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## The Logogen Model and Orthographic Structure

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## 1 Introduction

This short chapter has been written by request of the editor who asked: 'How in principle could the logogen model be extended to take account of writing and spelling?' It is thus an exercise in the methodology of theory. I will start by describing the current state of the model together with the data prompting the most recent change. Then I will examine possible ways in which the model might in principle be extended to incorporate orthographical information. The model will not be totally described and the reader is advised to read the primary sources before drawing too many conclusions. There they will find many more details and justification.

## 2 The logogen model 1977

The model describes separable stages of processing of (mostly) linguistic material. In all except one publication (Morton, 1968) I have focused on single words; detailed accounts of the evolution of the model and data contributing to its form can be found in Morton (1969, 1970, 1977, 1979a, b).

An essential part of the model is the logogen system. This used to be a single system but the effect of the most recent changes has been to split it into three separate systems. The relations among these systems and between them and other processing systems are shown in Fig. 1.

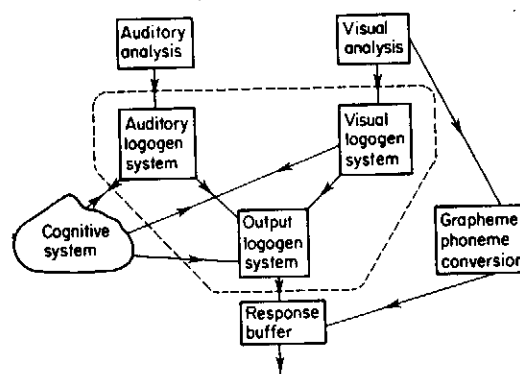


FIG. 1

The dotted line indicates the three systems which have taken over the functions of the single logogen system in the old model. They are called the visual input logogen system, the auditory input logogen system and the output logogen system.

### 2.1 *Output logogen system*

This system contains a defining feature of the old system – the units are terminally active when a particular word is available as a response. Thus, if you see the word TABLE, hear it spoken or see the object then if you say the name to yourself, the same output logogen is involved in all cases. The output logogen system produces phonological codes and sends them to the response buffer. It receives inputs from the cognitive system in a 'semantic' code (see Morton and Patterson, 1979) and from the input logogen systems by means of a one-to-one mapping at the morpheme level (cf. Murrell and Morton, 1974; van der Molen and Morton, 1979; Schwartz *et al.*, 1979).

### 2.2 *Input logogen system*

The input logogen systems preserve the input functions of the old logogen system. They serve as passive categorisation systems which receive information from their respective sensory analysis systems. This information will include, in the case of visual inputs, which letters are present and in what positions but will also include more global information such as word shape, and more particular information such as individual visual features. In most cases there is redundancy in the input and so it is possible to get good performance when global cues are ABOLISHED, as long as the stimulus information is clear. The important factor is that logogens are evidence collectors with thresholds – in fact two thresholds – and as such it is not *necessary* for all the letters to be recognisable in order for the word to be recognised. When a particular logogen has collected evidence in excess of its first threshold it sends a code to the cognitive system. Evidence beyond the second threshold results in a code being sent to the corresponding output logogen (see the debate on this route: Morton and Patterson, 1979; Shallice and Warrington, 1979; Schwartz *et al.*, 1979). It is possible for the first threshold to be exceeded without the second being exceeded. Thus it is possible in principle to understand the word without 'knowing what it is' (cf. Marcel, *in press*). There is contextual feedback from the cognitive system to the input logogen systems in such a way that with continuous inputs contextual and sensory evidence add in a simple way (Morton, 1969).

Note that there is no semantic information in the logogen systems. As such they differ from lexicons in most uses of that term. Semantics is the province of the cognitive system.

### 2.3 *Response buffer*

The response buffer is the system which temporarily stores phonological codes. It has two outputs, one to the speech production system and another by which information is fed back to the other systems. This feedback would be used for silent rehearsal among other things. In this respect it shares some functions of working memory (Baddeley and Hitch, 1974; Morton, 1977).

