

DIRECT DYSLEXIA

PRESERVED ORAL READING OF REAL WORDS IN WERNICKE'S APHASIA

by W. W. LYTTON and J. C. M. BRUST

(From the Department of Neurology, Harlem Hospital Center and Columbia University College of Physicians and Surgeons, New York, USA)

SUMMARY

A 70-yr-old man was able to read aloud, without comprehending what he read, following a stroke that caused Wernicke's aphasia with severely impaired comprehension of speech. Tested on admission, and at 3 and 9 months, he could read aloud both orthographically simple and orthographically complex real words, and showed neither semantic errors, preference for nouns, nor difficulty with function words. He could not, however, read aloud orthographically simple nonwords. His disorder thus appears to be the first pure example of 'direct dyslexia', which, in contrast to previously well-documented examples of 'deep' and 'surface' dyslexia, implies the existence in reading of a direct route, independent of phonology or semantics, between visual and oral word representations.

INTRODUCTION

Acquired dyslexia has been characterized by linguistic criteria into two major syndromes, deep and surface dyslexia. Patients with deep dyslexia have difficulty with phonological processing, especially when reading nonwords or nonsense syllables (Coltheart, 1987; Coltheart *et al.*, 1987; Marshall and Newcombe, 1987). Performance on reading words aloud varies with part-of-speech. Nouns are read most easily, then adjectives, and then verbs; function words (e.g., prepositions, articles, or conjunctions) are especially difficult. Reading performance is also better with concrete or imageable nouns than with abstract nouns. Patients with deep dyslexia make semantic and inflectional errors, with substitution of a word of similar meaning or class (e.g., cow to horse). Semantic errors suggest at least partially preserved semantic comprehension; such patients may be able to match correctly pictures with words they can neither read aloud nor understand. These patients also make derivational errors: the substitution changes declension or conjugation through the suffix (marry to married) or by some other change (birth to born); and they make visual errors: the substituted word looks like the original

Correspondence to: Dr John C. M. Brust, Department of Neurology, Harlem Hospital Center, 506 Lenox Avenue, New York, NY 10037, USA.

© Oxford University Press 1989

(gallant to gallon; crowd to crown). Function words tend to be substituted for one another.

Patients with surface dyslexia can read aloud orthographically regular words and nonwords (and can thereby comprehend the former), presumably by grapheme-phoneme rules (using correspondences between letters or groups of letters and sounds), but cannot read orthographically irregular words correctly because of slavish application of these rules (Newcombe and Marshall, 1985). In reading 'tough', such patients might say 'to-ugh'. They show derivational and visual errors but do not make semantic errors.

Surface dyslexia can occur with or without aphasia. Deep dyslexia has always been reported in association with aphasic disorders. Particular aphasic symptoms (e.g., fluency, comprehension of speech, agraphia) do not predict the type of dyslexia. These dyslexic syndromes led to a model of two independent processing modules for normal reading: a direct (or visual) route from the visual word-form system to the semantic system, and a phonological route from the visual word-form system to phonological processing systems. In the direct route, words are interpreted as whole symbols, like Chinese ideograms; comprehension thus precedes verbalization. In the phonological route, letter symbols are converted to sounds in order to construct words; pronunciation precedes comprehension. The reference to ideograms is not gratuitous; deep and surface dyslexia have occurred in Japanese patients with selective difficulty in reading either the ideographic (kanji) or phonetic (kana) symbols of Japanese writing (Sasanuma, 1987).

Loss of one processing route with complete preservation of the other does not, however, readily explain all the features of deep or surface dyslexia. In particular, the presence in deep dyslexia of semantic errors and dissociated impairment of concrete and abstract nouns and parts of speech has implied to some workers a disturbance in the semantic route itself (in addition to the more severe disruption of the phonological route). Such a view received support from a case of so-called 'phonological dyslexia' (Beauvois and Déroutésne, 1979), in which there was inability to read aloud nonwords, yet, in contrast to deep dyslexia, real words were read without semantic errors and without regard to orthographic complexity, concreteness, or part of speech. The syndrome was interpreted as a more pure or 'single component' form of deep dyslexia. A problem with this syndrome was that as further cases were reported, considerable variability among them became apparent. As noted in a review of 15 patients said to have phonological dyslexia (Sartori *et al.*, 1984), nonword reading ability ranged from zero to 80% correct and word reading from 40 to 100%; reading comprehension was considered intact in some (especially when tested with matching tasks) but impaired (or not systematically tested) in others.

