included *crabe* being reproduced as *homard*, *auto* as *voiture*, *biche* as *gazelle*. With a task involving pairs of easily identifiable everyday sounds to be labelled, with a written response, the patient scored 90 per cent of the stimuli from the left ear and 70 per cent from the right ear. As Michel remarks, this could be due to the temporal properties of the sounds which did permit a switch of attention from ear to ear.

Finally it is clear that the patient is agrammatic in all modalities. Thus, in a written answer to the written question *Où est la Tour Eiffel?* he wrote *315 mètres*. All French children know the height of the Eiffel Tower and the imagined question is a likely one. In answer to the spoken question 'Who is the president of the U.S.A.?' he began to write a list of all the presidents he could remember.

From the point of view of trying to model deep dyslexia, this patient is very significant. His pattern of performance helps to answer a problem which existed when only the deep dyslexic pattern had been described, namely that the reading functions might be considered more complex or more-vulnerable (since more recently learned) than repetition skills. If this were so, then the functional separation of reading skills and repetition skills need not be asserted. One could simply say that the more complex skills are more liable to disturbance. The existence of these two patients amounts to evidence for a double dissociation and as such is more convincing evidence for a modality separation.

References

Byers Brown, D. B. and Ives, L. (1969) The re-education of a dysphasic adult. *British Journal of Disorder of Communication*, *4*, 176–96.

Cruse, D. A. (in press) Aspects of word recognition in an adult aphasic. *Brain and Language*.

Marcel, A. J. (in press) Conscious and unconscious reading: the effects of visual masking on word perception. *Cognitive Psychology*.

Michel, F. (1979) Preservation du langage ecrit malgré un deficit majeur du langage oral. *Le Lyon Medical*, *241*, 141–9.

Morton, J. (1968) Grammar and computation. In J. C. Catford (ed.), *Studies in Language and Language Behaviour*, C.R.L.L.B. Progress Report no. VI, University of Michigan.

Patterson, K. E. and Marcel, A. J. (1977) Aphasia, dyslexia and the phonological coding of written words. *Quarterly Journal of Experimental Psychology*, *29*, 307–18.

10 Reading, phonological recoding, and deep dyslexia

Max Coltheart

A major characteristic of deep dyslexia is the patient's inability to gain access to, or to create, phonological representations of printed letter-strings. This inability has been demonstrated in a variety of ways. Some examples are:

(a) Deep dyslexic patients have great difficulty in pronouncing aloud even the simplest of pronounceable non-words.

(b) When the non-words are pseudo-homophones (i.e. have the same pronunciations as genuine words – examples are *brane* and *burd*), patients will sometimes pronounce them correctly, but it is clear that they do not do this by deriving a phonological code directly from the letter-string. Instead they use what might be termed 'approximate visual access'; they seek that English word which is *visually* the most similar to the pseudohomophonic non-word, and give this as the response (Saffran and Marin, 1977). This may even be done with non-words which are not pseudo-homophones (Patterson, 1978).

(c) Even in tasks which do not require overt articulation this phonological disability can be observed. For example, one patient chose *cough* rather than *cuff* as a rhyme for *rough*, and *choke* rather than *soap* as a rhyme for *hope*; clearly her rhyme decisions are made on the basis of *visual* similarity (Saffran and Marin, 1977).

(d) Furthermore, when patients are asked to perform the lexical decision task (classifying letter-strings as words or non-words), their 'No' responses are not impeded when non-word strings are pseudo-homophones (Patterson and Marcel, 1977), whereas

I thank Derek Besner and Estelle Doctor for useful discussions.

system to the output logogen system would be blocked but that to the cognitive system left intact. This meaning could be accessed even though no phonemic code was available. Note that this code does not account for the patient's inability to produce a full semantic description. By analogy with the deep dyslexics we might expect better – that is more complete as well as more accurate – semantic readings. Cruse's account of this is that with the critical words (−S, ½M) the phonological representation is lost very quickly, and the semantic processing is interrupted prior to completion. He could not find convincing evidence to support his account but it remains highly plausible. Certainly we need to account for the patient's inability or unwillingness to attempt to respond on the basis of the semantic information he had. This is most comfortably considered in terms of loss of the phenomenal aspect of the stimulus – being aware only of meaning without stimulus (c.f. Marcel, in press).