Inputs to the response buffer come from the output logogen system in the normal production of speech and in reading aloud. There is also a route from the input analysis systems to the response buffer. These are the pathways which permit the reproduction of nonsense words. Since nonsense words have no representation in the logogen system, without this feature the model would not be able to account for our ability to read nonsense words out loud and repeat them, when they are spoken to us. The connection between the visual analysis system and the response buffer is via a system of grapheme-phoneme conversion where-in are represented the rules of conversion from letters and letter sequences to phonemes. The equivalent system on the auditory side converts acoustic codes to phonological codes which are fed into the response buffer.

### 2.4 *Cognitive system*

The cognitive system is the cognitive residue. It contains everything which is not explicitly included elsewhere. It has been expanded in Morton (1968) to indicate ways of handling continuous language, in Morton (1977) with respect to memory, in Morton and Patterson (1979) with respect to a number of features relevant for the discussion of deep dyslexia, and in Warren and Morton (in preparation) with respect to picture recognition. The only feature I will mention here is that in contrast with most lexicons I do not see all the information relevant to a particular word as located in the same 'place' and accessed simultaneously. 'Meaning' is something to be computed as necessary, and not looked up as a unit. Other features of the cognitive system will be made apparent in the sections which follow.

## 3 *Reasons for the change in the model*

In the old version of the logogen model the same unit was active on input and output. Thus saying the word 'table' spontaneously and reading the word silently, involved the same logogen. The scope of the

logogens was defined from the results of experiments in facilitation. In general these experiments involve a pre-training session, where subjects are exposed to particular forms, and then a testing session, where tachistoscopic thresholds are measured or the intelligibility of spoken words in noise is assessed. The intention is to look for transfer or lack of transfer from the pre-training to the test session. Thus Neisser (1954) found that reading FRAYS aloud had no effect on the subsequent recognition of PHRASE. This was taken as evidence for separate logogens with identical outputs to the response buffer. Murrell and Morton (1974) showed transfer from SEEN to SEES but not from SEED to SEES. We conclude that this result identified the critical recognition unit as morphemic and also established no transfer, over the time-scale involved (15-45 minutes), as a result of visual overlap. There are a number of reasons for rejecting the idea of *semantic* overlap as opposed to *morphemic* overlap in this experiment. Let us take just two. Firstly it isn't clear what the semantic relationship is between SEES and SEEN compared with the semantic relationship between PAINED and BORING to select two other of the stimuli in the Murrell and Morton experiment. And all the other cognitive activity in the half hour or so between pre-training and test could add semantic cueing on most common words in the logogen system. The second reason is more mundane, possibly more convincing but less valid. It is that with the auditory equivalent, Steven Kempley, working with me, has shown good transfer from BRINGING to BRINGS but none at all from BROUGHT to BRINGS. The semantic relationships between the pairs is not going to differ sufficiently to account for the data. (Doubt as to the application of this result for the visual logogen system lies in my suspicion that there are a number of profound differences in their operation - even if this is not one!)

Facilitation was seen as the result of the particular logogen having been active, the activity leading to a sensitisation of the logogen by lowering the threshold by some amount. But, by definition, there could be no distinction between a logogen firing as a result of sensory inputs and firing as a result of other activity. The same result would be required in all cases. The data turn out not to support this requirement. Winnick and Daniel (1970) found no effect on tachistoscopic thresholds for words as a result of having named a picture or spoken the word in response to a definition. Such a result is clearly impossible with the old model. Clark and Morton (in preparation) have replicated the Winnick and Daniel result and have shown that there is good transfer between handwritten and printed forms of words but poor transfer from auditory presentation to visual testing. They also showed no difference between conditions in which the response in the pre-training session was that of

the word or its opposite. All these results tie the primary facilitation to the input portion of the divided logogen system. The auditory-visual symmetry was shown by Jackson and Morton (in preparation) who found only small effects of visual pre-training on auditory recognition. The result of these data has already been seen. There are three logogen systems and the primary facilitation effects are limited to the two input systems over the time scales of these experiments. In fact I believe there is facilitation in the output system over shorter time intervals and other facilitation effects at more than one time interval in the cognitive system, but they do not affect the structures already described.