Schwartz *et al.* (1979) described a patient who could not understand what she read, even with matching tests; she could, however, read aloud real words regardless of their orthographic complexity as well as some nonwords. Unlike patients with phonological dyslexia, this patient's ability to read aloud could not

be attributed to partially preserved semantic understanding of what she read. She therefore provided 'evidence for the role of word-specific print-to-sound associations in reading'. A third processing route, independent of either phonological or semantic access, was postulated to account for reading aloud real words, especially when orthographically irregular. Preservation of this 'direct (route) between visual and oral word-representations' in patients with damage to the semantic and phonological routes would produce, as Newcombe and Marshall (1981) called it, 'direct dyslexia'.

By this formulation, however, the patient described by Schwartz *et al.* was not a pure case, for she could read nonwords and had a tendency to regularize orthographically irregular words, demonstrating that her phonological route was functional. To our knowledge a truly prototypical case of direct dyslexia has not yet been reported. We were therefore interested to encounter a patient with pure direct dyslexia in association with Wernicke's aphasia.

CASE REPORT

G.H., a 70-yr-old right-handed man, was brought to the emergency room in July 1985 by his wife, who stated that he had been speaking nonsense for a month. She noted that his problem had been of sudden onset, but that his mental functioning had already been deteriorating over several months. She could not give more precise details.

On admission, he had aphasia characterized by fluent prosodic speech that consisted of real words but made no sense. Comprehension of speech, naming, repetition, writing, and reading were severely impaired as detailed below. He had a short-stepped gait, but neurological examination was otherwise normal with no cranial nerve, motor, sensory, or reflex asymmetries. The admitting diagnoses were dementia and stroke with Wernicke's aphasia. Normal studies included complete blood count, urinalysis, and serum sodium, potassium, vitamin B12, and calcium, as well as liver and thyroid function tests, ECG, and chest x-ray. An EEG showed diffuse slowing with no asymmetry. A CT scan (fig. 1) showed lucencies compatible with infarction in the left frontal and temporal lobes, including the planum temporale.

The patient had been schooled through the sixth grade in South Carolina. He had worked at a variety of manual jobs. Until the year before admission, he had read the New York Daily News thoroughly every day.

RESULTS

In addition to the admission examination, the patient received more extensive language evaluation at 3 months and 9 months following admission. We followed the format of the Boston Diagnostic Aphasia Examination where applicable, and supplemented it with other material designed to elucidate his reading abilities.

At all times, speech was fluent and prosodic. At 3 months his output was limited to stock phrases that he would repeat with minor variations: 'That was beautiful.' 'You're looking real good today.' He had few literal paraphasias and no verbal paraphasias but would frequently lapse into mumbling. At 9 months his output showed more variety as well as more literal paraphasias; at times his speech even

