PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Components of the Mental Lexicon

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Components of the mental lexicon

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This paper sets out to identify, in information-processing terms, the elementary functional components of the mental lexicon and their interrelations. In particular it is concerned with the independent status of lexical codes for written and spoken language, and their relations to each other and to a language-free cognitive representation. Our evidence is based on the performance of language transcoding tasks (such as reading aloud or writing to dictation) in brain-damaged adult subjects.

We review evidence for the functional independence of non-linguistic, cognitive representations, and for word-specific, lexical codes in both phonological and orthographic form. The data rule out the hypothesis of a modality-free or abstract lexicon mediating communication between lexical and cognitive representations. The data also reject the dominance of phonological over orthographic codes in access to and from word meanings. We can find no satisfactory evidence for independent lexicons used in language reception and language production.

Different syntactic word-classes are known to cause greater or less difficulty for various categories of aphasic patients. We show, however, that the relative difficulties of this or that word-class change according to the input and output modalities involved. We consider two theoretical accounts of these differences. Our discussion raises questions about the boundary between psychological mechanisms that are, properly, mechanisms of *language*, and those that, while necessary for the intelligent use of language, are themselves language-independent.

1. Introduction

In this paper we shall be concerned with some elementary questions about the internal organization of the mental lexicon. In the psychological study of language much of the scientific effort of the past 10 years has focused on two levels. The first of these concerns the problem of word recognition or 'lexical access', that is the marvellously rapid and efficient processes by which a spoken or written word evokes an appropriate and, if successful, unique lexical code (see, for example, Allport 1979; Henderson & Chard 1980; Marslen-Wilson & Tyler, this symposium). The second and as yet much less developed problem area relates to the non-linguistic 'cognitive' codes that embody our knowledge of the world – the codes into which natural language must be mapped (see, for example, Johnson-Laird, and Warrington, this symposium). In this paper we restrict ourselves to some quite preliminary questions about the nature of this mapping, and about the channels of communication *between* lexical codes, once these have been evoked.

Words can be specified over several different domains of attributes: acoustic, articulatory, orthographic, syntactic, semantic, etc. Our first and, we hope, least controversial assumption is that distinct domains of representation are embodied in separate psychological codes. Where the relations between these codes are arbitrary (for example, between Arabic numerals and their spoken names), there must necessarily be unique, word-specific (i.e. 'lexical') codes, and unique, word-specific channels of communication between them. Other code translations (possibly, for example, between phonological and articulatory representations, or between abstract letter-sequences and graphic, written form) might, in principle at least, be done by rule, and in that case would not necessarily require word-specific, *lexical* codes in both domains for their translation.

Many commonplace language tasks, such as reading silently or aloud, writing to dictation, spoken or written naming, oral repetition, matching words and objects, or matching spoken and written words, require translation between codes. By studying the performance of these simple transcription tasks, and in particular the selective breakdown in their performance in patients with acquired language disorders, we hope to provide answers to certain elementary questions such as the following:

Are lexical codes functionally separable from word meanings?

Are distinct lexical codes needed for reception and production: for listening v. speaking, and for reading v. writing?

Do phonological codes dominate orthographic codes in access to word meanings, or in any other code transcriptions?

Or is access to word meanings, or to any other codes, mediated by a modality-independent lexical 'master file'?

Are the answers to these questions uniform across all different categories of words? Or are the interrelations between lexical codes word-category specific?

Our method depends on the detailed investigation of language performance in individual brain-damaged patients. The rationale of this approach, including the use of data from language pathology to make inferences about normal language function, has been well set out recently by several authors, notably by Marin *et al.* (1976) and by Shallice (1979). As with other methods in science, its most important pragmatic vindication rests on the results themselves. To the extent that the dissociations of function that we observe are more economically described in terms of a reduced set of normal procedures, rather than of a wholly reorganized process, this simpler interpretation is surely to be preferred. Successful applications of the method, in this sense, from the pioneering work of Luria (1947) to recent progress in the investigation of reading disorders (see, for example, Coltheart *et al.* 1980) are thus its most persuasive ambassadors.