Before proceeding we can note that Fig. 2 is completely equivalent to Fig. 1. In what follows I find it convenient to use expansions based on the second arrangement. I have included both versions to make clearer the derivation.

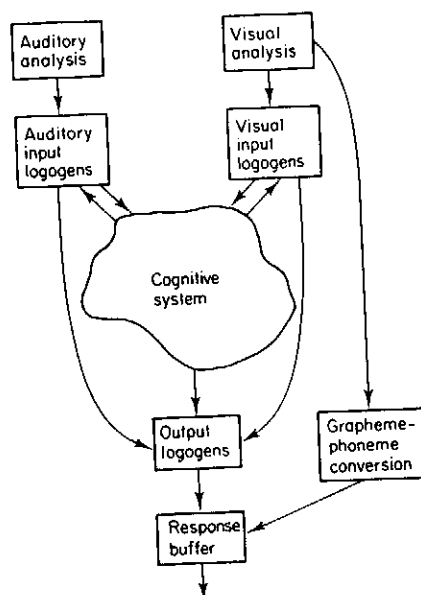


FIG. 2

#### 4 Extensions to the logogen model

The clearest extension is due to Seymour (1973). He modifies the logogen model in order to incorporate separate access and exit channels for verbal and pictorial stimuli. In Fig. 3 I have redrawn the model as he gives it in his paper in a transformed and slightly reduced form to make it compatible in appearance with the earlier ones in this chapter.

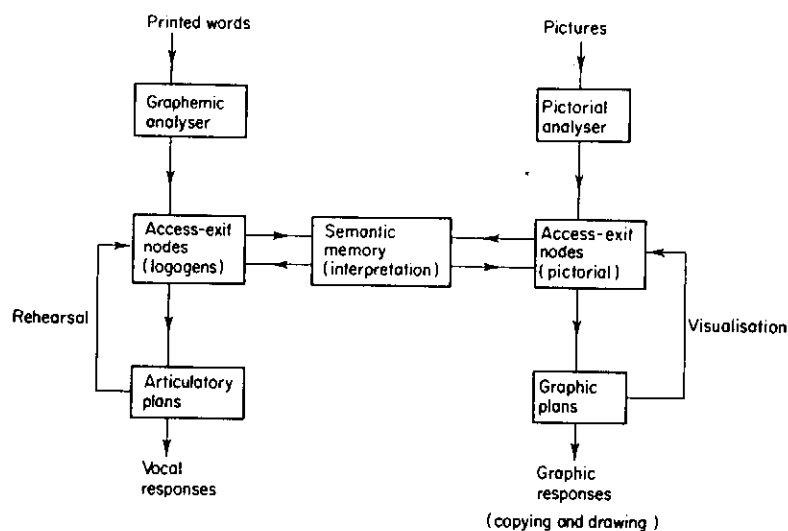


FIG. 3

The essential parts of his suggestions remain intact however. The model deals only with visual input as it stands but can be extended easily to incorporate auditory inputs. The power of the model in this extension is that it enabled Seymour to interpret a number of tasks in which we