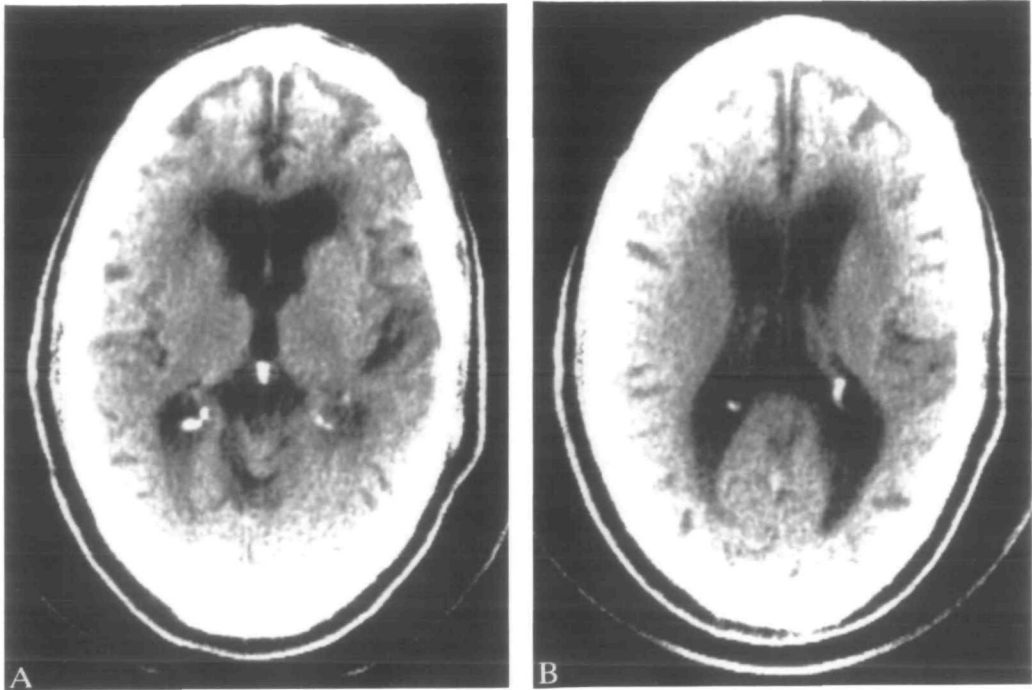


Fig. 1. A and B, computerized tomography of the head (without contrast). Seen in each slice are (1) frontal periventricular lucencies, on the left extending posteriorly across the corona radiata; (2) left temporal lobe lucency affecting both cortex and white matter, including posterior superior temporal gyrus (planum temporale); and (3) diffuse ventricular enlargement and sulcal widening, greater on the left.

became jargon: 'Affa, affa, belba-buract-no this was clined in case yekaleg-no it was all-I didn't hef it-no sir.'

Speech comprehension was always moderately to severely impaired. At 3 months, he followed a few simple commands on only one occasion, quickly lapsing into perseveration. On subsequent days he followed no commands. At 9 months, he followed simple commands fairly consistently, although he still perseverated after 4 or 5 correct executions such as protruding his tongue, raising his arm, standing, sitting, and touching various body parts. He was unable to identify named objects other than body parts. He never followed a two-step command but would generally do only the first part of it, and he did not answer simple yes-no questions appropriately. When asked 'Am I wearing a hat?' he touched the top of his head. He would sometimes simply repeat the question with appropriate grammatical alteration. For example, asked 'Is this your nose?' he said 'Is this my nose?' With continued questioning he would respond in jargon speech.

At 3 months he repeated some single words but mostly he would not repeat at all. Repetition of foreign phrases (i.e., for him nonwords) was impaired to the same degree as repetition of phrases in English. At 9 months, repetition came

more readily but was riddled with paraphasias. 'The man went home' elicited dissimilar jargon. 'Wristwatch' became 'wrist balda fide'; 'New York City'—'New York Kitty pity'; 'The president lives in Washington'—'Pres-president in fensy in pract', then 'Presidi in precifice in prensy'.

Naming on admission was circumlocutory but without paraphasias. Shown matches, he said 'This is for cigarettes.' Candy—'It's a treat, you eat it'. Examined at 3 months, he did not appear to understand the task and did not name anything to command or spontaneously. Shown a picture of a house he said 'two floors'. At 9 months, naming was neologistic: 'kallee' for hand; 'u' for pen.

Soon after admission, asked to write 'I am in the hospital' to dictation, he wrote 'cam I am a am'. At 3 months, he copied single words and wrote his name spontaneously but wrote nothing to dictation. At 9 months he wrote his name to command and then perseverated, writing his name when asked to write other words. Later, he wrote 'cat' and 'dog' to dictation. For 'New York' he wrote 'new new'. For 'tough' he wrote 'cap'; he was able to copy writing in capital printing but not in lower case script.

Oral reading was generally correct for words or short phrases. At 3 months he easily named single letters and read the words of section IIa of the Boston Diagnostic Aphasia Examination (Appendix 1) without error. He read list IIIa with only 2 errors, saying 'Mammy' for 'Mama' and slurring 'huckleberry'.