2 Michel (1979)

This patient suffered a left temporal lesion in 1973 at the age of 45 as the result of a fall. He did not have any particular problems apart from linguistic ones, preserving, for example, good arithmetic ability from the beginning, and no visual or motor problems. His audiogram was almost normal and he had a performance I.Q. of 107. The main contrast in this patient's language function is in the mode of output, his writing being relatively good but his speech being highly aphasic. The outstanding feature of his performance from our current viewpoint is his repetition behaviour. First of all he was completely incapable of repeating nonsense words. He could only repeat concrete nouns and adjectives, with any degree of success, had a lot of difficulty with abstract nouns, verbs and adverbs and would rarely attempt pronouns, prepositions, conjunctions, or articles. With concrete nouns his repetition attempts were typified by semantic paraphasias. In one session where he attempted 50 concrete nouns, he managed to repeat only 24 per cent correctly and made 58 per cent semantic errors. These errors included:

'buffet' → 'divan'
'jumeau' → 'bébé'
'ballon' → 'cerf-volant'
'mendiant' → 'clochard'

'noyau' → 'pêche'
'chaussons' → 'pantoufle'
'sommeil' → 'paupière'

Of a set of 23 adjectives 10 were correct and of 21 verbs only three were repeated correctly. All three were in the infinitive form of the verb, though not all the infinitives were repeated correctly. There were a couple of derivational errors

'mangerais' → 'manger'
'lu' → 'lire'

where the responses were in the infinitive. The semantic errors included

'coucher' → 'dormir'.

In one of the earlier examinations this feature of the patient's behaviour surprised his examiners and they explained the task again to him, emphasising that he should repeat the stimulus word and not give free associations. Michel reports that the patient was perplexed at this and almost annoyed that they should suspect him of not following instructions. At a later stage he was asked to free associate to the stimulus words and, not unexpectedly, he took longer to produce responses under these conditions than when producing equivalent kinds of responses under the instructions to repeat the words. This confirmed that the semantic errors under the repetition conditions were not strategic but involuntary.

In contrast to the patient's performance in the repetition task, Michel reports that he could read any word or nonsense syllable. In these respects, then, the patient conforms precisely to the requirements set out at the beginning of the chapter.

Not unexpectedly, the patient presented a number of other symptoms. His speech was paraphasic; object-naming was very difficult, and the patient preferred to spell the word out loud rather than grope around trying to find phonological form. Performance in a dichotic task was quite dramatic. Four years after his accident he showed a total suppression of the right ear with monosyllabic words or disyllabic words. In addition his responses to the left ear, whether spoken or written, included a number of semantic errors. These

S: 'Is it something you put on the garden?'
E: 'What for?'
S: 'I don't know . . . to kill insects?'

(b) the subject described a visual image evoked by the stimulus word, e.g.
E: 'brass'
S: 'I suddenly got a picture . . . an old-fashioned bedstead . . . you know the kind . . . with knobs. Is it something to do with sleeping?'

(c) the stimulus word evoked a bodily reaction, e.g.
(i) E: 'sergeant'
S: 'I can feel my legs going . . . as if I was marching. Is it something to do with the army?'
(ii) E: 'trombone'
S: (went through the motions of playing the trombone)
E: 'What are you doing?'
S: 'I've got it . . . gymnastics . . . I'm on the tromboline.'

This last response is more complex, involving a nonsense word which is a blend of 'trombone' and 'trampoline'. We will not attempt to trace its possible aetiology.

Cruse reports that with the words giving rise to this class of responses the patient did not behave as if he had recognised the stimuli. Nor, when given the written form of the word immediately afterwards, did he recognise it as what he had just heard. However, he was always able to give a satisfactory definition of the written form of the word. He described his own state of mind in the (½M) condition by saying that he was making 'an educated guess'.

(−M) the patient made no attempt at a definition or, very rarely, suggested an unrelated meaning.

The patient's performance to the spoken stimuli is shown in Table 9.1.

