuropsychologia*, **14**, 547-553.
- Warrington, E. K., & Rabin, P. 1971. Visual span of apprehension in patients with unilateral cerebral lesions. *Quarterly Journal of Experimental Psychology*, **23**, 423-431.
- Warrington, E. K., & Shallice, T. 1980. Word-form dyslexia. *Brain*, **103**, 99-112.
- Wolpert, I. 1924. Die Simultanagnosie-Störung der Gesamtauffassung. *Zeitschrift fuer die gesamte Neurologie und Psychiatrie*, **93**, 397-415.
- Yamadori, A. 1975. Ideogram reading in alexia. *Brain*, **98**, 231-238.
- Zaidel, E. 1976. Auditory language comprehension in the right hemisphere following cerebral commissurotomy and hemispherectomy: A comparison with child language and aphasia. In E. Zurif & A. Caramazza (Eds.), *The acquisition and breakdown of language: Parallels and divergencies*. Baltimore: Johns Hopkins Press.