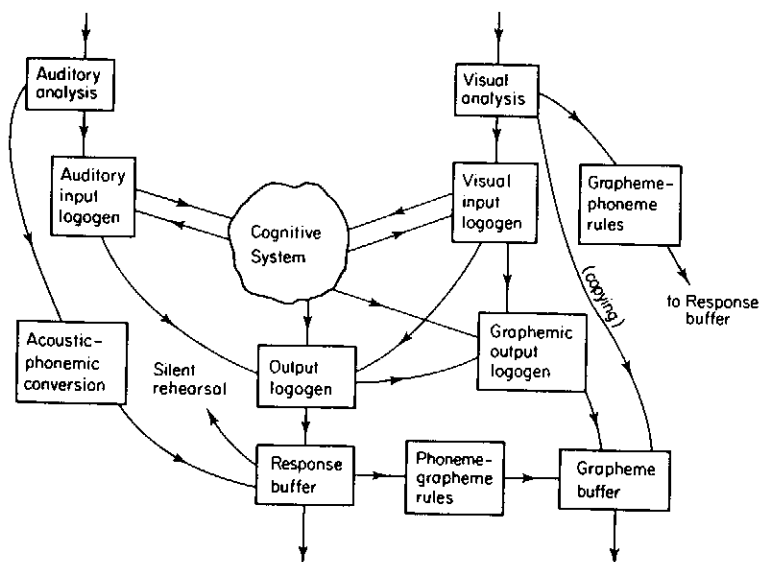


FIG. 4



measure how long it takes someone to read words, name objects or compare printed names and objects. The extension which Seymour has made is entirely within the spirit of the original model in that he separates out distinct coding stages and categorisation stages and attempts successfully to encompass a wide variety of data. You will see that in Chapter 20 in this volume Seymour and Porpodas have changed the format of his model somewhat. We have included the earlier version however so that the ancestral lines are more clearly visible.

An alternative way of representing the sub-systems is shown in Fig. 4 where I adopt Fig. 3 to allow for graphical output with connections from the visual analysis system, the visual input logogen and the response buffer. Let me justify these connections.

- 1 *Visual analysis system* – the direct connection to the grapheme buffer is labelled *copying*. This is the route which enables people to copy nonsense words, changing the format from print to script or vice versa. In principle this could be done by converting the letters into a phonological code going via the response buffer and thence via the phoneme-grapheme rules into the grapheme buffer. The argument in favour of the copying route is that there are patients with brain damage who can copy but cannot write to dictation, although they can repeat and understand spoken words (Weigl and Fradis, 1977). It is also a part of classical conduction aphasia, though in this case without the repetition ability (Hecaen and Albert, 1978, p. 43).
- 2 *Grapheme output logogen system* – the primary evidence for such a system would be from patients who could write words fluently but not copy nonsense syllables or write them to dictation. There are also patients who can only write fluently; as soon as they try to write with deliberation – even their own ideas – their writing goes to pieces. Connections to the grapheme output logogen have been made from the cognitive system, the output logogen system and from the visual input logogen system. The justification for the latter connection is purely the symmetry of the resulting system. It should be possible to find evidence to justify keeping or erasing that connection.
- 3 *Response buffer* – the main piece of evidence favouring a connection from the response buffer to the grapheme buffer via a system of phoneme-grapheme rules is our ability to write down nonsense words to dictation. Note here a patient reported by Beauvois and Derouesne (1978) who could write non-words to dictation but could not then read them. This justifies the separation of the grapheme-phoneme rules from the phoneme-grapheme rules. It is also going to be a possible route for talking about phonologically induced spelling errors in writing.

The reader who does not like the notation of information processing models will be at a grave disadvantage here. It would be possible to express all the relationships in Fig. 4 in verbal form; in doing this, however, one would simply lose the impression of simultaneity which the flow diagram expresses. The contents of the boxes are, in most cases, underspecified. And if the model has a grave fault it is that it underestimates the complexity of the mental processes it is trying to model. There are many degrees of freedom in the model at the moment with respect to writing, but as the model faces up to data these options should become reduced rapidly.

### 5 A little data with analysis

- 1 When I am writing I sometimes produce a word which is a homophone of the one I intend. The most common example in my own writing is a substitution of *THEIR* for *THERE* or the other way round. This happens when I am writing with a pen or when I am using a typewriter (see also Hotopf, Chapter 13).
- 2 Sometimes when I am asked how to spell a word I am not quite sure about I will write down the alternatives and will then be sure which one of them is correct by looking at them. It isn't that I know that one of them is right, it is that I know that one of them *looks* right (see also Tenney, Chapter 10).