The functional separability of different components of language, or of other information-processing systems, implies a highly modular organization of the nervous system. We are impressed with the evidence from neurophysiology, of the high level of local specialization of cerebral function (Eccles 1977; Hubel *et al.* 1979). In the visual modality, for example, the incoming projection from the retina is mapped repeatedly in neighbouring cortical areas, each specializing in the analysis of different properties of the input, such as colour, motion, contour, and stereo depth. In the rhesus monkey there is evidence of at least eight distinct visual areas; in the cat, as many as thirteen (Cowey 1979). Localized cerebral injury can thus deprive an individual, man or monkey, of selective aspects of visual function, of the discrimination of colour, for example, or the recognition of faces or other complex forms, while leaving other visual functions intact (Hécaen & Albert 1978; Heilman & Valenstein 1979). The same kind of functional modularity, we argue in the remainder of this paper, extends also to the mechanisms of human language.

We note that work in artificial intelligence, especially in the development of large-scale 'expert' systems, has also tended to prefer a highly modular form of organization (Michie 1979;

Waterman & Hayes-Roth 1978). The control structure of such systems must then be specified over the patterns of intercommunication available between independent modules (Hewitt 1979; Smith & Davis 1978). Lexical codes, we suggest, should likewise be thought of not as passive data-structures but as independent computationally active elements. The present paper represents a very simple attempt to specify constraints on the intercommunication of modular components of the mental lexicon.

2. Separability of lexical and cognitive codes

Schwartz *et al.* (1980) describe a profoundly demented patient who could correctly read aloud a wide range of written words having 'inconsistent' or exceptional spelling–sound relations (leopard, shoe, flood, tortoise, etc.), even when she was completely unable to match the written or spoken word to an appropriate object, nor even to determine whether the word denoted an animal or a non-living thing. ('Hyena,' she said, reading the word aloud correctly, 'what in the heck is that?') Correct pronunciation of these written words demonstrates the preservation, and thus the functional independence, of word-specific ('lexical') codes, both orthographic and phonological, and of word-specific links between them, in the absence of access to corresponding cognitive reference. Other cases of so-called isolation of the language function (Whitaker 1976) or 'mixed transcortical aphasias' (Goldstein 1948) argue for a similar interpretation. The relative preservation of reading aloud is also reported in some Wernicke's aphasics whose spontaneous speech is confined to disordered, neologistic jargon (Lecours & Rouillon 1977).

There are also many demonstrations of the converse: the preservation of high-level non-linguistic, *cognitive* abilities accompanied by more or less comprehensive loss of both receptive and expressive language. One patient (H.K.) whom we have studied was deprived, following a stroke, of the ability to produce any intelligible oral or written language, although he still produced the sounds of speech, in the form of fluent, prosodic, but wholly uninterpretable phonemic jargon without recognizable words: in effect, without language. His comprehension was also severely compromised. For example, in a series of very simple tests of auditory comprehension (Whurr 1974), most of which required pointing to one of five alternatives in response to a single spoken word, H.K. responded correctly on 5 out of 40 trials (chance). In similar tests, with just two unrelated alternatives, he achieved 15/18 (above chance) and 10/18 (chance). Yet this same patient maintained many social and intellectual skills intact. His non-linguistic understanding of objects, places and times was still impressively sound. He could play (and win) board-games. Among other abilities he could still find his way, unaccompanied, in central London, and he was able to navigate for another motorist (by pointing) a known but complex route across the metropolis.

Luria *et al.* (1965) described a well known Soviet composer who became totally aphasic, but continued to compose symphonies. In less comprehensive deficits of language, Saffran *et al.* (1980) have recently shown that many of the contrasts that asyntactic patients apparently fail to understand linguistically – such as that between agent and patient – are perfectly well understood in non-linguistic tasks. And similar dissociations can be observed in respect of referential meaning (see, for example, Dennis 1976).

Doubtless the non-linguistic, cognitive domain itself comprises multiple independent codes, codes proper to different sense modalities, to the representation of non-sensory functional attributes, to spatial and temporal relations, as well as to other more abstract domains of representation (Allport 1980; Shallice 1981; Warrington, this symposium). When we refer here, for simplicity, to communication between phonological, orthographic, and '*cognitive*' codes, this is a purely heuristic simplification. We do not at all wish to imply that there is only *one* 'cognitive' code.

3. Phonological and orthographic lexical codes

We now turn to evidence for the separability of orthographic, and phonological, word-specific units ('lexical codes'). How do they and the cognitive codes intercommunicate?

