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Reversal of the Concreteness Effect in a Patient with Semantic Dementia

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Temple University, Philadelphia, USA

Normal subjects are better at identifying and remembering concrete as compared to abstract words (the concreteness effect). We present data on a patient, DM, who shows the opposite pattern. DM has a progressive semantic loss due to atrophic changes in his temporal lobes, particularly on the left. His semantic impairment predominantly involves object terms, with relative sparing of abstract nouns and most aspects of verb meaning. DM showed an advantage for abstract words on a wide range of tasks (e.g. producing definitions, synonymy judgments). These data challenge accounts that attribute the concreteness effect to a quantitative superiority at the level of the underlying conceptual representations. We suggest that there are qualitative differences between abstract and concrete concepts, and that, in particular, concrete concepts are more dependent on perceptual attributes that were disproportionately impaired in DM. We propose, further, that perceptual components of semantic representations are associated with structures in the inferior temporal lobe(s).

INTRODUCTION

Most of us share the intuition that abstract words are more difficult to learn, comprehend, define, and remember than concrete words. The results of empirical studies are consistent with this intuition. Brown (1957)

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The authors wish to thank Kimberly Feldman for her assistance in preparing test materials, and testing control subjects, and Drs. Nadine Martin, Allan Paivio, Max Coltheart, and two anonymous reviewers for their comments on earlier versions of this manuscript. We would also like to thank DM and his wife for their time and patience during many long hours of testing.

Parts of the research reported here were presented at the Sixth Annual Meeting of the CUNY Sentence Processing Conference and at the Thirty-Fourth Annual Meeting of the Psychonomics Society.

and Gentner (1982) have noted that the vocabulary of young children consists primarily of concrete nouns; abstract nouns and verbs are acquired later. In adult subjects, there is a large body of work demonstrating better performance on free-recall, cued-recall, paired associates, and recognition memory tests for concrete words than abstract words (see Paivio, 1991, for review). Subjects are also faster at making lexical decisions to visually presented concrete words than abstract words (James, 1975; Kroll & Merves, 1986). This advantage is known as the concreteness effect.

In addition, the neuropsychological literature contains numerous reports of amplification of the concreteness effect following brain damage. Deep dyslexics are more impaired at reading abstract words than concrete words (see Coltheart, 1980, for review), and deep dysphasics show the same pattern in word repetition (e.g. Katz & Goodglass, 1990; Martin & Saffran, 1992); some patients with very reduced short-term memory spans perform better with concrete words than abstract words in serial recall (Saffran & Martin, 1990); and aphasics, in general, show a concreteness advantage in word retrieval (Goodglass, Hyde, & Blumstein, 1969).

There are, however, several reports of patients who demonstrate reversal of this effect. One of the three cases described in Warrington's (1975) seminal paper on semantic memory disorders, AB, was significantly better at defining abstract words than concrete words. Since 1975, at least three other cases have been documented: CAV, who was better at reading abstract words than concrete words, and showed the same pattern in matching words to pictures (Warrington, 1981); SBY, who like AB was better at defining abstract words than concrete words and, like CAV, showed an abstract advantage in word–picture matching (Warrington & Shallice, 1984); and FB, who was better at defining abstract words than concrete words, and produced more abstract words than concrete words on verbal fluency tests (Sirigu, Duhamel, & Poncet, 1991).

The existence of such patients appears to have gone unnoticed outside the field of cognitive neuropsychology.[1] Yet evidence of reversal of the concreteness effect has implications for current explanations of the concreteness effect in the normal population, and for theories of conceptual representation more generally. An adequate theory should offer a coherent account of the reversal of the concreteness effect with some forms of brain damage, as well as its magnification with others. In this paper, we address these issues from the vantage point of evidence obtained from a fifth patient who demonstrates an advantage for abstract words across a range of tasks.

[1]A case in point is a recent review paper by Paivio (1991), in which an entire section is devoted to cognitive neuropsychological evidence of the concreteness effect but no reference is made to the patients who show a reversal of this effect.

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Explanations of the Concreteness Effect in the Normal Population

We will review three accounts of the concreteness effect considered in the recent literature: (1) the Dual Coding Theory; (2) the Context Availability Hypothesis; and (3) the Differential Number of Semantic Features Hypothesis. Although this is not an exhaustive list, it is representative (see Kieras, 1978, for review of other theories). All three theories assume that the representations of concrete concepts include some additional component or mechanism for processing that makes them easier to access and remember; where they differ is with respect to the nature of this additional component or mechanism. Although these theories can account for many of the effects found in normal processing of concrete words, two are unable to explain better performance with abstract words, at least not without significant modification. There are other grounds for challenging the third, which offers a computational account of the reversal.

Dual Coding Theory

The Dual Coding Theory, perhaps the one most commonly associated with the concreteness effect, was proposed by Paivio (1971) to explain subjects' better performance on memory tests with pictures or concrete word stimuli as compared with abstract words. The theory, which continues to be tested and modified (Paivio, 1991), assumes memory to be a multimodal representational system. In Paivio's own words (1991, p. 257):

> The theory assumes an orthogonal relation between symbolic systems and specific sensorimotor systems. Verbal and nonverbal systems symbolically represent the structural and functional properties of language and the nonlinguistic world, respectively. However, both classes of events come in different modalities—visual (printed words vs. visual objects), auditory (spoken words vs. environmental sounds), haptic (tactual and motor feedback from writing vs. manipulation of objects)—and the internal symbolic systems presumably retain these distinctions.

Paivio argues that subjects are better at recalling concrete words than abstract words because concrete words are coded in two ways rather than one. The concrete word *cat* activates both a verbal code and a nonverbal (imaginal) code. In contrast, the abstract word *destiny* activates only a verbal code and is therefore less likely to be remembered.

Context Availability Hypothesis

The Context Availability Hypothesis has been put forward to explain the absence of concreteness effects in the presence of contextual information (Schwanenflugel & Shoben, 1983; Schwanenflugel, 1991). Schwanenflugel and Shoben found that reading times were slower for abstract sentences than concrete sentences. However, when the sentences were preceded by a paragraph that provided context, there was no difference in reading times for the two sentence types. In addition, they found that differences in lexical decision times for concrete and abstract words disappeared when the target was presented as the last word of a sentence. According to Schwanenflugel, Akin, and Luh (1992, p. 97), the

> . . . context availability hypothesis emphasises the availability of information from prior knowledge to explain concreteness effects. Successful comprehension and later recall are said to be a reflection of the ability of the person to relate the to-be-remembered materials to the contextual information present in the person's knowledge base. Abstract verbal materials are said to be more poorly comprehended and, therefore, poorly recalled, because people experience greater difficulty in accessing the relevant world knowledge necessary for understanding such materials. Therefore, abstract materials are recalled more poorly than concrete materials, not because of the lesser availability of imagery, but because of the availability of associated contextual information in memory for such materials.

Kieras (1978) suggested two reasons for the contextual advantage enjoyed by concrete words. First, these items are likely to be more familiar; items that are familiar are likely to be associated with more propositions in memory, and these propositions are likely to be richly connected to other propositions; consequently, it should be easier to assign a context for a concrete word. A second possible source for the contextual advantage is that the representations for concrete words include perceptual propositions and have access to perceptual contexts in which the concept has appeared. These additional propositions should facilitate the development of an appropriate context.

Differential Number of Semantic Features Hypothesis

The third type of explanation has evolved within cognitive neuropsychology, largely as an attempt to accommodate the exaggerated concreteness effect that is one of the defining features of deep dyslexia (e.g. Coltheart, Patterson, & Marshall, 1980). Jones (1985) has linked this effect to a parameter that he termed "ease-of-predication." This parameter, which is based on normal subjects' estimates of the number of predicates that can be generated for the word, correlates highly with imageability, which, in turn, is a good predictor of the oral reading pattern in deep dyslexia. Ease-of-predication presumably reflects the richness of the underlying semantic representation, and appears closely related to the Context Availability Hypothesis.

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Plaut and Shallice (1991; 1993) have developed a connectionist model of reading in which they attempt to simulate features of the reading performance of deep dyslexics, among them the advantage for concrete words. On this model, ease-of-predication is implemented in terms of numbers of semantic features: Concrete words are endowed with more semantic features than abstract words. Consequently, when the visual word processing system is damaged, abstract words are likely to be more difficult to retrieve than concrete words, because they have fewer semantic features.

As one test of the generality of their model, Plaut and Shallice examine its ability to account for the reversal of the concreteness effect in reading that Warrington (1981) demonstrated in patient CAV. Their attempt to account for the greater preservation of abstract words hinges on an important feature of the architecture of the model: The use of "attractors" (or "clean-up" units) that essentially push the activation pattern that a word generates in the network further in the direction of the correct meaning. Although lesions elsewhere in the network are more damaging to abstract words, lesioning the clean-up system has the opposite effect: Abstract words are better preserved than concrete words. Plaut and Shallice (1993, p. 461) note that:

> When processing a concrete word, most clean-up units receive strong input (positive or negative) from semantics and are driven to states near 0 or 1. In contrast, clean-up units receive relatively weak input from semantics when processing an abstract word, and so tend to remain in states near 0.5. In this sense, the clean-up units play less of a role generating the correct semantics of abstract words than they do for concrete words.

Later, we will consider some possible weaknesses of this account. For now, it will suffice to note that feature numerosity is the sole difference between abstract and concrete words on the Plaut and Shallice model, and that a quantitative advantage for concrete words is also at the heart of the other accounts of the concreteness effect that we have considered.[2]

Having reviewed several explanations of the concreteness effect, we will present data for patient DM that demonstrate his reversal of this effect. We then go on to re-examine these theories in light of the evidence from DM.

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[2]The same applies to accounts that invoke hemispheric differences to explain the exaggerated concreteness effects associated with left hemisphere lesions, specifically, that the left hemisphere supports both abstract and concrete concepts, and the right hemisphere only the latter (see Coltheart, 1980, for review of relevant data).

PATIENT DESCRIPTION

DM is a 56-year-old, right-handed professional with a master's degree who first exhibited cognitive impairments 4½ years ago, in 1988, when he began to have difficulty remembering names and appointments. This forgetfulness was originally attributed to and treated as depression. However, when no improvement was noted after 18 months of treatment, DM underwent neuropsychological evaluation which demonstrated evidence of "mild dementia." DM was referred to our laboratory when he began to have difficulty reading in the spring of 1991. He continued to work full-time until his retirement 9 months ago in autumn 1992.

During the two years that we have been testing DM, his performance has been relatively stable (see Appendix A for repeated measures of background tests and Appendix B for a time-line of the main experiments). Much of this is due to his efforts and those of his very supportive family. DM is aware of his cognitive deficits and uses testing sessions to identify problem areas, which he then works on at home. For example, realising that he was having difficulty with animals, DM began to study children's books on animals and make notes for himself (see Fig. 1). DM makes his own appointments for testing and often drives himself to the laboratory. He always arrives on time and has never forgotten an appointment.

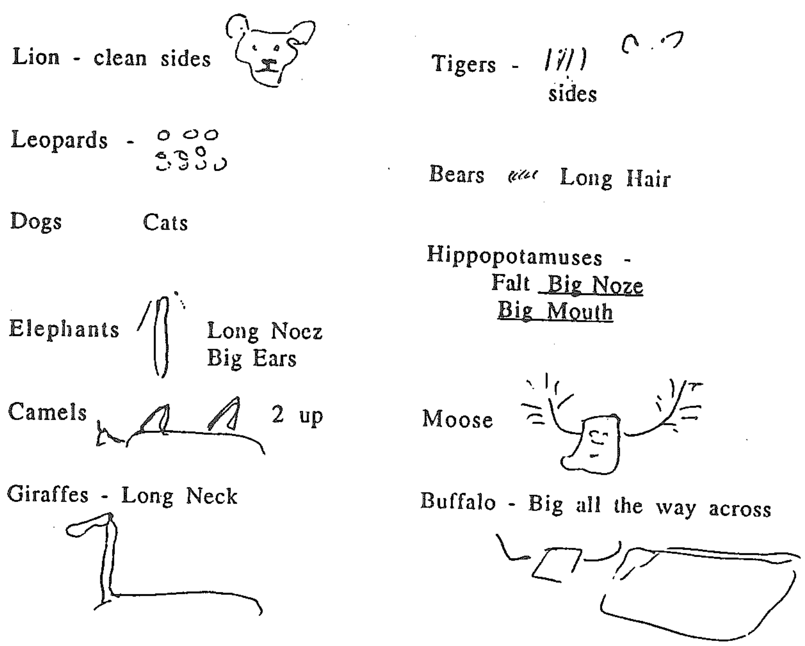

FIG. 1 Examples of DM's notes and drawings.