Further examination was directed at determining whether he read phonetically or semantically. On reading different kinds of real words, he made infrequent errors, all either derivational or visual. For example, he read a list (Appendix 2) of 10 orthographically complex words (words that cannot be sounded out) with one error—saying 'hästy' for 'hasty'. Given a list (Appendix 3, A and B) of 20 3-letter nouns, he made only 3 errors: 'carna' for 'car', corrected with prompting; 'zeg' then 'zug' for 'zoo'; and 'intense' for 'ant'. On 20 nonrepresentational nouns (3-C), he made 4 errors: 'cave' for 'eve', 'rip' for 'rap', 'i-r-e' (spelling word) for 'ire', and 'gig' for 'jig'. On 20 non-nouns (3-D), the 4 errors were as follows: 'u-j, u-linging' for 'ugh' 'couch' for 'coy', 'on' for 'one', 'āgo' for 'ago'. On the other hand, given 20 nonsense words (3-E) he correctly read only 3, and he read even these with uncharacteristic hesitation. Generally, presented with a nonword, he would remain silent. This was in marked contrast to his behaviour with real word reading when he would respond promptly and seem eager. If pressed for a response, he would spell out the word or decompose it into a letter and a 2-letter word. In two cases, he tried to make real words out of nonwords, giving 'cafe' for 'caf' and saying 'When I looked at the eggs on the table' for 'heg'. On each occasion, following the testing for nonword reading, he was able to read real words with the same degree of proficiency as before. He was also able to read sentences. Shown 'No ifs and or buts', he initially read 'No fits or buts', but then read it correctly when asked to read it again. He was able to read Gray reading selection 1 (Appendix 4) rapidly with only a few errors, saying 'body' for 'boy' in one place and 'dog' for 'boy' in another, 'tie' for 'cry', and 'can't' for 'cannot'. After reading

this selection on one occasion, he spontaneously added 'He probably wanted the dog to go home.'

Reading comprehension was severely limited. On testing at 3 months, on the same day that he followed a few verbal commands, he also followed several simple written commands after reading them aloud. Thereafter he never appeared to comprehend any. On examination at 3 months attempts were made to engage the patient in a variety of matching tasks, including verbal to written, picture to written, object to written, and the converse of each of these. Despite being attentive, he showed no understanding of what was required of him. When pressed, he seemed aware that some choice was required from among the objects or words placed before him but his choices were no better than random. At 9 months, he read aloud simple commands correctly without following them. Reading 'Am I wearing a hat?' he touched the top of his head. He again failed to perform any matching tasks.

He was able to read numbers easily, both single digits and numbers in the tens and hundreds, sometimes interpolating 'dollar' as if he were reading a price. He was also generally successful in reading time off a clock face drawn without numbers, making the correct distinction between the hour and the minute hand.

Two years later he was reexamined in a nursing home. Receiving thiothixene and benztropine for agitation, he had parkinsonian bradykinesia and a stooped gait. Although cooperative and docile, he made little eye contact, had no spontaneous speech except when queried, and had great difficulty getting the gist of nonverbal instructions. Speech was still fluent and prosodic, with considerable literal paraphasic contamination ('You got a wa wa eso jo sa ringsa day'). He followed no commands and did not indicate affirmative or negative to yes-no questions. Object naming and repetition testing produced several syllables of literal jargon; it was unclear if he was actually trying to name or repeat. He made no attempt to read or write.

DISCUSSION

The most striking feature of this patient's dyslexia was his preserved ability to read real words, whether orthographically regular or irregular, in the presence of (1) severe Wernicke's aphasia, and (2) inability either to read aloud nonwords or to comprehend what he read. His lack of reading comprehension appeared total; he failed at matching words with pictures and made no semantic errors. When reading aloud, he showed no preference for concrete over abstract nouns or for nouns over other parts of speech, including function words. He made rare derivational and functional errors. Although his reading of nonwords gradually improved, he never read them correctly; conversely, the real words he missed were uncommon (e.g., 'ire', 'coy') and may not have been part of his vocabulary.

Previous reports of preserved reading in aphasia have usually involved patients with intact reading comprehension in the setting of impaired comprehension of

speech. Sevush *et al.* (1983) reported 2 patients who showed this dissociation. Their first patient, a 53-yr-old man, presented with aphasia, right hemiparesis, and right homonymous hemianopia. On examination one year later he had paraphasias on spontaneous speech and poor repetition and naming. Comprehension was also impaired although intact for simple phrases. His writing showed word substitutions. Reading was said to be 'slow and effortful' but his comprehension of what he read was better than his comprehension of spoken speech. His oral reading was also considered better than his spontaneous speech, showing fewer paraphasic errors. His reading showed the stigmata of surface dyslexia, with characteristic mispronunciations of orthographically irregular words. The second patient, a man of the same age without hemiparesis or visual field loss, had Wernicke's aphasia with profoundly impaired speech comprehension. Reading comprehension, however, was intact for sentences, and reading aloud produced less jargon and paraphasias than did spontaneous speech.