Consider the three alternative arrangements schematized in figure 1. Model A represents the dominance of phonological over orthographic lexical codes in access to and from cognitive representations. Model B, in contrast, has specific and independent channels of communication between each of these codes. Diagram C serves to represent two distinct hypotheses. (1) The

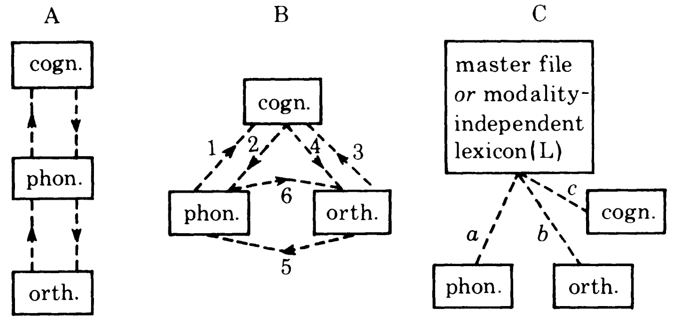

Figure 1. Three models of communication between cognitive (cogn.) codes and word-specific lexical codes: phonological (phon.) and orthographic (orth.)

first asserts the existence of a modality-independent lexical code: an entity seemingly implied by the claim that languages are 'independent of the medium in which they are manifest' (Lyons, this symposium), and by early versions of the *logogen* model (Morton 1968, 1977). (2) Diagram C also represents Forster's (1976) model of the lexicon, in which *all* the information about a word (phonological, orthographic, etc.) is collected in a single master file, addressed by domain-specific access codes.

The following empirical observations set constraints on these alternative models.

Deep dyslexia

There has recently been intensive study of the selective disabilities seen in so-called deep dyslexic patients (Coltheart *et al.* 1980). These are formerly skilled readers who appear to have lost the ability to translate between graphic and phonological codes, and whose reading aloud is characterized by 'semantic' errors. Some examples of reading errors of this kind made by a patient (S.K.) whom we have studied, are shown in table 1.

Deep dyslexic patients appear unable to carry out any task that would require translation directly from print to sound, either with familiar words or with nonsense-spellings. Thus they are unable to judge whether printed words rhyme, or, for example, what object the letter-string KOTE, if sounded out, might name (Saffran & Marin 1977). Their only means of translating print to sound, it appears, is via a cognitive code (Marshall & Newcombe 1973; Morton & Patterson 1980*a*). Thus S.K., when asked to read aloud the letter-sequence SKEL, said, after a brief hesitation, 'bones'. She can readily tell that VIP means 'important person' and that IRA denotes 'terrorists'; yet she cannot consistently name, nor sound out, any of the letters.

This pattern of disabilities appears radically inconsistent with both models A and C. In model A, translation to a phonological code is represented as a necessary condition of access to a cognitive code. Yet the deep dyslexic patients understand many written words while failing this condition. The semantic errors themselves testify to access to a cognitive code, and a variety of other tests with the use of synonym judgements or word–picture matching do likewise (Patterson 1981). Similar arguments appear damaging for model C also. Consider first the version of model C in which L represents an abstract lexical code, and in which *a*, *b* and *c* are bi-directional channels. In terms of this model, the deep dyslexic patients can perform code transcriptions by using channels *b–c* (orthographic to cognitive) and *c–a* (object-naming). But they are apparently unable to use the path sequence *b–a*. The model seems incapable of offering a consistent account of this pattern of performance. As regards Forster's model, without further

TABLE 1. EXAMPLES OF S.K.'S SEMANTICALLY RELATED ERRORS IN READING ALOUD ISOLATED WORDS (THE STIMULUS WORD IS SHOWN ON THE LEFT, S.K.'S READING RESPONSE ON THE RIGHT)

commerce	business	applause	audience
victory	triumph	anecdote	narrator
mishap	accident	ambition	career
propellor	catapult	saddle	stirrup
binocular	telescope	parachute	balloon
apricot	peach	glacier	icicle
element	substance	sandal	slipper

specification of the way in which codes in the master file are interrelated it remains unclear how these dissociations are to be explained. Model B, on the other hand, economically represents the fundamental disability in deep dyslexia as a functional disconnection between orthographic and phonological codes (route 5). In some of these patients, though not all, the impairment is bi-directional (route 6), with the consequence that similar 'semantic' errors are observed also in writing to dictation (see, for example, Marshall & Newcombe 1966). This latter observation therefore also provides empirical motivation for route 4.