These two observations about myself are common enough. What are we to make of them? While the first example will tell us a lot about spelling, I feel that the second piece of data tells us nothing about spelling but a little about reading. If we are not sure about the spelling of a word then we may proceed by analogy. The confirmation of the correct spelling, however, I would assume to be mediated by the action of the input logogen system. Only the correct word will correspond to the pattern accepted by a logogen. This will then arrive at a location in the semantic part of the cognitive system and thus be classified as word-like and give the feeling of being correct. The incorrect one will excite a logogen only inasmuch as its spelling resembles the correct spelling.

We can now take the first example. The fact that I produce a word which is a homonym seems to have a very simple explanation – namely that there is an intervening phonological code and this is simply translated into a graphical code by means of a set of phoneme-grapheme rules. In Fig. 4, this would pass via the response buffer. The rules would look like the grapheme-phoneme rules in reverse (see Smith, Chapter 2). These rules will admit of more than one way of converting a phonological code into letters and the wrong one gets selected.

This account has two flaws, one of them obvious – that I normally spell *THERE* and *THEIR* correctly. Thus we cannot conclude that we *always* go via a phonological code in a simple way, for in that case we would expect 50% errors of spelling. Thus the best we can say is that on occasion we go via a phonological code and convert it with some phoneme-grapheme rules. The second flaw in the premature conclusion is that the spelling errors of the type illustrated (i.e. caused by slips rather than ignorance) are not random. I never make spelling errors such as replacing *HEIR* by *HAIR* or *BEAR* by *BEIR*. If I ever used a simple set of phoneme-grapheme rules, taking a phonological string at one end and producing a string of letters at the other then I would expect to find errors of those kinds. This is because simple replacement rules could not know about a letter sequence actually being a word with a different pronunciation from the original and so could not detect that *HAIR* was not pronounced like *HEIR*.

Simple rules have no notion of wordness. This is why we can read nonsense syllables using the grapheme-phoneme rules. Deep dyslexics, who lack these rules can only read via a word representation and cannot read nonsense syllables at all (see Morton and Patterson, 1979). In the same way the rule system would not know whether the output string did indeed correspond to a real-word. So if we are going to use the idea of writing via the phoneme-grapheme rules at all then we have to introduce an extra stage in the sequence. This stage would take the letter string which the rules had generated and check this for its wordness and for its pronunciation, to check whether it corresponded with the target in this respect. This could not, of course, be done using the grapheme-phoneme rules, for that system has no concept of word either (as already mentioned). Neither would it be sure of the pronunciation of *HAIR* and *HEIR* in any case. The checking would have to be done by passing through some word-based systems which took an orthographic input and produced a phonological output, such as the visual input logogen to output logogen route. The production of an output would guarantee that a word had been produced and the output itself could be used to check the pronunciation. Homophones are the only errors which would slip through this net.

If we elaborate the comparison system a little more we can return to the idea of using the phonological code all the time. All we need to do is run a second check of the 'semantics' of the word against the original intentions. The homophone errors would then be attributed simply to faults in that part of the check.

Another possibility is to avoid the idea of simple rules. Instead we could imagine that a phonological code is indeed produced first and

that this code is used as a unit to access the letter code for the word. This would be like using a phonological code to access the grapheme output logogen system in Fig. 4. This could constitute an argument for a connection between the two output logogen systems.

In a perverse fashion I managed to produce a counter-example to my claim as I was in the act of writing about it. I was in the process of typing the word *SURE* and started typing *sh* before stopping in some alarm. There is no such word as *SHURE* (and I do not pronounce *SURE* to make it a homophone of *SHORE*). So in this case it looks as though I was simply going through a rule system. It isn't clear what checking procedures trapped the error.