Hier and Mohr (1977) reported a 28-yr-old man with Wernicke's aphasia after encephalitis. He could write names that he could not say and, although unable to read aloud, understood written language better than speech.

Heilman *et al.* (1979) reported 3 similar patients, although only 1 had fluent speech. This patient, a 60-yr-old man, had aphasia, visual field loss, and mild right hemiparesis. Speech contained paraphasias; naming, repetition, and auditory comprehension were poor. Reading comprehension was somewhat better. Oral reading was not directly compared with spontaneous speech. The patient was able to read both words and nonwords and employ phonetic values in rhyme and meaning matching tests.

The patients of Sevush *et al.* and Heilman *et al.* thus had Wernicke's aphasia with relatively preserved reading comprehension and oral reading of words and nonwords. Hier and Mohr's patient had Wernicke's aphasia with loss of ability to read aloud but relatively preserved reading comprehension. In contrast to these patients, our patient had Wernicke's aphasia with preserved oral reading of real words but loss of reading comprehension and inability to read nonwords.

Reading aloud is a form of repetition, involving phonetic reproduction of speech input from a visual rather than an auditory source. Our patient and those of Sevush *et al.* and Heilman *et al.* had difficulty with auditory repetition; their reading abilities cannot be a result of preservation of this function. Nonetheless, reading could improve speech by providing a constant external check for both phonology and semantics, in contrast to spontaneous speech in which any such check must be entirely internal. The patients of Sevush *et al.* and of Heilman *et al.* had access in their reading to information both phonological (with intact reading of nonwords) and semantic (with relatively preserved reading comprehension). Such information would be essential in the feedback role of reading aloud. Our patient had no access to such information, yet he could read aloud only real words. It must be presumed, therefore, that he was using a processing route that led directly

from visual to oral real-word representations, bypassing both semantics and phonetics.

As noted, the existence of such a route was first suggested by Schwartz *et al.* (1987). In an earlier report, their patient, a 62-yr-old woman, was described as having a progressive dementing illness with fluent speech, severely impaired confrontational naming and speech comprehension, and relatively preserved oral repetition (i.e., transcortical sensory aphasia) (Schwartz *et al.*, 1979). It was further observed that her speech and speech comprehension displayed relative preservation of syntactic compared with semantic processing. Moreover, she could read aloud both words (regular and irregular) and nonwords. In their later report the authors found this ability to be associated with total lack of reading comprehension (as shown by random performance on picture-matching and categorical word-sorting, as well as absence of semantic errors). The authors speculated that in reading she was employing 'a more direct lexical mechanism, one which proceeds directly from visual word form (visual input logogen) to a stored representation in a phonological lexicon (output logogen)'.

In a psycholinguistic classification of acquired dyslexia, Newcombe and Marshall (1981) offered a block diagram, reproduced here in fig. 2, that recognized the existence of these direct, semantically-independent word-specific associations between print and sound ('barking at print'). Deep dyslexia would result when there was disruption of routes C ('grapheme-phoneme correspondence rules') and B ('direct association between visual and oral word representations'), with reading then depending solely on route A ('lexical semantic representations'). Surface dyslexia would occur with disruption of routes A and B. Theoretically, there should then exist a 'direct dyslexia', resulting from disruption of routes A and C. The authors pointed out that the case of Schwartz *et al.* was not a pure example of direct dyslexia, for her ability to read nonwords and her tendency to 'regularize' orthographically irregular words showed that she was still using route C.

Lebrun and Devreux (1984) also observed a patient with fluent aphasia who read sentences aloud without comprehension, but further details were not given. Glass *et al.* (1973) described 4 patients with global aphasia who were able to make written word/nonword distinctions of a sorting task despite being unable to do picture/written word matching. These patients provide further evidence for the existence of word knowledge independent of semantic knowledge. They might be thought of as showing a direct dyslexia masked by their aphasia and illustrate the importance of examining a patient's reading abilities in the context of overall language ability.