Spoken–written word matching

We have obtained further evidence indicative of translation failure between written and spoken word-forms, evidence hostile to both models A and C, in a severely aphasic patient A.L. We found that A.L. was unable to match simple spoken to written nonsense-syllables with better than chance accuracy (see table 2). Neither, indeed, could he read them aloud. In contrast, when presented with the written names of two common objects, e.g. SOCK and GLOVE, and the spoken name of one of them ('glove'), A.L. could select the correct written alternative without error. This task could be done, in principle, either by direct translation between written and spoken word-forms, or by comparison of word-meanings. The third task required him to decide which of two written words were more closely related in meaning to a spoken word (e.g. SOCK, GLOVE; 'mitten'), and could presumably be done only by comparison of cognitive codes. Again A.L. performed the task successfully. Finally we gave him a task of the same form as the second task but in which the two written alternatives were as nearly as possible identical in meaning, e.g. DRESS v. FROCK, HUT v. SHED, MAT v. RUG. This task is easy to perform by direct translation of orthographic to phonological lexical codes, but it must be difficult, if not impossible, by comparing cognitive codes alone. On this task, A.L.'s performance dropped to chance (9/16). Models A and C both appear incapable of accommodating this pattern of results.

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Notice that, if the cognitive codes in model B still had a one–one correspondence with words in the language – i.e. if they represented *lexemes – there should still be no difficulty in discriminating* DRESS and FROCK, HUT and SHED, etc., in terms of them. On the other hand, if the cognitive codes represent only non-linguistic sensory, functional and other attributes, the task should be impossible for anyone, like A. L., who cannot directly translate from print to sound. Our results suggest that the task is, in this sense, impossible. We are led to infer that the *abstract lexical code* postulated, if we understand correctly, by Lyons (this symposium) does not exist.

TABLE 2. SPOKEN–WRITTEN WORD MATCHING (A.L.): EXAMPLE STIMULI, AND RESULTS, FROM FOUR DIFFERENT EXPERIMENTAL TASKS

(*n*, Number of choice alternatives; see the text.)

task	written	spoken	score	*n*
1	COBE DOOP	'doop'	2/10	10
2	SOCK GLOVE	'sock'	16/16	2
3	SOCK GLOVE	'mitten'	16/16	2
4	DRESS FROCK	'dress'	9/16	2

Word-meaning deafness

If model B in figure 1 is correct, it should also be possible to observe people for whom direct translation between phonological and cognitive codes (route 1) is impaired, yet whose comprehension of written words (route 3) is preserved, a finding that would be wholly inexplicable by model A.

Several authors have reported cases of 'pure word deafness', in which the patient, without significant hearing loss and often without loss of musical perception, is profoundly impaired in the comprehension of spoken words; yet he is still able to understand written words, and to speak and write fluently (Goldstein 1974). However, in many of these cases at least, the disorder appears to be 'pre-lexical', in that the patient's phonetic discrimination can be shown to be grossly disturbed (see, for example, Saffran *et al.* 1976), so that the syndrome does not necessarily challenge any of the models in figure 1.

The less-often reported 'word-meaning deafness', on the other hand (Lichtheim 1885; Symonds 1953), is of great theoretical significance. We shall take as representative the case illustrated in some detail by Bramwell (1897). Similar patients have been sometimes described under the category of 'transcortical sensory aphasia' (Goldstein 1915). Others, with a less comprehensive or clear-cut word-meaning deafness, have been reported, for example, by Yamadori & Albert (1973) and by Luria (1976).

As in pure word-deafness, the understanding of spoken words is grossly compromised, while spontaneous speech and writing, reading aloud and silent reading comprehension are essentially unimpaired. In contrast with word-deafness, however, the patient is also able to repeat long and complex sentences spoken to him and, most importantly, to write them to dictation. Thus after one spoken presentation, Bramwell's patient transcribed the sentence 'Do you like to come to Edinburgh?' Only after reading what she had written was she able to understand what was said, and to reply. This performance, including the transcription of orthographically irregular words, must depend on translation between intact phonological and orthographic lexical codes. Such a combination of abilities and disabilities cannot be consistently represented in terms of model A or of model C in figure 1. Model C is unable to accommodate the phenomenon of word-meaning deafness, regardless of whether the Master file is thought of as containing all lexical and cognitive codes (Forster 1976), or simply as a set of modality-independent, abstract lexemes. The reader is invited to test this conclusion for himself.