Note that my case with simple and frequently used homophones is very different from performance with words which are either unfamiliar or rarely experienced in the written form. In such cases there is good reason for supposing that simple rules are being used – though it should be remembered that the same results would be obtained if one operated by analogy with words one knew. Thus, if the word *CARE* were heard, the novice might think that the word began with the same sound as the word *KITTEN* and ended with the same sound as *BEAR*. Then he might try the spelling *kear* as possible. Note that solving the problem by analogy in this way is equivalent to creating one's own phoneme-grapheme rules as one goes along. And note that Fig. 4 would need considerable elaboration to deal with problem solving.

## 6 Some evidence from a case study

The data in this section came from a young woman, Gail,<sup>1</sup> who suffered an embolism resulting in damage to her left temporo-parietal region. This patient was drawn to my attention by Margaret Hatfield and we have been studying her for the past four years. Complete descriptions of the patient are in preparation.

The earliest indication that Gail was going to provide clues regarding representation of orthographic information came when she was asked to generate instances from categories. In general we used one of two topics, asking her to produce as many names of countries or animals as she could. She was under no particular time pressure for this task but we did try to encourage her to continue to search for more names after it seemed to her that she had no more available. She had a pencil in her hand during this task and just after her accident would write down at least the initial letter before all her responses. Without this cue she did not seem able to produce any responses. So on one occasion she started

<sup>1</sup> Please note that 'Gail' is a pseudonym.

off a list of animals by writing a D and then saying 'dog', writing a C and saying 'cat' and so on.

The obvious interpretation of such behaviour is that she had access to the concepts but could not access the phonemic code directly from the concept. In terms of Fig. 4 we would say that the connection between the cognitive system and the output logogen system was damaged. The written code, however, was available, and the initial letter was in most cases sufficient to deblock the phonemic code via the grapheme-phoneme rules and the response buffer. Thus far one could imagine that the orthographic code was available as a string ready to be written, from which only the first letter need be produced. However her behaviour was not always so simple. On occasions, with rarer words in general, she had to write more than one letter before she could make any spoken response. The remarkable thing was that these letters were not always contiguous, and that she did not write them fluently but rather had to search for every one. Here are three examples from one session.

- 1 She writes an initial H; pause, then she writes a g some distance away from the H. Then she says 'hedgehog'.
- 2 Writes an initial P, then pauses and finally writes a k some distance away before saying 'peacock'. On another day she wrote P c before getting 'peacock'.
- 3 Writes a series of things. The separate lines below indicate the result after each alteration.

Pol

Polar

Polar (says: 'Is that right?')

Polar R

Polar B

Polar Bear (and finally says 'polar bear').

Later in the same session she was trying to retrieve the names of countries. Among her responses were:

Potl 'Portugal'

In a

she then wrote down ABCD, and then inserted the d in the name of the country, added the i and said 'India'. (Note the case of the letters was correct.) Another string of countries included:

N Z New Zealand

Tur y Turkey

J p n Japan

C na China

The last is a good indication that it is genuinely an orthographic code and not a translation from a partly suppressed phonemic code.

In the latter case we could not expect the initial C without the following *h*; and we have every reason to believe that Gail wrote down all the letters she could in sequence.

- 4 On one occasion she wrote down D T H before saying 'Holland' and on another occasion she wrote *Du* and then said 'Holland'. This complicates matters enormously since such a connection can only be made in the cognitive system. I am forced to assume that an internal code corresponding to DUTCH was fed back to the conceptual unit of HOLLAND. The block must in this case have been at the conceptual level *not* in the output system.
- 5 To allow the reader to get a better flavour of Gail I will quote a discussion we had about one country. Some of the dialogue is suppressed since it concerned my attempts to guess what she was aiming at.

*Gail:* writes SAR

*Gail:* Do you know it?

*JM:* I'm not sure what you are looking for

*Gail:* It's . . . it's 's' – its a very small place. It's a very small country

*JM:* An island?

*Gail:* Yes. I've been there

. . . . .

*JM:* How did you get there?