Our patient is the first to fit the model of direct dyslexia as predicated by Newcombe and Marshall, and his retained ability to read real words aloud offers further evidence for the existence of direct, semantically independent 'word-specific print-to-sound associations'. No anatomical conclusions can be drawn from his dissociated language abilities. (Although the history and CT scan suggested left cerebral ischaemia, his earlier history suggested the intriguing possibility that, like

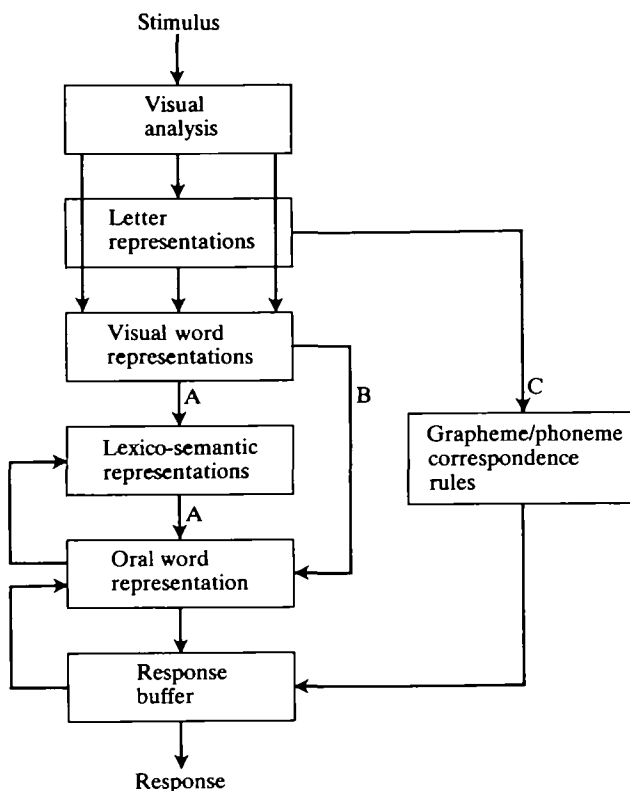


Fig. 2. Diagram representing different routes in reading. Deep dyslexia would follow damage to routes C and B; surface dyslexia would follow damage to routes A and B; direct dyslexia would follow damage to routes A and C. (From Newcombe and Marshall, 1981, reprinted by permission of the Orton Dyslexia Society.)

the patient of Schwartz *et al.*, he also had a more diffuse dementing illness, but historical details were not available. When last examined, 2 yrs later, his mentation had deteriorated, but he was receiving neuroleptic and anticholinergic drugs at the time.) Indeed, it should be emphasized that the dyslexic models of Newcombe and Marshall are psycholinguistic, not anatomical or physiological, and at present do not readily account for such phenomena as semantic paraphasias in deep dyslexia (or their absence in 'phonological dyslexia'), difficulty with abstract as compared to concrete nouns and with function words, and visual or derivational errors (Shallice and Warrington, 1987). Neither do they explain unusual syndromes such as 'semantic access dyslexia' (Warrington and Shallice, 1979), 'concrete word dyslexia' (Shallice, 1981), or 'word-form dyslexia' (Warrington and Shallice, 1980). As Newcombe and Marshall pointed out, there is a need 'to provide explanatory accounts of the patients and symptoms that appear to have no obvious interpretation within the confines of our current block diagrams. It may well turn out that as we attempt that enterprise . . . much of our current framework will have to be dispensed with.'

The development of an alternate model of cognitive processes, namely parallel distributed processing (McClelland, 1986; McClelland *et al.*, 1986; Sejnowski and Rosenberg, 1987) suggests new ways to look at language disorders. Rather than exploring dyslexia in isolation, it might be more profitable to consider a dyslexia in the setting of any accompanying aphasia and develop models that would help explain the patient's entire disability. In parallel distributed processing models, the various aspects of language processing—semantic, linguistic, phonetic and others—are not represented in distinct isolated modules but are represented to various extents in small independent neuron-like processing units. Instead of looking at the deficits that result when a single module is removed, one observes the residual function of which a network is capable after particular areas have been damaged. Thus G.H.'s 'dyslexia' may be best described as a 'lexia', a standing relic among extensive ruins.