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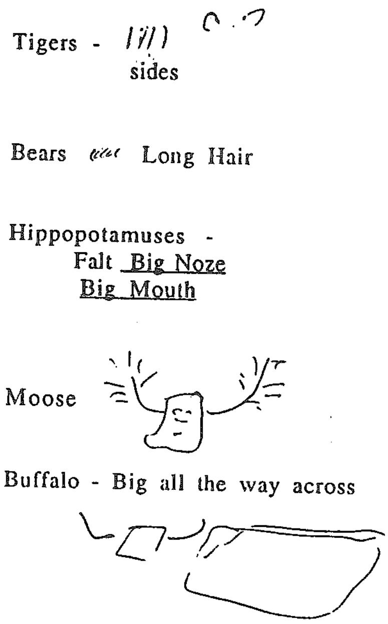

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Neurologic examination except for mental status was normal. MRI scan with 3mm slice thickness and 2mm gap performed at the time of the testing reported here demonstrated no abnormalities on axial, coronal, or sagittal images. A SPECT scan obtained with HM-PAO, administered while the patient was at rest with eyes closed, demonstrated decreased uptake in the inferior temporal and occipito-temporal gyri bilaterally; the deficit was more pronounced on the left.

Several additional analyses using recently developed software (Bio-Imaging Corp., see also Holcomb et al., 1993; in press) were undertaken to quantify the perfusion deficit. The technique permits corresponding MRI and SPECT datasets to be co-registered. Employing this co-registration technique, quantified SPECT data may be displayed and analysed with reference to the precise anatomic data available from MRI.

Registration is performed by displaying the mid-slice of the MRI in the axial, sagittal, and coronal planes and overlaying the mid-slice of the corresponding SPECT study; mid-slices are determined by a computer-generated middle of the actual image data. Each plane is displayed individually and the SPECT study adjusted to match the most prominent mid-line structures present on both MRI and SPECT. Previous investigations employing this technique suggest that the general error range is 1.5–2mm.

Registered data sets are resliced by displaying a sagittal mid-slice of the MRI, placing a line connecting the anterior and posterior commissures, and selecting slice thickness and number of slices. Registered SPECT studies are then resampled in the identical manner using the MRI as a reference.

For the analyses reported here, Regions of Interest (ROIs) were defined on the sagittal and coronal slices of the MRI. The mean intensity scores for the ROIs defined using the precise anatomic landmarks available on the MRI were calculated by averaging the mean intensity scores for the voxels included in the ROI. The mean intensity score for the whole brain was also calculated using the entire brain as the ROI.

For the purposes of comparing blood flow in different cortical regions, mean intensity scores for selected cortical ROIs were expressed as a ratio of the mean whole brain intensity score. Mean intensity scores for the anterior temporal lobe, operationally defined for this purpose as the anterior 5cm of the temporal lobe, and the posterior inferior temporal lobes, defined here as the tissue extending from 5 to 9cm from the temporal tip, were calculated independently. As indicated in Fig. 2, the ROI to Whole Brain ratio was substantially lower for the anterior temporal lobe; ROI to Whole Brain ratios for the posterior portion of the inferior temporal gyri and the middle and superior temporal gyri did not differ from other frontal and parietal cortical ROIs. A second relevant finding was that the ROI to Whole Brain ratio for the left anterior inferior temporal gyrus was approximately 10% lower than that of the right anterior inferior temporal gyrus. Although minor right/left asymmetries were noted in other ROIs, right/left asymmetries of comparable magnitude were not observed in any other cortical or subcortical ROI (including those assessed but not depicted).

An additional analysis was performed to define more precisely the anatomic locus of the inferior temporal gyrus perfusion deficit. Figure 3 depicts the ROI/Whole Brain mean intensity scores for the right and left inferior temporal gyrus as a function of distance from the anterior temporal tip. These data demonstrate that the perfusion deficit was maximal at approximately 25–30mm from the temporal tip, where the mean intensity scores on the left were approximately 50–60% of the value of the posterior portions of the inferior temporal gyri. Similar localised perfusion deficits were not observed in comparable analyses of the middle and superior temporal gyri of normal controls.

The decrease in perfusion in the inferior temporal lobes, and the inferior temporal gyrus in particular, is illustrated in Plates 1 and 2, which depict the co-registration of the SPECT and MRI datasets in coronal sections 25 and 45mm posterior to the temporal tips.

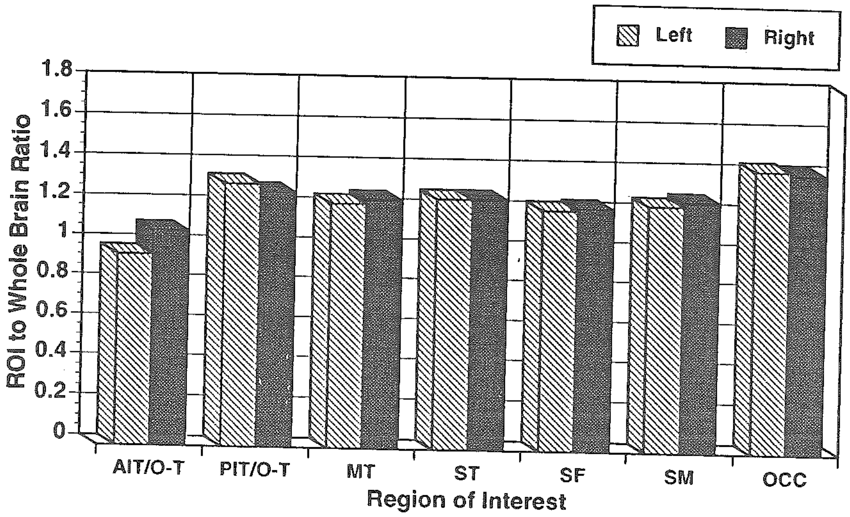
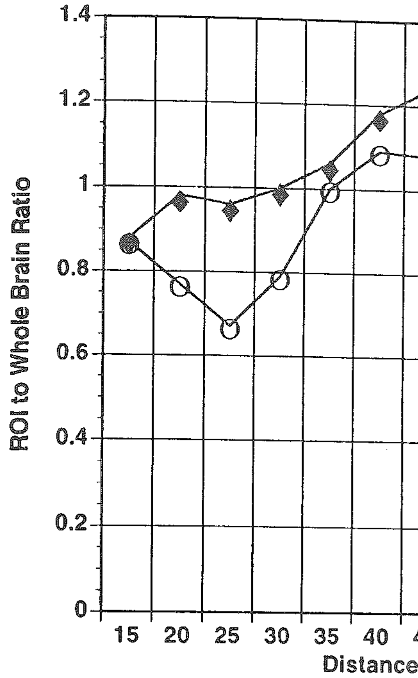


FIG. 2 Mean intensity scores for selected ROIs expressed as a ratio of the Whole Brain mean intensity score. (Note: AIT/O-T = anterior inferior temporal and occipito-temporal; PIT/O-T = posterior inferior temporal and occipito-temporal; MT = middle temporal; ST = superior temporal; SF = superior frontal; SM = supramarginal; OCC = occipital lobe.)



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Language Processing

Naming

DM has a severe naming deficit.
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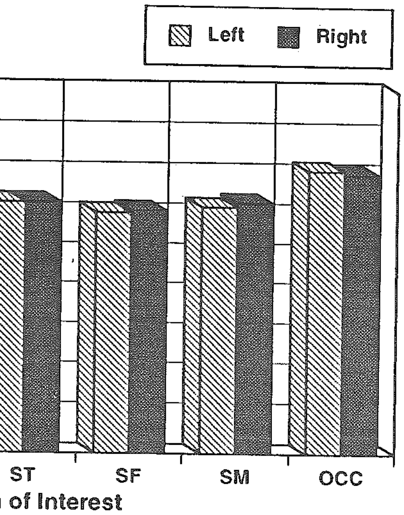

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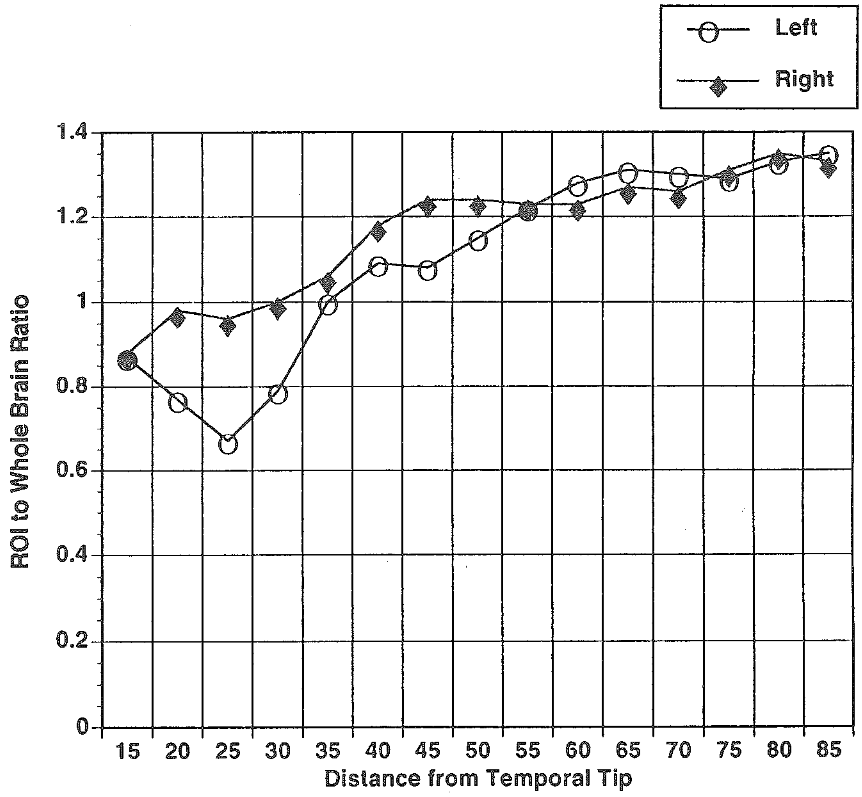

FIG. 3 Mean intensity scores for the right and left inferior temporal and occipito-temporal gyri as a function of distance from the temporal tip (in mm).

General Neuropsychological Evaluation

On the Dementia Rating Scale (Coblentz et al., 1973), DM obtained a score of 120 out of a possible 144, indicating mild to moderate dementia. His IQ as measured by the WAIS was 86; he scored 83 on the verbal subtests and 92 on the performance subtests, which, given his educational level, clearly represents a decline in intellectual function. DM obtained a memory quotient of 73 on the Wechsler Memory Scale.