*Gail:* By – er – by ship

*JM:* Where from?

*Gail:* Which countries? do you mean?

*JM:* Yes

*Gail:* . . . Gibraltar – er – Italy. . . . ( . . . ) on the map it's a long thing (draws it). Do you know what I mean?

*JM:* O.K. The next letter is D

*Gail:* Writes so she now has SARDINA, adding the INA without any prompting from me. She needed much prompting to read this out and couldn't say whether it was correctly spelled. When the additional *I* was indicated and written in she was still uncertain.

- 6 On occasions it was apparent that structural information was also available. Not only did she usually leave sufficient space for intervening letters when she wrote down parts of words but she also explicitly referred to word length. Thus we had this exchange in the course of a conversation:
 

*JM:* What kind of bird?

*Gail:* A swallow

*JM:* What kind of swallow?

*Gail:* Not a house swallow. It's a four-letter word. (wrote H) no, not H, it's B. Barn.

The examples above relate to Gail's output problems in the weeks after her accident. As time went on this problem virtually vanished and she only occasionally has recourse to a pencil when trying to find a word. Sometimes however, she will trace the beginning of a letter in the air before producing a word and claims that she visualises words she is trying to define.

More recently we have been looking at her receptive problems. In particular it seems as though, in terms of Fig. 4, she cannot get from the auditory input logogen to the cognitive system directly but has to go via a graphemic code.

The clearest evidence for the conversion of an auditory code to a visual one occurs when the conversion goes wrong. Two good examples of this occurred in one session when she was being asked to define words which were spoken to her. Note to start with that Gail has no problems whatsoever in repeating words or nonsense syllables. Any receptive loss must be central. Typically, she gives a definition straight away, or pauses, looks up in the air or starts to write the word down. Often she has no need to complete the words before saying something like 'Oh, I know it . . .' and then giving some kind of definition. Sometimes she goes through a different sequence, looking puzzled and asking 'Is it really a word?' and then trying to write it down. At this stage the reason for her puzzlement becomes apparent. In the particular session in question she was given the word *ACUTE* which she claimed not to know. She then wrote down *aquate* looked at it and then wrote down the word correctly. Later, with the word *DESTINY* she wrote down *dectiny* and again corrected herself spontaneously before giving a definition.

In the same session she wrote correctly *PORTLY* and *CASUAL*, and wrote parts of words on several occasions, including *compet* for *COMPETITION*; *trans* for *TRANSPARENT*; *opa* for *OPAQUE*. In cases like these she stops with the word incomplete, repeats it and then defines it.

In the cases of *ACUTE* and *DESTINY*, I assume that the phonological code is passed through a low grade conversion system to get an orthographical code, i.e. by way of the acoustic-phonemic conversion to the response buffer, through the phoneme-grapheme rules and to the graphemic buffer.

Similar findings were obtained in a dictation task. She was being asked to write down a mixed list of words and non-words. This might have biased the strategy she used but that does not invalidate our position. Among her responses were the following which were spontaneously corrected: *cride* (*cried*); *phome* (*foam*); *near* . . . (*nurse*). In addi-

tion DEEP was spelled **deap** without being corrected. In the same session she wrote correctly words such as AERIAL, SHIELD and POULTRY.

My interpretation of data such as these is that there is a method of conversion from an acoustic code to an orthographic one (via the response buffer in Fig. 4). From time to time this conversion operates at the level of the individual character. Only this way could the sound /s/ be converted to the letter *c*. It is equally clear that this cannot be the only way of operating as the following example shows. She was being asked to define the spoken word PLOUGH. She had no idea of its meaning but then wrote it down correctly – not as PLOW, which would have been the obvious result of a simple phoneme-grapheme conversion. She still seemed to have no idea of what it meant and then said, 'I've forgotten what it is – (pause) see it in a field – using some sort of machine – something to do with soil . . .?'