Independence of speech and writing

The discussion so far has largely concerned receptive language comprehension, but comparable dissociations can also be observed in language production. Thus, in a recent detailed investigation of a patient with almost total loss of lexical spelling, Beauvois & Dérouesné (1981) could discover no other signs whatever of aphasia in the patient's oral language. Conversely, in acquired disorders of spoken language, written language production is sometimes notably less impaired than spontaneous speech (see, for example, Basso *et al.* 1978; Hier & Mohr 1977).

4. Lexical codes for reception and production?

We have already referred to more than one kind of functional dissociation between receptive and productive language. The patient studied by Beauvois & Dérouesné (1981), referred to above, who had lost practically all ability to write or spell orthographically irregular words correctly (though his spellings were still phonetically accurate), was nonetheless quite able to

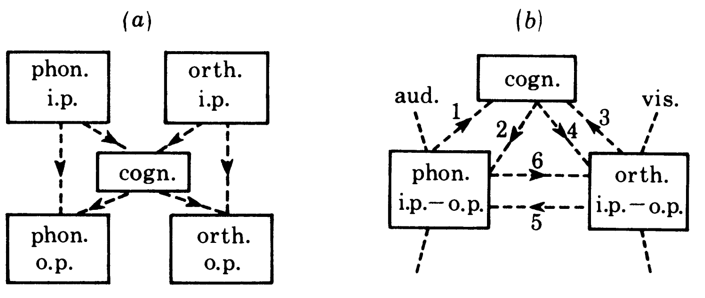

Figure 2. Two models of communication between phonological (phon.), orthographic (orth.) and cognitive (cogn.) codes. (*a*) Functionally independent input (i.p.) and output (o.p.) lexicons; (*b*) combined.

read these same words aloud. In fact his difficulties in reading – confined largely to the pronunciation of non-lexical stimuli (nonsense-words) – appeared to be just the reverse of his spelling disability. The authors argue from this that the orthographic lexical codes used in reading must therefore be functionally dissociable from those used in written or spoken spelling. This proposal, and the corresponding separation in respect of oral language, is represented diagrammatically in figure 2*a*. A similar suggestion, motivated by quite different observations, has been put forward recently by Morton (1979, 1980). We shall turn to Morton's arguments shortly.

It will be clear, however, that the dissociation observed by Beauvois & Dérouesné, in the form of impaired lexical spelling and intact lexical reading, is itself theoretically neutral with respect to the alternatives represented in figure 2. That is, it might be attributed, as those authors apparently do, to the selective impairment or isolation of orthographic lexical codes for spelling *production*, as in figure 2*a*, leaving reception intact. But it is equally consistent with impairment of the outgoing communication channels (paths 4 and 6), thus preventing expressive access to *one* orthographic lexicon used equally for reception and production. (What their patient's performance does seem to require, however, is a functionally separable mechanism of non-lexical 'phonetic' spelling).

A similar argument applies to the observable, complementary dissociations in oral language: the varieties of word-deafness with relatively intact spontaneous speech, on the one hand, and the frequently observed ability of anomic aphasics to understand spoken words that they do not spontaneously produce, on the other. For example, the patient A.L., referred to earlier, fails in picture naming to produce the names of almost any specific objects. Yet in receptive tests, in which he is required for example to match spoken object names to the same pictures, he performs relatively successfully, even with closely conceptually related distractors (brush–comb, shoe–boot, etc.) (15/18). His difficulty is evidently not a result of selective injury to the productive lexical codes ('output logogens'?) themselves, since he also succeeds in reading many of the same set of specific object-names aloud (11/18). A.L. can not read aloud simple four-letter nonsense-words, nor match them to spoken syllables with greater than chance success, so that it is unlikely that his reading aloud of object-names is other than lexical.

Although at first sight one might be tempted, on the strength of some of these dissociations between receptive and productive abilities, to propose the existence of functionally independent lexical representations for 'input' and for 'output', it is clear that the data do not demand this interpretation. Morton (1979, 1980) has recently made strong claims for the independence of lexical word-units for reception and for production ('input and output logogens'), respectively in both spoken and written language. We must now examine these claims.