Language Processing

Naming

DM has a severe naming deficit. On 2 separate administrations of the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983), he named only 11 and 13 of 60 items respectively. In addition, we examined DM's naming ability with several different modalities of presentation. DM heard

50 familiar sounds (e.g. a telephone ringing, slurping through a straw) and was instructed to name the source of the sound; a week later, he was asked to name 50 pictures depicting the source of the sounds. DM named 27 of 50 sounds and 26 of 50 pictures. Control subjects are at ceiling for both modalities of presentation. DM was also tested on a subset of Zingeser and Berndt's (1988) noun–verb picture naming test. In this task, the subject sees pictures depicting objects (e.g. a *bell*) and actions (e.g. a man *shooting* a gun) matched for frequency of occurrence, and must name the pictures. DM successfully named 13 of the 26 nouns and 13 of the 28 verbs showing no difference between nouns and verbs; control subjects are at ceiling on this task. We tested DM on his ability to name to definitions for the same items and his performance was better; he named 16 of the 26 nouns and 23 of the 28 verbs. Although he was better at naming verbs than nouns the difference was not statistically significant ($\chi^2[1] = 2.85$, $P < 0.09$). However, DM was significantly better at naming to definitions than to pictures ($\chi^2[1] = 5.56$, $P < 0.02$).[3]

In general, DM is aware of his naming impairment. He either names the pictured object correctly or says "that one [word] doesn't come to me." He does not produce phonemic errors or neologisms. However, we have instructed him to give us any information he can when he cannot produce the name. This strategy has yielded intriguing glimpses into DM's disintegrating semantics (see Appendix C for examples of naming "errors").

Lexical Comprehension

DM's lexical comprehension was measured with the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1981). His performance was assessed relative to norms for 40-year-old subjects (the highest age level for which norms were available). DM obtained a standard score of 50, a performance level more than 3 standard deviations below the normal mean (X = 100; sd = 15).

Reading

Examination of DM's reading at the onset of this study showed that he was able to read regular words but was impaired at reading irregular words, the pattern that defines surface dyslexia (cf. Patterson, Marshall, & Coltheart, 1985). The effect of regularity was tested by means of a list reported by Shallice, Warrington, and McCarthy (1983), in which orthographically regular words are contrasted with words of two different degrees of irregularity. DM read regular words at 95% accuracy (e.g. security); his performance declined (83%) on mildly irregular words (e.g.

[3]When n > 40, we report χ^2 corrected for continuity as recommended by Siegel and Castellan (1988).

worm) and was quite poor (48%) on words that were highly irregular (e.g. lieutenant). More recently, DM has begun to have difficulty reading regular words as well (83%).

Speech Production

DM's spontaneous speech is fluent with good articulation. When we first began testing DM, his word retrieval problem was apparent in spontaneous speech only when he was asked very specific questions. Recently his anomia has become more apparent in spontaneous speech as well as in naming. He also seems to rely on a set of well-rehearsed stories when talking with people.

Sentence Comprehension

DM performs perfectly on sentence–picture matching tasks, which is surprising in light of his poor lexical comprehension. One possible explanation for his good performance is that the nouns used in these sentences tend to be both familiar and distinguishable from each other, since the primary function of these tasks is to assess syntactic abilities and not lexical comprehension. In addition, he appears to use syntactic information to disambiguate lexical confusions. A more detailed account of DM's syntactic processing is presented in Breedin and Saffran (in preparation).

Visual Processing

Although his good performance on sentence–picture matching suggests otherwise, one possible explanation for DM's impairments on lexical comprehension and naming tasks is a difficulty in processing visually presented material. To rule out this possibility, DM was tested on several measures of visual processing. The tests administered included Warrington and James' (1991) Visual Object and Space Perception Battery, which examines the ability to recognise degraded representations of objects and to utilise spatial information. DM's performance was normal for all but two of the subtests, both of which involve naming silhouettes; the difficulty here could involve object recognition and/or name retrieval. Data on object recognition are presented later.

Visual processing was also tested in a Matching Across Views test modelled on Warrington and Taylor (1978). In this test, the patient is shown a photograph of a common object at either a usual or unusual viewing angle and must match the picture to one of three pictured objects. Only one of the choices is of the same object, which is presented at a different viewing angle. DM made no errors on this task.

We also assessed DM's visual processing by asking him to copy pictures of objects and nonobjects (see Fig. 4). DM's copies were very good and

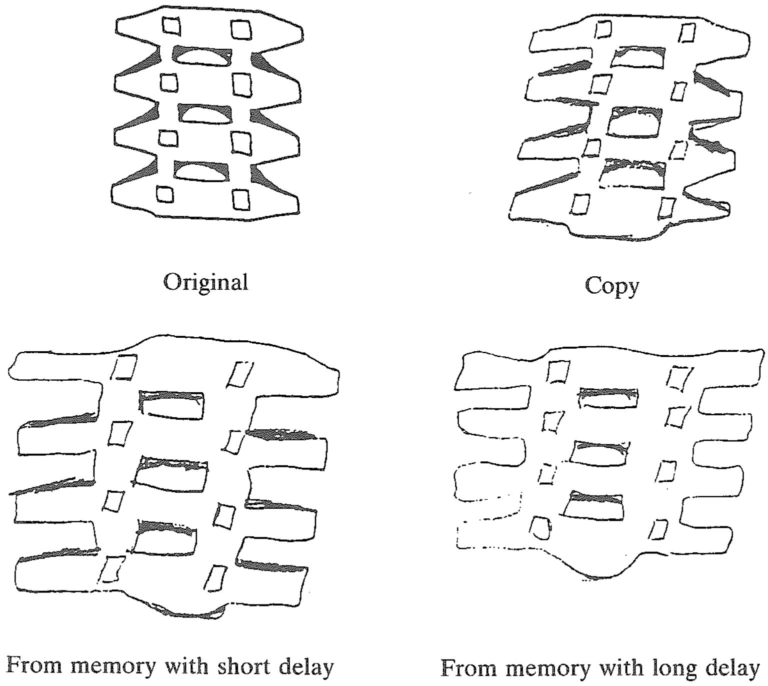

FIG. 4 Example of DM's copying and drawing from memory.

indicate preserved visual processing, although it is possible that he was slavishly copying the drawings. To rule out this possibility, we asked him to draw the pictures that he had copied, either immediately after copying or after a delay during which he copied another figure. Again, his drawings were quite good, suggesting intact visual processing and memory (see Fig. 4). Finally, we examined DM's colour perception using the Farnsworth D-15 panel. This test involves ordering 15 coloured circles by their hue. DM ordered all 15 circles correctly, indicating normal colour perception.

Visual Object Recognition

Although DM's visual processing appears to be intact, there was evidence of difficulty with visual object recognition. In this section, we present data from two tests of DM's ability to recognise visually presented objects.

Nonobject Decision Task

This test was adapted from a task developed by Riddoch and Humphreys (1987). Poor performance on this test, in conjunction with good performance on other tests of visual perception, suggests problems at higher levels

of visual processing, most likely at th
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consists of 60 items, 30 objects and 3
individually for object decision. DM ma
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Of the 13 errors, 8 were on animals. T
was 3.4 (range: 1–9). Although not se
performance was clearly below the no

Colouring Objects

Earlier, we demonstrated that DM'
task, we examined his knowledge of t
presented DM with 28 line drawings o
(e.g. carrots are orange, elephants ar
a time and was given a choice of four
in the line drawing. DM selected the
drawings. His incorrect choices inclu
rhinoceros, and grey for carrot.

Memory

DM's verbal short-term memory was
digit span of seven items. Long-term
assessed by his performance on Wa
(1984). DM was 66% correct for the v
On both, his performance was below t
in his age group.

Although it is difficult to assess
semantic memory, which is impaired
that DM's day-to-day memory is relat
episodic memory involve his ability to
tions with the experimenter that occ
his frequent comments indicating tha
has seen the same stimulus items in
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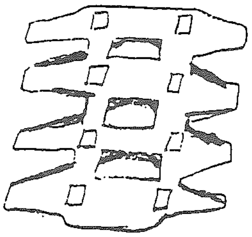
matching famous names and faces, h
graphs of laboratory personnel, all o
from a larger set that included unfam



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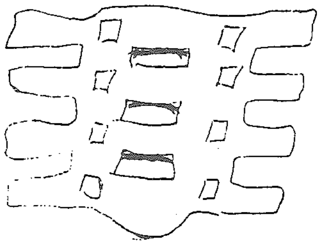

From memory with long delay

from memory.

although it is possible that he was
e out this possibility, we asked him
d, either immediately after copying
another figure. Again, his drawings
al processing and memory (see Fig.
r perception using the Farnsworth
g 15 coloured circles by their hue.
dicating normal colour perception.

ars to be intact, there was evidence
on. In this section, we present data
gnise visually presented objects.

eloped by Riddoch and Humphreys
in conjunction with good perform-
, suggests problems at higher levels

of visual processing, most likely at the level of structural descriptions or at the interface between structural descriptions and the conceptual or semantic system. In this test, subjects must decide whether line drawings represent objects or nonobjects. The nonobjects are created by combining parts of real objects (e.g. a cat's body with an elephant's head). The task consists of 60 items, 30 objects and 30 nonobjects, which are presented individually for object decision. DM made 13 errors: 6 errors were incorrect rejections of real objects and 7 were incorrect acceptances of nonobjects. Of the 13 errors, 8 were on animals. The mean error rate for 10 controls was 3.4 (range: 1–9). Although not severely impaired on this task, DM's performance was clearly below the normal range.

Colouring Objects

Earlier, we demonstrated that DM's colour perception is intact. In this task, we examined his knowledge of the colour attributes of objects. We presented DM with 28 line drawings of objects that have a specific colour (e.g. carrots are orange, elephants are grey). He saw the pictures one at a time and was given a choice of four coloured pens with which to colour in the line drawing. DM selected the correct colour for only 10 of the 28 drawings. His incorrect choices included orange for mouse, purple for rhinoceros, and grey for carrot.

Memory

DM's verbal short-term memory was normal, as indicated by his auditory digit span of seven items. Long-term memory was impaired, however, as assessed by his performance on Warrington's Recognition Memory Test (1984). DM was 66% correct for the words and 56% correct for the faces. On both, his performance was below the 5th percentile for control subjects in his age group.

Although it is difficult to assess episodic memory in isolation from semantic memory, which is impaired in DM, anecdotal evidence suggests that DM's day-to-day memory is relatively intact. Examples of DM's good episodic memory involve his ability to recall details of telephone conversations with the experimenter that occurred several weeks in the past and his frequent comments indicating that he remembers—correctly—that he has seen the same stimulus items in a task administered several hours earlier. In addition, although he performed poorly on a test that required matching famous names and faces, he had no difficulty selecting photographs of laboratory personnel, all of whom were recent acquaintances, from a larger set that included unfamiliar faces.

Semantic Knowledge

In addition to performing poorly on lexical comprehension tests, DM was impaired on several tests that were developed to identify impairments to semantic representations. The first three tests do not involve processing of words either auditorily or visually. The fourth test does not involve visual processing.

Pyramids and Palm Trees

DM was given Howard and Patterson's (1992) Pyramids and Palm Trees test, which uses pictorial stimuli to evaluate a patient's ability to access semantic representations. The patient sees a picture (e.g. a pyramid) and must select which one of two other pictures (e.g. palm tree or pine tree) is most closely related or associated. Normal subjects scored 98.5% correct on this test and none made more than 3 errors on the total of 52 items. DM obtained a score of 60% correct, indicating impaired representation of, or access to, semantic information.

Interpreting Spatial and Semantic Picture Sequences

This task evaluates a patient's ability to follow the logic of spatial and semantic picture sequences (Schwartz & Chawluk, 1990). Each trial involves a sequence of line drawings representing three stages of an event sequence. One of the three stages is indicated by a question mark. The patient's task is to select one of two pictures that best fills that stage of the picture sequence. The spatial sequences involve direction or movement. For example, the train sequence shows (1) a train entering a tunnel; (2) the train in the middle of the tunnel; (3) choice stage: (a) the train coming out of the other side of the tunnel; (b) the train coming out of the same side of the tunnel that it entered. The logic of the semantic sequences depends on specific knowledge of the relations among objects and events. For example, the cake sequence shows (1) the ingredients for a cake; (2) the cake batter in a bowl; (3) choice stage: (a) a roast; (b) a cake. Normal controls scored 91% correct on the spatial sequences (range: 67%–100%) and 98% on the semantic sequences (range: 89%–100%). Thus, controls found the spatial sequences more difficult than the semantic sequences. DM showed the opposite pattern: he was 100% correct on the spatial sequences but only 72% correct on the semantic sequences. In addition to providing further evidence of DM's semantic impairment, these results testify to the preservation of function in other domains.