In G.H.'s case, fluency and failure of comprehension are two attributes that are common to both his reading and his spontaneous output and auditory language processing. Interestingly but not surprisingly, the fluctuations in his comprehension affected both his reading and his oral comprehension at the same time. In fact, during the course of a single examination he showed identical behaviour (touching his head) when first reading and then being asked orally whether the examiner was wearing a hat. Although we did not see any evidence of parallel fluctuation in his degree of fluency, his greater tendency to paraphasias in his spontaneous speech on examination at 9 months was matched by his tendency to add phrases of jargon when he read aloud either words or nonwords. On the other hand his inability to read nonwords was not matched by particular difficulty in repeating nonwords presented orally.

In presenting G.H.'s case, we have attempted to show how his language disorder compares with those of other reported patients and how it might be described in terms both of modular and distributed models of language process. This case confirms a prediction made on the basis of the modular model and therefore provides evidence in favour of that model. On the other hand, newer modelling techniques may provide opportunities to explore language problems on a broader scale. Perhaps both modelling paradigms will prove to be complementary in elucidating the mechanisms of brain function.

ACKNOWLEDGEMENTS

We thank Dr Allan Schwartz for radiological interpretation, Dr Lewis P. Rowland for helpful suggestions, and Ms Debbie Bailey for assistance in preparing the manuscript.

REFERENCES

- BEAUVOIS MF, DÉROUESNÉ J (1979) Phonological alexia: three dissociations. *Journal of Neurology, Neurosurgery and Psychiatry*, **42**, 1115–1124.
- COLTHEART M (1987) Deep dyslexia: a right-hemisphere hypothesis. In: *Deep Dyslexia*. Second

- edition. Edited by M. Coltheart, K. Patterson and J. C. Marshall. London: Routledge and Kegan Paul, pp. 326-380.
- COLTHEART M, PATTERSON K, MARSHALL JC (1987) Deep dyslexia since 1980. In: *Deep Dyslexia*. Second edition. Edited by M. Coltheart, K. Patterson and J. C. Marshall. London: Routledge and Kegan Paul, pp. 407-451.
- GLASS AV, GAZZANIGA MS, PREMACK D (1973) Artificial language training in global aphasics. *Neuropsychologia*, **11**, 95-103.
- HEILMAN KM, ROTH L, CAMPANELLA D, WOLFSON S (1979) Wernicke's and global aphasia without alexia. *Archives of Neurology, Chicago*, **36**, 129-133.
- HIER DB, MOHR JP (1977) Incongruous oral and written naming: evidence for a subdivision of the syndrome of Wernicke's aphasia. *Brain and Language*, **4**, 115-126.
- LEBRUN Y, DEVREUX F (1984) Alexia in relation to aphasia and agnosia. In: *Dyslexia: A Global Issue*. Edited by R. N. Malatesha and H. A. Whitaker. The Hague: Martinus Nijhoff, pp. 191-209.
- MCLELLAND JL (1986) The programmable blackboard model of reading. In: *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*, Volume 2. By J. L. McClelland, D. E. Rumelhart and the PDP Research Group. Cambridge, MA and London: MIT Press, pp. 122-169.
- MCLELLAND JL, RUMELHART GE, HINTON GE (1986) The appeal of parallel distributed processing. In: *Parallel Distributed Processing: Explorations in the Microstructure of Cognition*, Volume 1. By D. E. Rumelhart, J. L. McClelland and the PDP Research Group. Cambridge, MA and London: MIT Press, pp. 3-44.
- MARSHALL JC, NEWCOMBE F (1987) The conceptual status of deep dyslexia: an historical perspective. In: *Deep Dyslexia*. Second edition. Edited by M. Coltheart, K. Patterson and J. C. Marshall. London: Routledge and Kegan Paul, pp. 1-21.
- NEWCOMBE F, MARSHALL JC (1981) On psycholinguistic classifications of the acquired dyslexias. *Bulletin of the Orton Society*, **31**, 29-46.
- NEWCOMBE F, MARSHALL JC (1985) Reading and writing by letter sounds. In: *Surface Dyslexia: Neuropsychological and Cognitive Studies of Phonological Reading*. Edited by K. E. Patterson, J. C. Marshall and M. Coltheart. London: Lawrence Erlbaum, pp. 35-51.
- ROSENBERGER PB, MOHR JP, STODDARD LT, SIDMAN M (1968) Inter- and intra-modality matching deficits in a dysphasic youth. *Archives of Neurology, Chicago*, **18**, 549-562.
- SARTORI G, BARRY C, JOB R (1984) Phonological dyslexia: a review. In: *Dyslexia: A Global Issue*. Edited by R. N. Malatesha and H. A. Whitaker. The Hague: Martinus Nijhoff, pp. 339-356.
- SASANUMA S (1987) Acquired dyslexia in Japanese: clinical features and underlying mechanisms. In: *Deep Dyslexia*. Second edition. Edited by M. Coltheart, K. Patterson and J. C. Marshall. London: Routledge and Kegan Paul, pp. 48-90.
- SCHWARTZ MF, MARIN OSM, SAFFRAN EM (1979) Dissociations of language function in dementia: a case study. *Brain and Language*, **7**, 277-306.
- SCHWARTZ MF, SAFFRAN EM, MARIN OSM (1987) Fractionating the reading process in dementia: evidence for word-specific print-to-sound associations. In: *Deep Dyslexia*. Second edition. Edited by M. Coltheart, K. Patterson and J. C. Marshall. London: Routledge and Kegan Paul, pp. 259-269.
- SEJNOWSKI TJ, ROSENBERG CR (1987) Parallel networks that learn to pronounce English text. *Complex Systems*, **1**, 145-168.
- SEVUSH S, ROELTGEN DP, CAMPANELLA DJ, HEILMAN KM (1983) Preserved oral reading in Wernicke's aphasia. *Neurology, Cleveland*, **33**, 916-920.
- SHALLICE T (1981) Neurological impairment of cognitive processes. *British Medical Bulletin*, **37**, 187-192.
- SHALLICE T, WARRINGTON EK (1987) Single and multiple component central dyslexic syndromes. In: *Deep Dyslexia*. Second edition. Edited by M. Coltheart, K. Patterson and J. C. Marshall. London: Routledge and Kegan Paul, pp. 119-145.