Morton's argument rests on a phenomenon of perceptual facilitation (in terms of enhanced speed or accuracy of identification) observed on the second or subsequent presentations of the same stimulus word, with or without simple inflectional changes (see Morton, this symposium). Let us call this the word-repetition effect. Effects of this kind can be remarkably long-lasting (over hours or even weeks) for words, but short-lived for nonsense-words (Scarborough *et al.* 1977), and occur equally for physically identical repetitions of the word and for the same word repeated by a speaker of the opposite sex, or printed in a different case, or in script versus type (Scarborough *et al.* 1977; Morton 1979). However, these word- or morpheme-specific repetition effects are largely absent when the repetition is across modality, from spoken to written or from written to spoken presentations, at least over repetition intervals greater than 1 or 2 min (Kirsner & Smith 1974; Morton 1979). Furthermore, no repetition effect is found between speaking a word aloud and its subsequent visual recognition (Winnick & Daniel 1970; Morton 1979), and the effect does not appear to transfer to translation-equivalents for bilingual subjects (Kirsner 1980). Together, this pattern of results clearly implies that the phenomenon depends, in some way, on a word-specific but also *modality-specific* lexical code. (In this it is to be distinguished from a relatively short-lasting facilitation between conceptually associated words (Meyer *et al.* 1975) or pictures (Sperber *et al.* 1979) lasting only a few seconds, and which does transfer between modalities (see, for example, Swinney *et al.* 1979).)

Morton (1979) has argued that results of this kind, in particular those of Winnick & Daniel, also demand independent word-units dedicated respectively to reception and production ('input and output logogens') for written (Morton 1980) as well as for spoken language. Surprisingly, Morton (1979) did not describe what might seem to be the crucial experiments needed to motivate his conclusion, namely to demonstrate the absence of a repetition effect between speaking a word and subsequently hearing it, or between writing and subsequent visual recognition, nor indeed between these same pairings of events in the reverse temporal sequence.

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However, even if or when such demonstrations can be obtained (Gipson 1981), the results would still not demand separate 'input' and 'output' logogens, for the following reason. The fundamental assumption in Morton's interpretation of these experiments is that the repetition effect reflects some long-lasting change in the word-units (logogens) themselves. But nothing in the results requires this assumption. The data are equally compatible with the view that the facilitation is specific to the pathways of *access to* logogen units, of course at a level of representation that generalizes across letter-identity in different case (McClelland 1976; Adams 1979), etc. But, if so, the effects would naturally fail to transfer from word-production to recognition (or vice versa), since different access paths are involved. Consequently, unless independent evidence can be found to eliminate this interpretation, the failure of transfer in the repetition effect is equally consistent with a *single* lexical code, and cannot therefore be used to motivate functionally independent logogens for input and output, nor for spoken and written words (see also Fay & Cutler 1977).

In view of the arguments set out earlier, and on grounds of parsimony, we are inclined to prefer the more cautious view that the same, modality-specific, lexical codes are addressed both in the reception and the production of language, as diagrammed in figure 2*b*.

5. Word-class differences

Our discussion has been presented, so far, as if lexical and cognitive codes, and the channels of communication between them, were uniform across all classes of lexical morpheme. As will be clear, this view is too simple.

One of the more provocative observations in aphasia is that referential and syntactic functions of language sometimes appear to be disrupted more or less independently. This is especially apparent in spontaneous speech. On the one hand, there are patients whose speech production consists almost entirely of isolated, referential nouns; phrase structure, syntactic morphemes and inflections are all lacking. At the other extreme can be found aphasic patients whose utterances are generally syntactically well formed, but in which the specific referential words are strikingly absent.

Some impression of these contrasting speech patterns may be obtained from the following two examples. The first comes from an anomic patient, A.L., who is describing a picture, taken from the Boston Aphasia Inventory. In the picture a woman stands at a kitchen sink washing dishes. The tap is running, but the woman is apparently oblivious that the water is overflowing the basin onto the floor. Behind her a boy and a girl are reaching for biscuits from the cupboard. The stool on which the boy is standing is about to fall.

A.L.'s speech is prosodic and fluent, but marked by frequent pauses and repeated false starts, while he appears to be struggling to find an appropriate word with which to refer to specific objects and events in the scene. He can generally indicate to the interviewer, by mime or by pointing to particular features in the picture, the word that he is seeking. To help the reader in following this excerpt we have inserted these presumed target words, in square brackets, in the transcript.