We can describe this matrix in the following way:

1 If he knew the meaning completely then he could nearly always repeat it adequately.

2 If he could only make an attempt at repeating the word without getting it unambiguously right (½S) then the odds were that he did not know its meaning (−M).

3 If he only knew something of the meaning (½M) then the odds were that he had not attempted to repeat it (−S). This is the category of interest, which corresponds most nearly to the semantic errors in deep dyslexia. Since all the stimulus words were monomorphemic, the subject must have analysed the sound more or less completely in order to get any aspect of the meaning. Cruse rightly points out that this is something of a problem for the published versions of the logogen system. Within that framework one might be tempted to suggest that a 'response block' has developed – similar to the account given of deep dyslexia in Morton (1968). However the subject was able to read out all except one of the stimulus words correctly. In the framework of the old model this would not have been possible if the output from the logogen had been blocked. Indeed, on one occasion the patient actually used the stimulus word as an example of the general category he was trying to illustrate without being aware that it was in fact the stimulus word.

TABLE 9.1

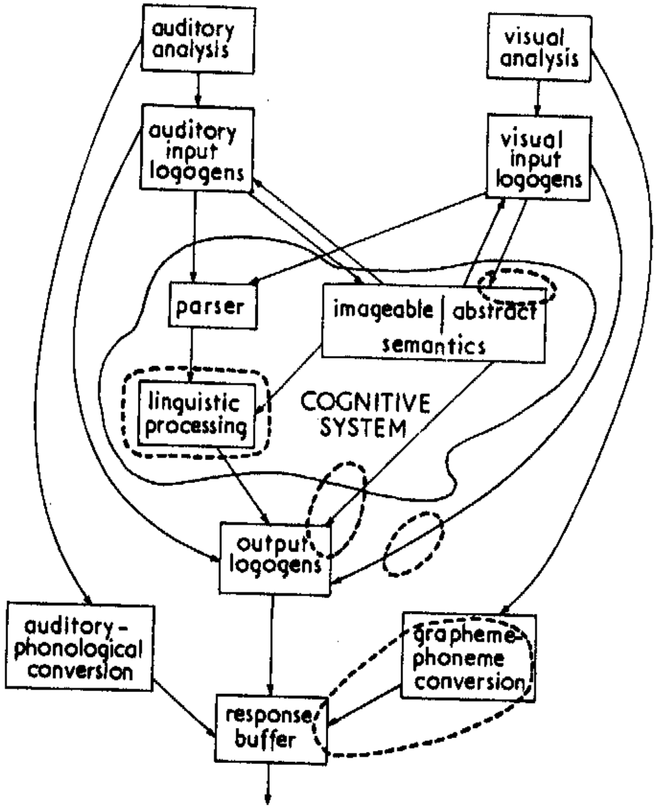
		Accuracy of the repetition (+S)	(½S)	(−S)
Accuracy of the definition	(+M)	122	11	0
	(½M)	6	9	29
	(−M)	34	54	13

However, once the visual and auditory input logogens are separated the notion of a response block becomes possible again. Thus, in the new form of the logogen system, I would account for this patient's performance in the following way.

1 The patient has no system for converting directly from an acoustic code to a phonological code. In normal people, this system, equivalent to the grapheme-phoneme system, allows nonsense words to be repeated. With other patients one could imagine that this system provides an alternative way of repeating words when other routes are damaged.

2 There is an exit block in the auditory logogen system such that information cannot pass from the auditory logogen system to the output system. This may apply to all words or only to those in the (½S) and (−S) classes.

3 For the (½M, −S) words, the route from the auditory logogen



disconnection of the direct route between the auditory logogen system and the output logogen system. A case as pure as this would be too much to hope for and we would expect to find other problems present for anatomical reasons rather than functional ones, as with most of the deep dyslexics.

It is possible that qualifying cases could be found in the literature under the headings of word deafness or conduction aphasia. To attempt to include such patients would involve a lengthy discussion of taxonomy and so I prefer to describe briefly two recent cases who contain the elements of the syndrome I wish to illustrate.

1 Cruse (in press)

This patient has a 'left-sided posterior lesion . . . confirmed by EMI scan', caused by a cerebro-vascular accident 'presumed to be embolic in nature'. This occurred at age 46. A history of his early treatment can be found by Byers Brown and Ives (1969). The patient showed severe problems in auditory recognition and comprehension together with a severe word finding difficulty. Speech was fluent with severe paraphasia.