Functional Similarity

This test, modelled on Warrington and James (1967), examines the ability to match common objects according to their function. The patient sees three photographs of common objects and must select the two that

are used for the same purpose. For exa
are (1) a button; (2) a zipper; and (3)
the functionally unrelated item is visu
objects (e.g. the dime and the button)
for 10 normal controls was 95% corre
DM's performance is impaired relative
errors (12/13) involved selecting the 2

Semantic Category Synonymy T

DM's performance on these tasks d
able semantic deficit. In this study, we
semantic categories by using a synon
presented with three words from the s
the one that was least related in mean
animal triplet *toad–frog–turtle*, *turtle* is
of the *tool* triplet *shears–pliers–scissor*
This task has the advantage of avoidi
retrieving names or in object recognit
motivated, in part, by reports of "
patients with semantic impairments
Warrington & McCarthy, 1987).

Materials. Triplets were develope
triplets in a category varied as a fun
category that could be used for the t
animals; body parts; clothing; countr
household appliances and gadgets; in
tions; sports; man-made structures; to
was made to use a lexical item only o
There was a total of 269 triplets, sele
to 10 age and education matched norm
than one of the control subjects was in
set. Due to the nature of the catego
quency of occurrence. Thus, for exam
tend to occur infrequently in the wri
and *occupations*. However, we exami
the natural log frequency of each c
measure of triplet frequency. By ch
tools were comparable in their mean t
triplet frequency of 1.25 (range: 0–
frequency of 1.24 (range: 0–3.19).

Procedure. The triplets were pres
word appeared in the upper left corn

n lexical comprehension tests, DM was
developed to identify impairments to
three tests do not involve processing of
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(3) choice stage: (a) the train coming
(b) the train coming out of the same
The logic of the semantic sequences
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n and James (1967), examines the
rding to their function. The patient
bjects and must select the two that

are used for the same purpose. For example, on one trial the three objects are (1) a button; (2) a zipper; and (3) a dime (small coin). On each trial, the functionally unrelated item is visually similar to one of the two other objects (e.g. the dime and the button). DM was 64% correct. The mean for 10 normal controls was 95% correct (range: 81% to 100%). Clearly, DM's performance is impaired relative to the control subjects. Most of his errors (12/13) involved selecting the 2 visually related objects.

Semantic Category Synonymy Task

DM's performance on these tasks demonstrates that he has a considerable semantic deficit. In this study, we examine his knowledge of specific semantic categories by using a synonymy judgment paradigm. DM was presented with three words from the same category and asked to indicate the one that was least related in meaning. For example, in the case of the *animal* triplet *toad–frog–turtle*, *turtle* is least related in meaning; in the case of the *tool* triplet *shears–pliers–scissors*, *pliers* is least related in meaning. This task has the advantage of avoiding any problems DM might have in retrieving names or in object recognition. The selection of categories was motivated, in part, by reports of "category-specific" deficits in other patients with semantic impairments (e.g. Warrington & Shallice, 1984; Warrington & McCarthy, 1987).

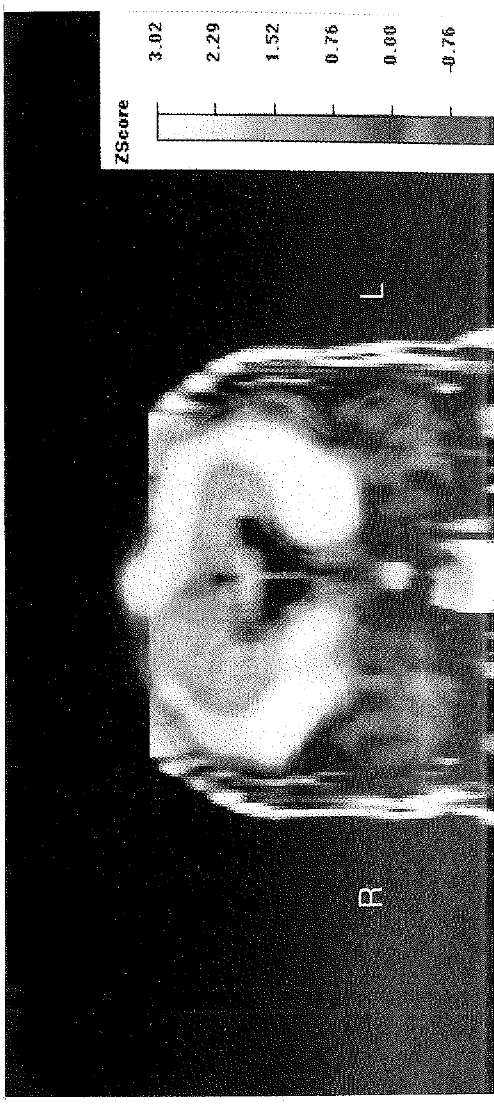
Materials. Triplets were developed from 16 categories. The number of triplets in a category varied as a function of the number of items in the category that could be used for the task. The categories were as follows: animals; body parts; clothing; countries; famous people; food; furniture; household appliances and gadgets; insects; musical instruments; occupations; sports; man-made structures; tools; vehicles; and weapons. An effort was made to use a lexical item only once, but some items were used twice. There was a total of 269 triplets, selected from a larger set of items given to 10 age and education matched normal controls. Any item on which more than one of the control subjects was incorrect was deleted from the original set. Due to the nature of the categories, they were not matched for frequency of occurrence. Thus, for example, *insects* and *musical instruments* tend to occur infrequently in the written language relative to *body parts* and *occupations*. However, we examined frequency by using the mean of the natural log frequency of each of the words within the triplet as a measure of triplet frequency. By chance, the categories of *animals* and *tools* were comparable in their mean triplet frequency. *Animals* had a mean triplet frequency of 1.25 (range: 0–2.83) and *tools* had a mean triplet frequency of 1.24 (range: 0–3.19).

Procedure. The triplets were presented on a computer screen. The first word appeared in the upper left corner of the screen; a keypress brought up the second word in the centre of the screen and another keypress brought up the third word in the lower right corner of the screen. The experimenter read each word aloud as it appeared on the screen. All three words remained on the screen until a response was made. Subjects were instructed to hit one of three keys corresponding to the position on the screen of the word that was less similar in meaning to the other two. The number "1" key was assigned to the first word to appear, the number "2" key to the second, and the number "3" key to the third. There were 10 practice trials to familiarise subjects with the procedure. For the practice trials, two of the three words that appeared on the screen were identical (e.g. good–bad–good). The test was administered in 2 45min sessions with at least 1 day between sessions. Within each session there were an equal number of triplets from each category, and triplets were randomised within each session.

Results and Discussion. DM was given the test on three separate occasions with approximately three months between each administration. DM's performance on each category and administration is presented in Table 1, along with the means and ranges for the control subjects. DM was at chance on *animals, insects*, and *musical instruments*; he also per-

TABLE 1
Number Correct for DM and Control Subjects on the Semantic Category Synonymy Task

	DM				*Controls*	
Category	*8/92*	*11/92*	*2/93*	*Mean*	*Mean*	*Range*
Animals (n = 20)	6	6	8	6.6	19.6	(18–20)
Body Parts (n = 18)	14	14	14	14.0	17.6	(17–18)
Clothing (n = 17)	9	11	9	9.6	16.3	(15–17)
Countries (n = 18)	8	11	11	10.0	17.3	(17–18)
Famous People (n = 24)	8	11	12	10.3	22.9	(21–24)
Food (n = 24)	13	9	10	10.7	23.2	(22–24)
Furniture (n = 14)	12	8	12	10.7	13.7	(13–14)
Household (n = 20)	7	11	10	9.3	19.4	(17–20)
Insects (n = 10)	3	4	3	3.3	9.8	(9–10)
Musical Instruments (n = 12)	4	5	4	4.3	11.4	(10–12)
Occupations (n = 24)	17	16	17	16.6	23.6	(22–24)
Sports (n = 12)	7	4	5	5.3	11.6	(11–12)
Structures (n = 14)	7	10	8	8.3	13.6	(12–14)
Tools (n = 21)	13	13	9	11.7	19.8	(17–21)
Vehicles (n = 14)	6	11	8	8.3	13.4	(13–14)
Weapons (n = 7)	4	4	3	3.7	6.9	(6–7)



ntre of the screen and another keypress
he lower right corner of the screen. The
oud as it appeared on the screen. All three
ntil a response was made. Subjects were
eys corresponding to the position on the
similar in meaning to the other two. The
the first word to appear, the number "2"
ber "3" key to the third. There were 10
ects with the procedure. For the practice
at appeared on the screen were identical
was administered in 2 45min sessions with
Within each session there were an equal
gory, and triplets were randomised within

M was given the test on three separate
ree months between each administration.
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and ranges for the control subjects. DM
ts, and *musical instruments*; he also per-

TABLE 1
M and Control Subjects on the
tegory Synonymy Task

DM		*Controls*	
2/93	*Mean*	*Mean*	*Range*
8	6.6	19.6	(18–20)
14	14.0	17.6	(17–18)
9	9.6	16.3	(15–17)
11	10.0	17.3	(17–18)
12	10.3	22.9	(21–24)
10	10.7	23.2	(22–24)
12	10.7	13.7	(13–14)
10	9.3	19.4	(17–20)
3	3.3	9.8	(9–10)
4	4.3	11.4	(10–12)
17	16.6	23.6	(22–24)
5	5.3	11.6	(11–12)
8	8.3	13.6	(12–14)
9	11.7	19.8	(17–21)
8	8.3	13.4	(13–14)
3	3.7	6.9	(6–7)

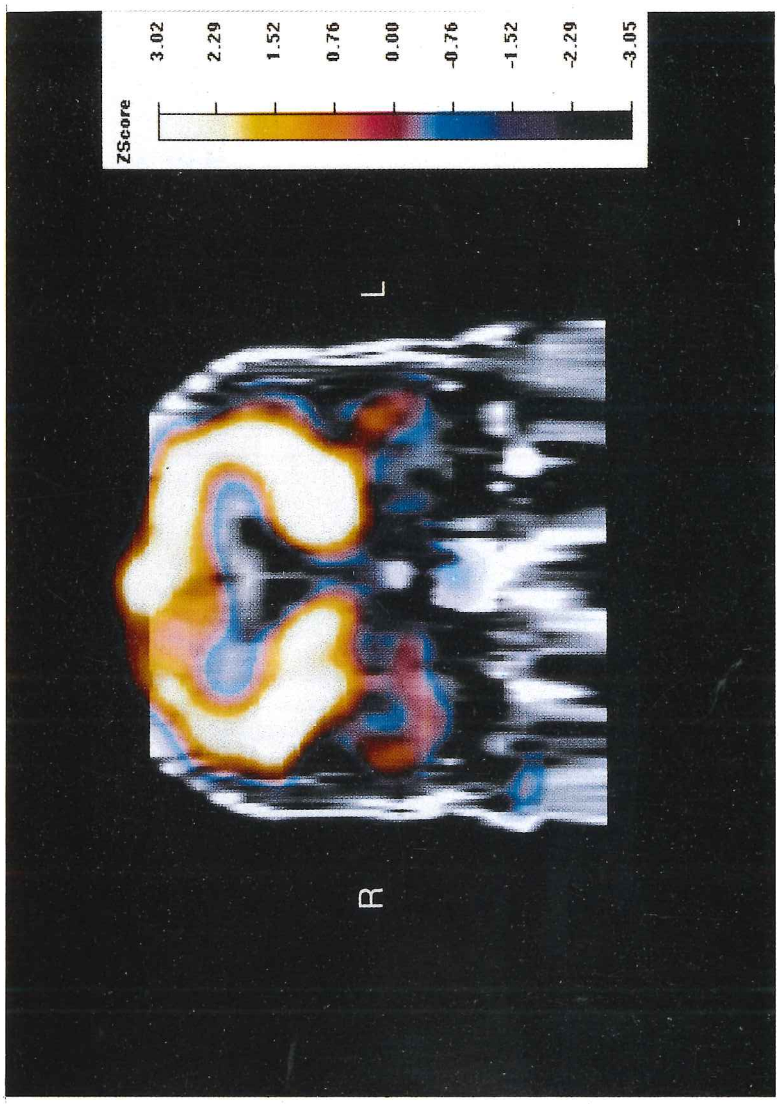

PLATE 1 A coronal section of the co-registered MRI and SPECT images at a distance of 25mm from the temporal tip demonstrating decreased blood flow (more precisely, mean intensity scores) for the inferior temporal gyri, especially on the left.