A.L.: 'Well, it's a...[kitchen?], it's a place, and it's a...girl and a boy, and they've got obviously something which is made, some...[biscuits], some... made.... Well...[the stool] it's just beginning to...[fall] go and be rather unpleasant.... And...this is the...[mother?] the woman, and she is...[pouring?] putting some...[water] stuff, and the...[water], it's...it's [overflowing] that's being really too... [full?] big to do, and nobody seems to have... [noticed?] got anything there at all... I'm rather surprised at that, but there you are....

'I suppose the idea is that the...er [children]...two people should be fairly good, but I think it's going to go somewhere; and as I say, it's down again....'

In a sample of 900 words, from which this transcript is taken, just 9 of the words, or 1 %, were even moderately specific, referential nouns: these were limited to the words *boy*, *girl*, *woman*, *car*, *people*. The remaining nouns and verbs were restricted to the most general 'thesaurus head' terms: verbs like *do*, *go*, *make* and *put*, and nouns such as *thing*, *stuff*, *place*, *idea*. Personal and demonstrative pronouns were used twice as often as these general nouns.

This performance can be contrasted with the description of the same picture by an agrammatic patient, R.C.

R.C.: 'Water...man, no woman... [*pointing to the boy*] child... no, man...and girl... oh dear...cupboard...man, falling...jar...cakes...head...face...window...tap....'

As is clear even from this brief excerpt, many different classes of words – the syntactic function words: articles, auxiliaries, prepositions, particles, conjunctions – are absent in R.C.'s speech. Her utterances appear more or less confined to just the word-classes that are conspicuously lacking in A.L.'s speech: specific object-names.

However, and this is a point that we wish to emphasize, the selective difficulty experienced by these patients with different word-classes is by no means constant over all language tasks. We have space to illustrate this point with only a few examples.

The anomic patient, A.L., in whose spontaneous speech syntactic functors are well represented, is completely unable to read these same words aloud. (In our sample, 0 % correct.) Moreover, tested with the complete set of 'thesaurus head' nouns (*stuff*, *thing*, *place*, etc.) and verbs (*do*, *go*, *put*, etc.) that predominate in his speech production, A.L. was able to read only 2/16, or 12 %, aloud. In direct contrast, he read aloud correctly 65 % of a set of specific concrete object-names.

We found a similar pattern in a task not requiring explicit speech production: matching spoken to written words in a 10- or 12-alternative array. In this task, A.L. was correct on every one of a set of 24 specific object-names, and on 10/12 'superordinate' names (*fruit*, *vehicle*, *sport*...); whereas he succeeded on only 42 % of the 'thesaurus head' nouns and verbs. On a set of pronouns he scored no better than chance, and fared little better with locative prepositions and a variety of syntactic functors.

In a remarkable sense, that is, A.L. appears to be 'anomic' in spontaneous speech, but 'agrammatic' in reading. An important question, therefore, is whether these selective performance deficits with different word-classes are properly speaking *syntactic* (or even linguistic) in origin.

Deep dyslexic patients are well known to be especially impaired in reading aloud syntactic functors (Coltheart 1980). Many of these patients are also agrammatic in oral language, but for some (see, for example, Low 1931) their 'agrammatism' is restricted, as with A.L., to written language. A.L., however, is not a deep dyslexic: in a sample of several hundred words presented for reading aloud, only one of A.L.'s responses (ANIMAL → 'bird, no, the other sort') could be classified relatively unambiguously as a 'semantic error'. In investigations of deep dyslexic reading it is often reported that there is a gradient of difficulty across the major syntactic classes of content words: nouns are read correctly more often than adjectives, adjectives more often than verbs (Marshall & Newcombe 1966; Coltheart 1980) (see table 3). However, it is also well known that the readiness with which a word evokes sensory imagery in normal subjects (its 'imageability') is a strong predictor of whether it will be successfully read aloud by deep dyslexics. Imageability is therefore an obvious potential confounding factor, in comparing sets of nouns and verbs, unless special care is taken in their selection, since the nouns are liable to be more 'imageable' than the verbs. Indeed, when a set of 30 nouns and 30 verbs, which had been carefully matched in terms of imageability and word-frequency, was given to five different deep dyslexic patients to read, no consistent advantage of nouns over verbs, remained (table 4). We have to ask, therefore, whether the apparent 'agrammatism' of these patients in failing to read syntactic functors, is not, similarly, a consequence of a *semantically* based difference in imageability.