There are two choices here. Both of them require that the auditory input logogen is operating and, as always, produces a code relevant to the word as a whole. Then the spelling of the word could be obtained from the graphical output logogen system via the output logogen system. The other option is that there is a direct connection between the auditory input system and the graphical output system. This connection only exists in Fig. 4 via the cognitive system. By the conventions to date, passing through the cognitive system would involve accessing some, at least, of the semantics. It is not clear whether such information as she produced was available before she wrote down the word. The important thing about the example, though, is that it forces us to think in terms of the auditory input logogen system being used, rather than the acoustic-phonemic route.

## 7 Conclusions

I have explained how the logogen system might be expanded to take account of writing and have described and analysed some data to show how the model can be used. This analysis has not been sufficient to force us to take positions on the connections between the sub-systems. I hope that by the time this book has been completed that there will be enough information to force us to severely restrict the options. At the moment, however, there appear to be the following possibilities with respect to spelling and writing information. Not all of them have been covered in the discussion above but remain possible in principle.

### 7.1 *Visual input logogen system*

This system does not *contain* any accessible information with regard to



spelling. It is responsible for recognising that certain letter strings correspond to words and for passing information concerning the identity of these strings to the cognitive system and the output buffers.

### *7.2 Grapheme output logogen system*

This system contains spelling patterns for words (or possibly morphemes). It is addressed by the cognitive system by means of a semantic code (by analogy with the output logogen system) and by the visual input logogen system by means of some simple one-to-one mapping procedures. Its output goes to the grapheme buffer where output is coordinated and different plans are made for typing and handwriting. It is also likely that there is the facility to feedback information from this system to other systems, such as the cognitive system and the phonological output logogen system. In this way we can understand how Gail uses a visual code to access the meaning of a spoken word sometimes without actually writing anything.

### *7.3 Phoneme-grapheme rules*

This system treats words and non-words alike and thus, if operated without any checking procedures, would fall foul of the one to many mapping aspects of the conversion rules. Clearly some spelling errors must arise from the operation of this system but the relative paucity of spelling errors resulting in non-words indicates that the outcome of the rules is checked for appropriate pronunciation and for wordfulness. This requires feedback which hasn't been indicated in Fig. 4 (or alternatively some device independent of the conventions of Fig. 4 which could perform monitoring and checking procedures anywhere in the system).

### *7.4 Cognitive system*

The cognitive system is a kind of residual legatee. Anything not specified elsewhere is currently lumped in the cognitive system. We could imagine that it contains writing patterns of certain kinds such as one's signature or the motor pattern for certain words when typing.

### *7.5 A remaining problem*

The model has most trouble in accounting for data from the patient Gail. It is easy enough to account, in general, for the way in which the graphemic code becomes available. The problem is that the grapheme

output systems are supposed to produce a string of characters which are intended to be processed from one end to the other. What Gail did was to pick elements out of the string – always beginning with the initial letter, but missing out middle letters sufficiently often to constitute a problem for our explanation. Recall also that she always knew that letters were missing and left blanks accordingly. There appear to be two solutions. The first is to locate a pictorial record of the word in the cognitive system. This record would be a part of the 'lexical entry' for the word. Such a possibility is easier to include in other models (e.g. Forster, 1976) than it is in the logogen model, since at the moment there is no real concept of lexical entry. The other solution is to say that the output from the grapheme output logogen can be fed back (to the visual analysis system for example – but that would mean that the code would have to be compatible with a visual sensory code – not a likely thing, so some recoding would also be necessary) or scanned by some device which has not yet been devised. Neither of these solutions is a happy one because they rely on *ad hoc* devices whose utility for other purposes is unknown. The one saving grace is that the phenomenon resembles the tip-of-the-tongue phenomenon in which we seem to know something about the properties of words we cannot find. The difference between the two is that the tip-of-the-tongue information is very liable to error and uncertainty whereas Gail was almost never wrong and usually completely certain that the information she produced was correct. This does help to describe the phenomena in logogen terms, and for the moment we must end with this feeling of dissatisfaction.

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