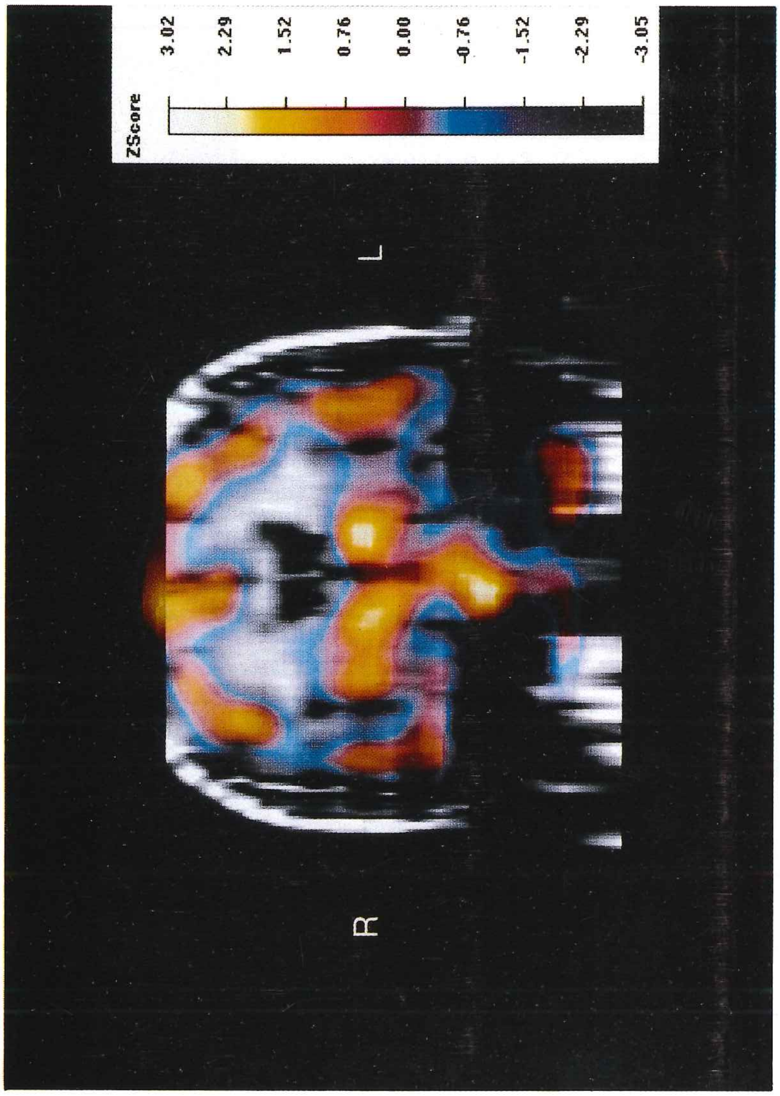

PLATE 2 A coronal section of the co-registered MRI and SPECT images at a distance of 45mm from the temporal tip, again demonstrating decreased blood flow (more precisely, mean intensity scores) for the inferior temporal gyri, especially on the left.

formed quite poorly on *famous peopl*
he showed relatively preserved know
occupations. To examine the consiste
vidual items across the three administr
number of items on which DM respon
or incorrect three times) with the num
chance. DM's performance was more
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$\chi^2[1] = 2.67, P < 0.2$). These results i
ance was at chance on *animals*, *insects*
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correct on one set of triplets and inco

Because DM's performance is subje
the role of frequency in this test by
each triplet's mean log frequency and
responded to the triplet (scores range
correlated with frequency ($r = 0.38,$

Clearly, frequency is a factor in D
only factor. The categories of *animals*
and DM showed a significant effect
$P < 0.03$) but not for *tools* ($r = 0$
performance was significantly worse f
of the three administrations of the t
$\chi^2[1] = 4.19$, $P < 0.04$; T_3: $\chi^2[1] =$
performance with *tools* than *animals*,
tions reported in some patients with s
Schwartz, 1994, for review).

Summary

The results of neuropsychological test
mild dementia with disproportionate
pattern of performance conforms t
"semantic dementia" (Hodges, Pat
Hodges, Patterson, & Tyler, 1994; S
The patients described under this label
ments characterised by fluent speech
comprehension, and surface dyslex
appeared to be preserved, as did their
Episodic memory was also relativel
tested. All of the patients were fou
particularly on the left. Earlier repo
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three cases described by Warrington (

PLATE 2 A coronal section of the co-registered MRI and SPECT images at a distance of 45mm from the temporal tip, again demonstrating decreased blood flow (more precisely, mean intensity scores) for the inferior temporal gyri, especially on the left.

formed quite poorly on *famous people, sports*, and *food*. In comparison, he showed relatively preserved knowledge of *body parts, furniture*, and *occupations*. To examine the consistency of DM's performance on individual items across the three administrations of the test, we compared the number of items on which DM responded consistently (correct three times or incorrect three times) with the number of consistent items expected by chance. DM's performance was more consistent than the chance estimates for all of the categories except two (food: $\chi^2[1] = 3.56$, $P < 0.1$; weapons: $\chi^2[1] = 2.67$, $P < 0.2$). These results indicate that although DM's performance was at chance on *animals*, *insects*, and *musical instruments*, it was not random. Across the three administrations of the test, he tended to be correct on one set of triplets and incorrect on another.

Because DM's performance is subject to frequency effects, we examined the role of frequency in this test by calculating the correlation between each triplet's mean log frequency and the number of times DM correctly responded to the triplet (scores ranged from 0 to 3). DM's performance correlated with frequency ($r = 0.38$, $P < 0.0001$).

Clearly, frequency is a factor in DM's semantic loss, but it is not the only factor. The categories of *animals* and *tools* are matched in frequency, and DM showed a significant effect of frequency for *animals* ($r = 0.49$, $P < 0.03$) but not for *tools* ($r = 0.2$, $P < 0.38$). In addition, DM's performance was significantly worse for *animals* than *tools* on the first two of the three administrations of the test (T_1: $\chi^2[1] = 4.19$, $P < 0.04$; T_2: $\chi^2[1] = 4.19$, $P < 0.04$; T_3: $\chi^2[1] = 0.03$, $P < 0.85$). This result, better performance with *tools* than *animals*, recalls the living–nonliving dissociations reported in some patients with semantic impairments (see Saffran & Schwartz, 1994, for review).

Summary

The results of neuropsychological testing indicate that DM has a relatively mild dementia with disproportionate loss of semantic knowledge. DM's pattern of performance conforms to the profile recently identified as "semantic dementia" (Hodges, Patterson, Oxbury, & Funnell, 1992; Hodges, Patterson, & Tyler, 1994; Snowden, Goulding, & Neary, 1989). The patients described under this label all had progressive language impairments characterised by fluent speech with severe anomia, poor single word comprehension, and surface dyslexia. In contrast, syntactic abilities appeared to be preserved, as did their perceptual and visuo-spatial abilities. Episodic memory was also relatively preserved, insofar as it could be tested. All of the patients were found to have temporal lobe atrophy, particularly on the left. Earlier reports of similar cases include those of Warrington (1975) and Schwartz, Marin, and Saffran (1979). One of the three cases described by Warrington (1975) is the patient AB, cited earlier as one of the rare instances in which brain damage produced reversal rather than magnification of the concreteness effect. Although this pattern has not been reported in other cases of semantic dementia, it should also be said that there is no indication that investigators other than Warrington have looked for it. The pattern was, however, demonstrable in DM, as will be seen in the next section.

EVIDENCE OF A REVERSE CONCRETENESS EFFECT

Defining Abstract and Concrete Words

As was noted in the Introduction, most of the evidence for reversal of the concreteness effect in the neuropsychological literature has come from word definition tasks in which patients have performed better on abstract words than concrete ones. We began our investigation of DM's knowledge of abstract and concrete words by asking him to provide definitions for a list of words that varied in concreteness and frequency.

Method

Materials. We asked DM to provide definitions for a list of 386 words used by Warrington (1981), which controlled for concreteness and frequency (high-frequency abstract, n = 98; high-frequency concrete, n = 88; low-frequency abstract, n = 94; low-frequency concrete, n = 106). High-frequency items were AA and A words in the Brown and Ure (1969) list and low-frequency words had frequencies between 1 and 50. Words were defined as high or low in concreteness based on ratings from Brown and Ure.

Procedure. The words were randomised and read aloud to DM one at a time. He was instructed to define each word. Responses were recorded on audio tape. Five testing sessions which spanned two months were required to complete the list.

Results

DM's definitions were transcribed from tape and edited for rating. Tentative wording was removed (e.g. *bully* was defined as "acting like an animal I guess" and the "I guess" was deleted from the transcription) and items that DM was unable to define were not included for rating. Of the 386 words, DM failed to provide definitions for 22.[4] All but one of these

[4] In Warrington's (1981) high-frequency abstract list, there were five colour terms. We removed these items from the list because colour terms require concrete definitions (e.g. to define the word *green*, people typically provide a concrete example like "green is the colour of grass").

items were low frequency; 11 were abstr
tions were rated by four Temple Univ
students, each of whom saw the definit
The raters, who were given no informat
tions or the design of the word list, were
on a scale of 1 (bad) to 7 (good). The
calculated. Words that were given a mea
as incorrect.[5] DM's performance is sum
at defining high-frequency words than lo
$P < 0.0001$). He also showed a reverse
better at defining abstract words tha
$P < 0.01$). When DM's definitions wer
frequency and concreteness, there w
frequency abstract and concrete words (χ
however, a significant difference for l
$P < 0.01$). Note that an effect of word f
ance on all tests, indicating that low-fre
to his semantic impairment. Thus, it
concreteness effect is limited to low-freq
there is no indication of the normal
frequency words in DM's performance.
DM's definitions of concrete words
ceptual descriptions. We counted the
by DM, and found only 13 in the 194 d

TABLE
Number and Proportion of DM's Abstrac
Mean Rating of

	High	
Words	*Number*	*Proportion*
Abstract	69/93	0.74
Concrete	61/88	0.70

[5] We selected a rating of 5 as a cut-off point
to 7, it would be a fairly conservative measure.
we examined the frequency distribution. Appro
mean ratings of 5 or above and half were give
abstract and concrete word definitions would als
4 or 6. There were not enough observations to u

[6] Perceptual terms were defined as words that
one of the five senses.

h brain damage produced reversal rather eness effect. Although this pattern has of semantic dementia, it should also be at investigators other than Warrington vas, however, demonstrable in DM, as

/ERSE CONCRETENESS FFECT

te Words

nost of the evidence for reversal of the ychological literature has come from nts have performed better on abstract n our investigation of DM's knowledge sking him to provide definitions for a ness and frequency.