Cruse did two experiments with this patient. In the first experiment he spoke individual words, all concrete nouns, one at a time to the patient 'whose task was first to attempt to repeat the word, then to give a gloss of its meaning sufficiently detailed to confirm that it was not being confused with any other word'. If the patient failed to repeat the word he was presented with it in written form and was asked first to read it and then to paraphrase its meaning. In all cases but one the patient succeeded in reading the words at hand and supplying a satisfactory definition. The interest lies in his response to spoken words.

The patient's attempts at repetition were classified in three groups:

+S – unambiguously identifiable;
½S – an attempt at the word;
−S – no attempt (usually) or an attempt with no relation to the target word.

A score was also given to the patient's attempt at the definition of each word. Again there were three categories used:

+M – a full account of the meaning, e.g.
E: 'herring'
S: 'sea fish . . . very nice grilled . . . the best . . . used for kippers . . . North Sea . . . trawlers'

½M – the subject gave a partial account of the meaning or made some reaction indicating that the meaning had been accessed. There were three main kinds of response:
(a) a verbal indication of the correct semantic field, e.g.
(i) E: 'pheasant'
S: 'some kind of large bird'
(ii) E: 'fertiliser'

Morton, J. ... rshall (eds), *Ps*

Morton, J. ... picture recogniti ... position. ... *ssing of Visible La*

Neely, J. H ... emory: roles of i ... attention

Newcombe, ... localizati ... G. C. Galbraith ... *An Otfrid Foerster Symposium.* Berlin: Springer Verlag.

Newcombe, F. and Marshall, J. C. (1979) Response monitoring and response blocking in deep dyslexia. Chapter 7, this volume.

Patterson, K. E. (1978) Phonemic dyslexia: errors of meaning and the meaning of errors. *Quarterly Journal of Experimental Psychology, 30,* 587–607.

Peuser, G. (1978) *Aphasie.* Munchen: Wilhelm Fink Verlag.

Saffran, E. M., Schwartz, M. F. and Marin, O. S. M. (1976) Semantic mechanisms in paralexia. *Brain and Language, 3,* 255–65.

Scarborough, D. L., Gerard, L. and Cortese, C. (1979) Accessing lexical memory: the transfer of word repetition effects across task and modality. *Memory and Cognition, 7,* 3–12.

Weigl, E. (1975) Neuropsychological approach to the problem of transcoding. *Linguistics, 154/155,* 105–35.

Weigl, E. and Bierwisch, M. (1970) Neuropsychology and linguistics: topics of common research. *Foundations of Language, 6,* 1–18.

Winograd, S. and Cowan, J. D. (1963) *Reliable Computation in the Presence of Noise.* Cambridge, Massachusetts: MIT.

9 Two auditory parallels to deep dyslexia

John Morton

In spite of their trouble with reading, their agrammatism and non-fluency the deep dyslexic patients in Cambridge do not, in general, have any problem with the repetition of words. Their repetition of nonsense words is slightly impaired – about 75 per cent correct with monosyllabic nonsense words (Patterson and Marcel, 1977) – but contrasted with their total inability to read nonsense words this is approaching normality. For these reasons Morton and Patterson (Chapter 4, this volume), in their description of the functional problems of the deep dyslexics, regard the auditory half of the system as untouched. This is clearly shown in their Figure 4.3, which is reproduced here. No attempt is made here to explain the model: it is assumed that the reader will have read Chapter 4.

The symmetry of the underlying model with respect to modality of input leads one naturally to speculate as to whether patients can be found with, roughly speaking, the mirror syndrome to the deep dyslexics. This would constitute:

1 No semantic paralexias.
2 No problem with reading nonsense words.
3 Semantic errors in repetition of words.
4 Inability to repeat nonsense words.

This pattern of problem would correspond to a disruption of the path involving the auditory-phonological conversion together with a

My thanks are due to Dr D. A. Cruse and Dr F. Michel for allowing me to report work in press and allowing me to use some unpublished data. I am grateful to Marie-Claire Goldblum for discussing some of the issues raised.