WARRINGTON EK, SHALLICE T (1979) Semantic access dyslexia. *Brain*, **102**, 43-63.

WARRINGTON EK, SHALLICE T (1980) Word-form dyslexia. *Brain*, **103**, 99-112.

(Received January 7, 1988. Revised May 23, 1988. Accepted July 8, 1988)

APPENDIX 1

(Word lists from the Boston Diagnostic Aphasia Examination)

IIA	IIIA
CHAIR	MAMA
CIRCLE	TIP-TOP
HAMMOCK	FIFTY-FIFTY
TRIANGLE	THANKS
FIFTEEN	HUCKLEBERRY
PURPLE	BASEBALL PLAYER
SEVEN-TWENTY-ONE	CATERPILLAR
DRIPPING	
BROWN	
SMOKING	

APPENDIX 2

(Orthographically difficult words)

TOWEL	CAUGHT	KNEE	WASTE	THOUGHT
KNOCK	CHANCE	HASTY	HALF	TOUGH

APPENDIX 3

(Taken from Rosenberger et al., 1968)

A	B	C	D	E
CAR	JUG	NAP	AGO	ZOJ
BEE	EGG	LOT	YES	CIJ
MAN	BAG	ONE	BUT	YUD
HOE	FAN	JIG	ONE	FET
BUG	NUT	PAR	COY	HEG
ZOO	DAM	IRE	UGH	GIX
HUT	APE	RAP	DUE	GOX
EAR	KEY	HIT	TOO	LAJ
BOX	SUN	SUM	ERR	CAF
CAT	PEN	GAP	SAD	KAP
HEN	RAT	TON	FAR	ZIF
COW	HAM	FUN	PRY	CEF
HAT	MAP	VIM	GET	YIL
PIE	ICE	EVE	OLD	DAX
AXE	GUN	CUT	HOT	WUB
DOG	ANT	BET	NOT	GAH
SAW	CAN	WAR	IRK	VUK
BOY	TUB	ART	MET	JOX
PIG	VAN	DIP	JAB	TOV
BED	WIG	ZIP	LOW	MEC

APPENDIX 4

(Selection 1 from *Standardized Oral Reading Paragraphs* by William S. Gray, *Services for Professional Educators*, 5341 Industrial Oaks Blvd., Austin, Texas 78735)

A boy had a dog.
 The dog ran into the woods.
 The boy ran after the dog.
 He wanted the dog to go home.
 But the dog would not go home.
 The little boy said,
 'I cannot go home without my dog'.
 Then the boy began to cry.