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act list, there were five colour terms. We terms require concrete definitions (e.g. to concrete example like "green is the colour

items were low frequency; 11 were abstract and 11 concrete. DM's definitions were rated by four Temple University speech pathology graduate students, each of whom saw the definitions in a different random order. The raters, who were given no information about the source of the definitions or the design of the word list, were instructed to rate each definition on a scale of 1 (bad) to 7 (good). The mean rating for each word was calculated. Words that were given a mean rating of less than 5 were treated as incorrect.[5] DM's performance is summarised in Table 2. He was better at defining high-frequency words than low-frequency words ($\chi^2[1] = 50.20$, $P < 0.0001$). He also showed a reverse concreteness effect, that is, he was better at defining abstract words than concrete words ($\chi^2[1] = 6.41$, $P < 0.01$). When DM's definitions were examined with respect to both frequency and concreteness, there was no difference between high-frequency abstract and concrete words ($\chi^2[1] = 0.32$, $P < 0.57$); there was, however, a significant difference for low-frequency items ($\chi^2[1] = 6.53$, $P < 0.01$). Note that an effect of word frequency pervades DM's performance on all tests, indicating that low-frequency words are more vulnerable to his semantic impairment. Thus, it is not surprising that the reverse concreteness effect is limited to low-frequency words. Note, however, that there is no indication of the normal concreteness advantage for high-frequency words in DM's performance.

DM's definitions of concrete words were notable for the lack of perceptual descriptions. We counted the number of perceptual terms[6] used by DM, and found only 13 in the 194 definitions that he generated. Three

TABLE 2
Number and Proportion of DM's Abstract–Concrete Word Definitions with a Mean Rating of 5 or Higher

	Frequency			
	High		*Low*	
Words	*Number*	*Proportion*	*Number*	*Proportion*
Abstract	69/93	0.74	42/94	0.45
Concrete	61/88	0.70	28/106	0.26

[5]We selected a rating of 5 as a cut-off point because we thought that on a scale from 1 to 7, it would be a fairly conservative measure. At the request of an anonymous reviewer, we examined the frequency distribution. Approximately half of the definitions were given mean ratings of 5 or above and half were given ratings below 5. The difference between abstract and concrete word definitions would also be significant if the cut-off point had been 4 or 6. There were not enough observations to use a cut-off of 7.

[6]Perceptual terms were defined as words that refer to a quality that is experienced through one of the five senses.

of the terms were used inappropriately (e.g. describing an eagle as having a long nose). Thus, in the three examples that follow, DM does not describe the appearance of a *ram*, the fluidity or colour of *ink*, or the shape or colour of a *carrot* (see Appendix D for additional examples of DM's definitions).

> ram—a little animal
> ink—something that covers
> carrot—having a concern or interest in . . . I'm thinking about caring (E—Okay, it wasn't caring but carrot) oh carrot, a carrot is something you eat . . . it's some kind of food you could eat

Note that DM incorrectly produced the definition of a phonologically related word rather than the word which was presented; this occurred on 10 trials, 3 times with concrete targets and 7 times with abstract targets. Warrington and Shallice's (1984) patient SBY also had a tendency to make phonological errors on the definition task. In contrast to his concrete word definitions, DM's definitions for abstract words tended to be complete and to the point.

> try—try is to endeavour to accomplish something
> opinion—your concept or perspective
> measurement—something to evaluate the size of something, whether it's big or small in size

Abstract–Concrete Comprehension

In the previous section, we examined DM's ability to define words as an index of his knowledge of word meanings. However, since DM is very impaired at naming, his difficulty in defining words could be due to a general lexical retrieval problem rather than a semantic impairment per se. In this section, we investigated DM's comprehension of abstract and concrete words on two tasks that did not require a verbal response.

Concrete/Abstract Word/Picture Matching

As a further test of DM's knowledge of concrete and abstract words, he was given the Shallice and McGill Concrete/Abstract Picture/Word Matching Test (reported in Warrington, 1981, and Warrington & Shallice, 1984). This test requires the subject to match a word, presented visually or auditorily, to one of four pictures. The test consists of 30 abstract words, 30 concrete words, and 15 emotion words. DM's performance and that of 5 controls from the United States and 20 British controls (tested by McGill and Shallice) are summarised in Table 3. (We tested local controls because

TABLE 3
Number Correct on Shallice and McGill Abstract/Concrete Word/Picture Matching Test

		US Controls (n = 5)		
	DM	*Mean*	*Range*	*British Controls (n = 20)*
Concrete (n = 30)	11	29	(28–30)	29.5
Abstract (n = 30)	16	27	(26–28)	26.0
Emotion (n = 15)	4	14	(13–15)	13.0

some of the words on the test are either less common in the United States [e.g. moor] or have a slightly different connotation.)

DM's performance was impaired on all three word types. He was worse on the concrete and emotion sets than on the abstract set but this difference was not significant for either the concrete ($\chi^2[1] = 1.68$, $P < 0.2$) or emotion (Fisher Exact Probability, $P < 0.12$)[7] sets. Nevertheless, his performance is striking for two reasons: first, because it is opposite to the pattern shown by the control subjects for both concrete and emotion words;[8] second, because the pictorial materials for the abstract set seem more difficult in that they require one to make a number of inferences. For example, the correct picture for the concrete word *lemonade* is a picture of a filled glass with ice; in contrast, the picture for the abstract word *disparity* shows two gloves of disparate sizes.

The difference in performance on abstract and emotion words may seem surprising. However, Paivio, Yuille, and Madigan (1968) found that although emotion words were rated as abstract they were also rated as high in imageability. Since the Paivio et al. corpus does not include all of the words on this test, imageability ratings are not available for the entire set. For the items that do appear, the abstract words (n = 22) had a mean concreteness rating of 2.28, where 1 is abstract and 7 concrete, and a mean imageability rating of 2.59, where 1 is difficult to image and 7 is easy to image. The emotion words (n = 7) had a mean concreteness rating of 2.06 and a mean imageability rating of 3.98. Thus, for the stimuli that had been rated, the emotion words were judged to be more imageable than the abstract words.

It should be noted, however, that these materials are not controlled for word frequency. The abstract words are the most frequent (mean

[7]The Fisher Exact Probability is used when n < 20, as recommended by Siegel and Castellan (1988).

[8]The individual data for each of the US controls was examined. All of the subjects performed better with concrete words than abstract words and all either showed no difference between the emotion and abstract words or did better with the emotion words.

frequency = 29.97) followed by the emotion words (mean frequency = 10.39) and then the concrete words (mean frequency = 3.67). Frequencies were obtained from Francis and Kuçera (1982). In view of the evidence for frequency effects on other tests of DM's word knowledge, it is possible that the abstract–concrete difference on this test is due to the higher frequency of the abstract stimuli. However, this would not account for better performance on concrete words than emotion words.

Abstract–Concrete Synonymy Task

In this task, we avoided any problems that DM might have in object recognition or picture interpretation by using a purely verbal paradigm to test his knowledge of abstract and concrete words. DM was presented with three related words (all abstract or all concrete) and was asked to indicate the one that was least related in meaning. For example, in the case of the abstract triplet *loyalty–obsession–allegiance*, *obsession* is least related in meaning; in the case of the concrete triplet *stream–brook–puddle*, *puddle* is less similar than the other two. On this test, an attempt was made to control for word frequency.

Materials. A set of 52 synonymy triplets, half consisting of abstract nouns and half of concrete nouns, was created by selecting triplets from lists previously developed by others.[9] These earlier sets, which had been given to control subjects who were 90–100% correct on the concrete triplets and 86–100% correct on the abstract triplets, were not controlled for frequency. In an attempt to match the frequency of the abstract and concrete sets, we used the mean of the natural log frequency of the three words within the triplet as a measure of its frequency and selected matched pairs of abstract and concrete triplets accordingly. Word frequencies were taken from Francis and Kuçera (1982). The mean triplet frequency for the abstract set was 3.18 (range: 1.5–4.9) and for the concrete set the mean was 3.20 (range: 1.6–4.9).

Concreteness ratings were not available for all 156 of the nouns used. The words within a triplet were selected using the criterion that concrete words should be easily picturable and that abstract items should not be. Examination of the concreteness ratings for words that appear in the Paivio et al. (1968) corpus indicate that this was a good strategy. The concrete items for which there were ratings ranged between 5.83 and 7, where a rating of 1 was abstract and 7 concrete. The ratings for abstract items ranged from 1.39 to 3.48, with the exception of 4 outliers with ratings that ranged from 4.12 to 6.41.

[9]We would like to thank Nadine Martin and Rita Berndt for making their lists of synonymy triplets available to us.

Procedure. DM was shown three wor
menter pointed to each word while reac
was instructed to point to the word that

Results. DM was significantly worse
of 26 correct) than the abstract word tripl
$P < 0.03$). Again, note that DM is show
control subjects, who are slightly worse

Auditory Lexical Decision Test

Several researchers have reported faster
words than abstract words in normal
Merves, 1986). In view of DM's superi
tasks, we wished to determine whether tl
decision. Because DM has difficulty re
rather than the visual task that is more

Method

Stimuli. Of the 360 stimuli, half we
words were selected from a corpus devel
in which abstract and concrete words
quency. The frequencies of the 90 high-f
15/million and those of the 90 low-frec
(Kuçera & Francis, 1967). Kroll and Me
from subjects on a scale from 1 (highly
Half of the words were rated as abstrac
as concrete (rating > 4). These materia
lexical decision test. Because visual and
equivalent, we created new nonwords.
developed by altering the initial, media
phonetic features. One-third were crea
locations in the word (beginning, mi
digitised (MacRecorder) by a male spea
a 22,000Hz sampling rate.

Procedure. Stimuli were presented
78dB through a loudspeaker (Realistic,
computer. Subjects were told that they
one at a time. Their task was to decid
was a word or not and to signal t
("1" = word; "2" = nonword). Reacti
puter with 1msec accuracy.

Procedure. DM was shown three words printed on a page. The experimenter pointed to each word while reading it aloud to the patient. DM was instructed to point to the word that was least similar in meaning.

Results. DM was significantly worse on the concrete word triplets (15 of 26 correct) than the abstract word triplets (22 of 26 correct; $\chi^2[1] = 4.59$, $P < 0.03$). Again, note that DM is showing the opposite pattern from the control subjects, who are slightly worse on the abstract triplets.

Auditory Lexical Decision Test

Several researchers have reported faster lexical decision times to concrete words than abstract words in normal subjects (James, 1975; Kroll & Merves, 1986). In view of DM's superiority for abstract words on other tasks, we wished to determine whether this pattern would extend to lexical decision. Because DM has difficulty reading we used an auditory task rather than the visual task that is more commonly used for this purpose.

Method

Stimuli. Of the 360 stimuli, half were words and half nonwords. The words were selected from a corpus developed by Kroll and Merves (1986), in which abstract and concrete words were matched for length and frequency. The frequencies of the 90 high-frequency words were greater than 15/million and those of the 90 low-frequency words less than 15/million (Kuçera & Francis, 1967). Kroll and Merves collected concreteness ratings from subjects on a scale from 1 (highly abstract) to 7 (highly concrete). Half of the words were rated as abstract (rating < 4) and half were rated as concrete (rating > 4). These materials had been developed for a visual lexical decision test. Because visual and auditory similarity are not always equivalent, we created new nonwords. Two-thirds of the nonwords were developed by altering the initial, medial, or final phoneme by one or two phonetic features. One-third were created by changing phonemes at two locations in the word (beginning, middle, or end). The stimuli were digitised (MacRecorder) by a male speaker onto a Macintosh computer at a 22,000Hz sampling rate.

Procedure. Stimuli were presented in the soundfield at approximately 78dB through a loudspeaker (Realistic, 13-1190) connected to a Macintosh computer. Subjects were told that they would be hearing items presented one at a time. Their task was to decide as quickly as possible if the item was a word or not and to signal their response by pressing a key ("1" = word; "2" = nonword). Reaction times were recorded by the computer with 1msec accuracy.