Table 3. Deep dyslexic performance in reading aloud isolated words: percentage correct

patient ...	G.R.†	K.F.‡
nouns	45	43
adjectives	16	32
verbs	6	7

† Marshall & Newcombe (1966); ‡ Shallice & Warrington (1975).

Table 4. Reading nouns and verbs matched in imageability and word-frequency: number correct (max. = 30)

patient ...	S.K.	P.W.†	D.E.†	B.B.†	R.W.†
nouns	22	14	18	24	5
verbs	20	14	21	27	9

† We are very grateful to Karalyn Patterson for testing these patients for us.

Nonetheless, it is clear that this cannot be the whole story, since the same word can sometimes be understood in its referential function, yet not in respect of its syntactic function (Morton & Patterson 1980*b*; Schwartz *et al.* 1980*b*). For instance, we tested the comprehension of another agrammatic patient, W.T., for spoken locative prepositions ('in', 'beside', 'above', etc.), by asking him to pick one of two simple spatial scenarios to match the word. He was correct on 19/20 trials at this task. However, when his task was to pick one of a pair of pictures that matched a spoken prepositional *phrase* (e.g. 'a box *in* a basket'), where the pictures, in this case, showed either a box in a basket or a basket in a box, even though we could show that he understood the words individually, his performance was if anything below chance (5/14).

An extension of these same tests to written words leads us back once more to our initial theme, the independence of spoken and written lexical representations. Thus W.T., who could select the appropriate spatial arrangement to match a spoken preposition (19/20) was quite unable to do so when the word was written (8/20). This failure, however, could not be the result simply of a failure of the written words to access a lexical representation, since W.T. performed successfully (10/10, 19/20) in two different versions of a lexical decision task using the same written prepositions. (In this task, the subject is confronted with a mixture of real words (e.g. below) and nonsense-words (betow), formed by changing one of the letters in such as way as not to disturb the item's general outline or orthographic regularity. The subject is then required to identify the real words.) These results show that W.T. can understand the referential function of spoken, but not of written, locative prepositions. Nevertheless, these written prepositions must access some word-specific, lexical code if they are to be recognized as real words. Thus, since these written words access a lexical code but cannot be understood, the lexical code they access must be a different code from that accessed by spoken words. Moreover, the lexical code for these words is manifestly separable from the representation of their referential meaning.

6. Conclusion

We can now summarize the position we have reached regarding the questions outlined in §1. First, it is clear that the ability to understand natural language must rely on the recipient's *non-linguistic* knowledge about the subject of discourse: on his ability to represent and to operate on objects, relations and actions in terms of a cognitive symbol system that is itself independent of natural language. We reviewed a variety of evidence (§3) requiring independent lexical codes for written and for spoken words, with independent communication to and from the cognitive system in both domains (model B, see figure 1). The results appear to exclude the hypothesis of any other, *modality-independent* lexicon. The question of separate lexical codes for reception and production (§4) could not be conclusively resolved, but we were unable to find any compelling evidence in favour of this separation. Finally (§5), we noted that the relative difficulty experienced by aphasic patients in dealing with different syntactic word-classes is itself a function of the language task, and of the input of output modalities employed. Thus patients can appear 'anomic' in one modality but 'asyntactic' in another. Moreover, not all the apparent differences in performance between syntactic word-classes, we found reason to believe, can be strictly syntactic in origin.

It is clear that the theoretical positions we find ourselves propelled towards by these empirical observations are frequently at variance with conjectures about 'the lexicon' (even sometimes 'the *mental* lexicon') to be found in theoretical linguistics: conjectures, for example, about the relative status of spoken and written language in access to and from word-meanings, or about the modality-independent representation of lexemes. Suppose, as can happen, that brain injury destroys both phonological and orthographic lexical codes. One might ask, what then remains of the mental lexicon that is *language-specific*? On the basis of the evidence reviewed here, we are disposed to answer: nothing at all.

Doubtless the really fundamental questions, in relation to the 'mental lexicon', have to do with the non-linguistic representation of an individual's knowledge of the world. But we undertook not to embark on them here. By way of apology for the quite elementary nature of the questions we have tried to ask, we would refer to an old Chinese saying. As in hunting, so in science:

十 鳥 在 樹 不 如 一 鳥 在 手。

In English, 'ten birds in the tree, not worth one in the hand.'

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