Control Subjects. Ten individuals matched to DM in age served as controls.

Results and Discussion

Accuracy data for DM and the control subjects are presented in Table 4. The control subjects were more accurate on concrete words than abstract words ($t[10] = 3.15$, $P < 0.01$), and more accurate on high-frequency words than low-frequency words ($t[10] = 3.24$, $P < 0.01$). In general, DM's performance is remarkably good. The difference in DM's performance between abstract and concrete words was not statistically significant ($\chi^2[1] = 1.86$, $P < 0.17$) nor was the difference between high- and low-frequency words ($\chi^2[1] = 1.86$, $P < 0.17$). His performance was within the range of the control subjects for nonwords and for all of the words except for low-frequency abstract words. This result is somewhat surprising, given DM's superior performance with abstract words on other tests. However, we should note that lexical decision does not require access to the same amount of information about words as the earlier tests. For example, since DM knows that a *ram* is an animal, he also knows that it is a word. However, he is not able to provide any other semantic information about *rams*. DM appears to have adopted a strict criterion for accepting an item as a word, as evidenced by his better performance on nonwords than words.

Reaction times in milliseconds for correct responses are presented in Table 5. To adjust for outliers, reaction times that were less than 0msec or greater than 4000msec were replaced with missing values. Then the mean and standard deviation was calculated for each cell and reaction times that were ±3sd from the mean for a given cell were replaced with the mean reaction time for that cell. Four percent of the control data were treated as outliers and three percent of DM's data were treated as outliers. DM's reaction times were always within the range of the control subjects and often faster than the mean. In general, DM's reaction times followed

TABLE 4
Percent Correct on Auditory Lexical Decision for DM and Mean (Range) for Controls

	Abstract		*Concrete*	
Words	*DM*	*Controls (n = 10)*	*DM*	*Controls (n = 10)*
Frequency				
High	84	91 (84–100)	89	94 (89–98)
Low	71	85 (78–91)	84	90 (84–98)
Nonwords				
High	93	93 (80–98)	98	93 (78–100)
Low	96	90 (80–96)	91	96 (91–100)

TABLE 5
Mean Reaction Time on Auditory Lexical Decision for DM and Mean (Range) for Controls

	Abstract		Concrete	
Words	*DM*	*Controls (n = 10)*	*DM*	*Controls (n = 10)*
Frequency				
High	339	392 (265–555)	376	396 (292–584)
Low	469	469 (312–629)	489	459 (291–692)
Nonwords				
High	417	583 (426–851)	565	586 (414–861)
Low	474	608 (390–923)	464	580 (356–815)

the same patterns as the controls. The control subjects were significantly faster ($F[1,9] = 24.85$, $P < 0.0008$) at accepting words (429msec) than rejecting nonwords (598msec). DM showed the same pattern (words = 415msec; nonwords = 481msec; $t[1] = 2.41$, $P < 0.02$). The controls also showed a frequency effect ($F[1,9] = 14.79$, $P < 0.004$), responding faster to high-frequency items (489msec) than to low-frequency items (529msec). DM was also faster to respond to high-frequency (429msec) than low-frequency (474msec) items, although the difference was not significant [$t[1] = 1.65$, $P < 0.1$). The controls showed a marginally significant main effect of abstractness ($F[1,9] = 4.81$, $P < 0.06$), with faster responses to concrete (505msec) than abstract (513msec) items. In this case, DM showed the opposite pattern from the controls, responding more slowly to concrete items (475msec) than abstract items (424msec; $t[1] = 1.89$, $P < 0.06$).[10] However, when we looked at the effect of abstractness for items separately for words and nonwords, the controls did not show a significant effect for words ($F[1,9] = 0.07$, $P < 0.79$) or nonwords ($F[1,9] = 1.34$, $P < 0.28$). DM responded 33msec faster to abstract words than concrete words, but this difference failed to reach significance ($t[1] = -0.86$, $P < 0.39$). DM responded 71msec faster to nonwords that were derived from abstract words than nonwords that were derived from concrete words ($t[1] = -1.86$, $P < 0.06$).

Interpretation of DM's reaction time data is difficult. On the one hand, indications of faster response times to abstract words could reflect a semantic influence in lexical decision. Conceivably, the integrity of the

[10] Although DM shows only a marginally significant reverse concreteness effect, we should note that we examined each of the 10 control subjects' data and none of them showed a significant concreteness or reverse concreteness effect. In addition, 7 of the subjects were faster at responding to the concrete items, the other 3 were slightly faster at responding to abstract items, but the mean difference in reaction time was never more than 4msec compared to the 51msec difference that DM showed.

lexicon is dependent upon regular interaction with an intact semantic system, an argument that has been made by Chertkow, Bub, and Seidenberg (1989) for visual word recognition, and by Patterson and Hodges (1992) for word pronunciation. On the other hand, the differences he shows between concrete and abstract items may be due to speed–accuracy trade-offs; note that his error rates were higher for abstract words. We are therefore reluctant to draw strong conclusions from these data. It is noteworthy, however, that lexical decision performance was not severely disrupted, given the extent of the semantic impairment in DM.

Verb–Noun Synonymy Task

Most of the research on semantic memory loss has focused on the semantics of nouns, with relatively little investigation of possible damage to other word classes. As DM shows a difference in his knowledge of abstract and concrete words, and because one dimension along which nouns and verbs differ is concreteness—verbs are rated as less concrete than nouns (Paivio, 1971)—we compared DM's knowledge of verb and noun concepts. DM was presented with three words (all nouns or all verbs) and was asked to indicate the word that was least related in meaning. For example, in the case of the verb triplet *to allow–to encourage–to permit*, *to encourage* is less related. Similarly, in the noun triplet *automobile–train–car*, *train* is less similar.

Method

Materials. Again the list was developed by selecting items that were matched in frequency from two sets of noun and verb triplets. The first set, taken from the Philadelphia Comprehension Battery (Saffran et al., 1989), contains 15 noun triplets and 15 verb triplets. The second set, assembled by Rita Berndt, contains 24 noun triplets and 24 verb triplets. The resulting lists contained 16 verb triplets with a mean triplet frequency of 3.12 (range: 2.2–5.0) and 16 noun triplets with a mean triplet frequency of 3.14 (range: 2.1–4.9).

Procedure. The procedure was the same as for the abstract–concrete synonymy task. The words were presented visually while the experimenter also read them aloud.

Results

DM identified the less related verb significantly more often (15 of 16) than the less related noun (10 of 16; Fisher Exact Probability one-tailed, $P < 0.04$). Normal control subjects were at ceiling on this test. These results are initially surprising, given that DM showed no difference

between nouns and verbs in naming. Ho
explanations for the differences in perfo
given the severity of DM's naming imp
sensitive measure of category differences
visual object recognition. In depicting a
are often very important for identifying
verb *to shoot*, one must identify the obje
the action is shooting). This argumen
performance at naming to definitions tha
ically significant, DM's performance on
favoured verbs over nouns. Finally, we s
in the synonymy task are more abstract a
naming task (e.g. *to allow–to encourag*
boast).

Summary of Evidence of a Revers
Effect

We have presented data demonstrating t
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DISCUSSION OF REVERS
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DM's performance across a range of
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these concepts are represented. Earlier
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superiority of the latter. We now turn
proposals can accommodate evidence f
effect as well.

The Dual Coding Theory attributes
to the additional nonverbal (imaginal) e

between nouns and verbs in naming. However, there are several possible explanations for the differences in performance on the two tasks. First, given the severity of DM's naming impairment, naming may not be a sensitive measure of category differences. Second, DM has difficulty with visual object recognition. In depicting actions, the objects in the picture are often very important for identifying the verb (e.g. in the case of the verb *to shoot*, one must identify the object as a gun in order to know that the action is shooting). This argument is supported by DM's better performance at naming to definitions than to pictures; although not statistically significant, DM's performance on noun–verb naming to definitions favoured verbs over nouns. Finally, we should note that some of the verbs in the synonymy task are more abstract and could not be tested in a picture naming task (e.g. *to allow–to encourage–to permit*; *to brag–to flatter–to boast*).

Summary of Evidence of a Reverse Concreteness Effect

We have presented data demonstrating that DM shows a reverse concreteness effect across a range of tasks. Like earlier cases (Warrington, 1975; 1981; Warrington & Shallice, 1984; Sirigu et al., 1991), DM is better at defining abstract words relative to concrete words and is better at matching abstract words to pictures than concrete words. In addition, DM showed the same pattern of performance for synonymy judgment tasks involving abstract and concrete words and verbs and nouns. Finally, DM's performance on auditory lexical decision appears remarkably normal in spite of his semantic deficits.

DISCUSSION OF REVERSE CONCRETENESS EFFECT

DM's performance across a range of tasks substantiates Warrington's (1975; 1981; Warrington & Shallice, 1984) reports of an unusual impairment pattern: A semantic disturbance characterised by the relative preservation of abstract compared with concrete concepts. This dissociation, together with the more commonly observed advantage for concrete words, argues compellingly for fundamental differences in the manner in which these concepts are represented. Earlier, we discussed several distinctions between abstract and concrete words put forth as explanations for the usual superiority of the latter. We now turn to the question of whether these proposals can accommodate evidence for the reversal of the concreteness effect as well.

The Dual Coding Theory attributes the superiority of concrete words to the additional nonverbal (imaginal) encoding opportunities provided by sensorimotor information. Loss of the nonverbal code should leave only verbal representations, rendering the semantic structures for abstract and concrete words essentially equivalent. The reversal of the concreteness effect demonstrated by DM is not predicted by this model, at least not without further elaboration.

The Context Availability Hypothesis offers two alternative accounts of the concreteness effect. The first is that concrete word meanings are more familiar than abstract word meanings. It is difficult, if not impossible, to explain why more familiar meanings would be more vulnerable than less familiar meanings. The second is similar to the Dual Coding Theory in that it invokes additional perceptual components for the representations of concrete words, and encounters the same difficulty. As the theory presently stands, there is no reason to expect better performance on abstract words when these additional components are compromised.

The Differential Number of Semantic Features Hypothesis proposes that concrete words have more semantic features than abstract words. Why damage to the word processing system would result in better performance on items which have fewer semantic features is not intuitively obvious. However, as was noted earlier, Plaut and Shallice (1993) showed that lesioning a particular component of their model would result in reversal of the concreteness effect. First, we should note that their simulation involves the concreteness effect in reading. It remains to be determined whether their model would generalise to other language tasks that depend on semantic representations. But perhaps of greater importance is their assumption that the difference between abstract and concrete words is simply one of numerical advantage, i.e., more semantic features for the latter. The empirical support for this assumption—Jones' (1985) ease-of-predication data—is modest, and the interpretation in terms of additional semantic features may be incorrect; an alternative possibility is that imageability facilitates predication. But even if we accept the premise that concrete words have richer representations, there are other reasons to take issue with the Plaut and Shallice account. A major one is that their model ignores fundamental distinctions between abstract and concrete words that must be recognised in any psychologically adequate theory of semantic representation. The most obvious is the difference with respect to perceptual properties, which are essential to the definitions of concrete terms but not abstract ones. This distinction is acknowledged in the Dual Coding and Context Availability theories. Where these accounts fall short is in their failure to assign a more central role to these attributes; removing features that provide only a numerical advantage will not produce a reversal of the concreteness effect.

In order to account for the reversals observed in DM and the patients studied by Warrington, it is necessary to assume that perceptual (or, more broadly, sensorimotor) attributes are of particular importance in the

representations of concrete concepts, and
of word meaning is a core feature of thei
review other neuropsychological evidence
well as theoretical frameworks that are co
For the present, let us consider this formu
DM.

There are some indications in the data
DM may have sustained greater loss of
aspects of word meaning. As was noted
notable for their lack of perceptual descri
matching task, he performed better with a
words, which are rated as more imagea
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on living things than non-living things.
(Warrington & Shallice, 1984; Warring
pointed out that living things are often d
properties (compare lion and tiger, for e
likely to have more significant functional
(consider the varied appearance of objec
authors have suggested that the loss of pe
underlies so-called "category-specific" dis
proportionately impaired on animals and
supported in a study by Farah and McClel
normal subjects to identify perceptual
dictionary definitions of biological and
perceptual to functional features was much
things. In the next section, we explore th
components of word representation predi

EVIDENCE FOR DAMAGE ASPECTS OF REPRE

Living–Non-living Attribute Test

Having found some evidence for catego
dicted by a loss of perceptual features (e.
animals and tools), we addressed the q
DM's knowledge of perceptual and non-p
non-living things.

Method

Materials. We selected 39 living (e.g
(e.g. anchor, vase) items that were matc
(in Italian) taken from a list developed by

representations of concrete concepts, and that disruption of these facets of word meaning is a core feature of their semantic impairment. We will review other neuropsychological evidence that bears on this point later, as well as theoretical frameworks that are consistent with these assumptions. For the present, let us consider this formulation in relation to our patient, DM.

There are some indications in the data we have presented thus far that DM may have sustained greater loss of perceptual than non-perceptual aspects of word meaning. As was noted earlier, DM's definitions were notable for their lack of perceptual descriptors. Also, on the word/picture matching task, he performed better with abstract as compared to emotion words, which are rated as more imageable than other abstract words. Finally, on the semantic category synonymy task, DM was more impaired on living things than non-living things. Warrington and her colleagues (Warrington & Shallice, 1984; Warrington & McCarthy, 1987) have pointed out that living things are often distinguished by their perceptual properties (compare lion and tiger, for example), whereas artefacts are likely to have more significant functional components to their descriptions (consider the varied appearance of objects that qualify as radios). These authors have suggested that the loss of perceptual components of meaning underlies so-called "category-specific" disorders, in which patients are disproportionately impaired on animals and other living things. This view was supported in a study by Farah and McClelland (1991), in which they asked normal subjects to identify perceptual and functional descriptors in dictionary definitions of biological and man-made objects. The ratio of perceptual to functional features was much higher for living than non-living things. In the next section, we explore the extent to which the perceptual components of word representation predict DM's performance.

EVIDENCE FOR DAMAGE TO PERCEPTUAL ASPECTS OF REPRESENTATION

Living–Non-living Attribute Test

Having found some evidence for category differences that would be predicted by a loss of perceptual features (e.g. significant difference between animals and tools), we addressed the question more directly by testing DM's knowledge of perceptual and non-perceptual attributes of living and non-living things.

Method

Materials. We selected 39 living (e.g. pear, ostrich) and 39 non-living (e.g. anchor, vase) items that were matched for frequency and familiarity (in Italian) taken from a list developed by Sartori, Miozzo, and Job (1993).

We then selected 17 attributes, ascertained through other tests, that DM understood. For example, we knew that DM understood the attributes of *hard*, *soft*, *safe*, *dangerous*, because he either provided correct definitions for these words, or was able to match words to pictures correctly. For each of the 78 living and non-living words, we developed two yes/no questions, one "yes," one "no," each using one attribute. For example, the two questions developed for *whale* were: "Does a whale live in the water?" and "Does a whale have four legs?"

Procedure. DM was told that he would be asked a series of questions and should respond either "yes" or "no." Items were presented in two sessions, such that he was only queried on a given word once per session. In each session, half the probes were affirmative and half negative. Within a session, items were presented in a random order.

Results

DM was slightly better at answering questions about living things (63 of 78) than non-living things (56 of 78). However, this difference was not significant ($\chi^2[1] = 1.28$, $P < 0.26$). Because we were interested in the role of perceptual features in DM's semantic impairment, we categorised the 17 attributes as either involving perceptual features (e.g. *dark*, *light*, *round*, *square*) or not (e.g. *safe*, *dangerous*, *used inside*, *used outside*). This division resulted in 85 perceptual questions and 71 non-perceptual questions. DM was worse at answering the perceptual questions (59 of 85) than the non-perceptual questions (61 of 71). This difference was significant ($\chi^2[1] = 5.04$, $P < 0.05$). The control subjects showed little difference between the two types of questions (perceptual: 96%; non-perceptual: 98%).

Perceptual Features of Verbs

Thus far, we have presented data suggesting that DM's difficulty with concrete nouns reflects damage to perceptual components of word meaning. The fact that concrete nouns are especially dependent on perceptual components of meaning could account for our earlier finding that DM tends to be more impaired on nouns than on verbs. However, verbs also have sensorimotor ("manner") features that specify characteristics of the action—compare *slide* vs. *slither*, for example. Some theorists have claimed, furthermore, that these properties of verbs are represented perceptually rather than abstractly (e.g. Jackendoff, 1987). In this experiment, we sought to determine whether DM's loss of perceptual features would generalise to verbs.

To test this hypothesis, we created three groups of synonymy triplets:

1. Non-relational triplets, where the o
from the other two (e.g. *to augment*–to
release–to grasp; to harvest–to reap–*to pl*
2. Manner triplets, where the three v
the odd verb differs from the other two
ceptual) component of the verb's represen
gulp; to crush–*to smear*–to mash; to babb
3. Relational triplets, where the three
the odd verb differs from the other two
roles to syntactic positions (e.g. *to remind*
to sell–to purchase; to convince–to persu

The relational verbs were used becau
that controls have some difficulty with the
aphasic patients are particularly impaired
that differ only with respect to the posi
assigned (Breedin, 1991; Byng, 1988).

Method

Materials. Three sets of verb triple
triplets in each set. In this study we d
according to word frequency. The mean
meaning verbs was 3.89 (range: 1.78–6.4
0.23–3.6), the relational verbs, 3.63 (ran

Procedure. The procedure was the
triplets task. Five control subjects matc
were also tested.

Results

DM's performance, along with the
is presented in Table 6. DM was with
relational and relational triplets and belo
triplets. He was also significantly worse
relational triplets ($\chi^2[1] = 5.08$, $P < 0.$
with the hypothesis that perceptual fe
differently from other aspects of verb m
not matched for frequency of occurrenc
performance on the manner triplets refl
to the other two sets. Although we cann
be noted that the control subjects were n
or manner triplets. In addition, we coll

1. Non-relational triplets, where the odd verb was opposite in meaning from the other two (e.g. *to augment*–to diminish–to lessen; to hold–*to release*–to grasp; to harvest–to reap–*to plant*).
2. Manner triplets, where the three verbs convey the same action but the odd verb differs from the other two verbs in the manner (i.e. perceptual) component of the verb's representation (e.g. *to gnaw*–to gobble–to gulp; to crush–*to smear*–to mash; to babble–to chatter–*to stutter*).
3. Relational triplets, where the three verbs involve the same event but the odd verb differs from the other two verbs in how it assigns thematic roles to syntactic positions (e.g. *to remind*–to remember–to recall; to buy–*to sell*–to purchase; to convince–to persuade–*to acquiesce*).

The relational verbs were used because previous research has shown that controls have some difficulty with them (Breedin, 1991) and that some aphasic patients are particularly impaired in distinguishing between verbs that differ only with respect to the positions to which thematic roles are assigned (Breedin, 1991; Byng, 1988).

Method

Materials. Three sets of verb triplets were created. There were 27 triplets in each set. In this study we did not attempt to match triplets according to word frequency. The mean triplet frequency for the opposite meaning verbs was 3.89 (range: 1.78–6.48), the manner verbs, 1.96 (range: 0.23–3.6), the relational verbs, 3.63 (range: 1.68–5.31).

Procedure. The procedure was the same as in the semantic category triplets task. Five control subjects matched to DM in age and education were also tested.

Results

DM's performance, along with the mean and range for the controls, is presented in Table 6. DM was within the normal range for the non-relational and relational triplets and below the normal range on the manner triplets. He was also significantly worse on the manner triplets than the relational triplets ($\chi^2[1] = 5.08$, $P < 0.024$). These results are consistent with the hypothesis that perceptual features are stored or represented differently from other aspects of verb meaning. However, the items were not matched for frequency of occurrence, and it is possible that his worse performance on the manner triplets reflects their lower frequency relative to the other two sets. Although we cannot exclude this possibility, it should be noted that the control subjects were not at ceiling on either the relational or manner triplets. In addition, we collected reaction time data and found

TABLE 6
Number Correct on Verb Synonymy Triplets

		Controls (n = 5)	
Verb Type	*DM*	*Mean*	*Range*
Opposites (n = 27)	25	26.6	(25–27)
Manner (n = 27)	13	23.5	(20–26)
Relational (n = 27)	21	23.0	(19–26)

that the control subjects responded more quickly to the manner triplets (mean RT = 3014msec, range 1531–4496msec) than to the relational triplets (mean RT = 3543msec, range 1993–5403msec). These results suggest that the relational triplets were more difficult than the manner triplets for the control subjects. In contrast, DM shows the opposite pattern, responding more quickly to the relational triplets (RT = 5867msec) than to the manner triplets (RT = 6770msec). Finally, we examined DM's performance on the subset of relational verbs that overlapped in frequency with a subset of the manner verbs. The subset of relational verbs had a mean triplet frequency of 2.87 (range: 1.68–3.62) and the subset of manner verbs had a mean triplet frequency of 2.63 (range: 1.68–3.61). DM showed the same pattern of performance that he did on the entire set (relational verbs: 9 of 12 correct; manner verbs: 6 of 12 correct). Thus, although not conclusive, the results of this study provide some support for the hypothesis that perceptual aspects of verb meaning are also disrupted in DM.

GENERAL DISCUSSION

We have presented a patient who, as the result of a degenerative disorder, shows a reverse concreteness effect. The data present a challenge to current theories, which are able to account for the concreteness effect in the normal population but not for its occasional reversal in cases of neurological impairment. All three of the theories that we have reviewed suggest that concrete concepts differ from abstract ones in that their representations entail additional information, and that it is this essentially quantitative advantage that renders concrete concepts more accessible and more resistant to decay. But this view cannot account for instances in which abstract words elicit better performance than concrete words. Two of the theories (Dual Coding and Context Availability) suggest that the perceptual nature of concrete concepts may be responsible for superior performance with concrete words, but loss of the perceptual features that confer this advantage would not, on these theories, render concrete concepts less

accessible than abstract concepts. Of th
Theory is the most compatible with the ac
we will offer here.
Allport (1985; Allport & Funnell, 1981
have proposed theoretical frameworks t
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accessible than abstract concepts. Of the three theories, Dual Coding Theory is the most compatible with the account of DM's impairment that we will offer here.

Allport (1985; Allport & Funnell, 1981), Jackendoff (1987) and others have proposed theoretical frameworks that appear capable of accommodating both the concreteness effect and instances of its reversal. Allport (1985) proposes that object knowledge is distributed across representations that are closely related to modalities through which one experiences the object, as well as to the nature of the knowledge that this experience engenders. For example, our knowledge of *telephones* is likely to be distributed across several "attribute domains," as Allport terms them, because we have multiple sensory exposure to this class of objects (e.g. visual, auditory, and kinesthetic) and, in addition to these sensory and motor properties, we encode other types of information about them as well (e.g. functional and factual). In contrast, the representation for an abstract concept like *destiny* may be less widely distributed, having few if any perceptual components to its representation.

Jackendoff and colleagues (Jackendoff, 1987; Landau & Jackendoff, 1993) make a similar distinction between the perceptual and non-perceptual representations of concepts. Specifically, they hypothesise that our knowledge of many concepts includes a representation of an object's visual form, encoded as a 3-D model, as well as propositional information. Jackendoff (1987, p. 104) notes that:

> . . . there are distinctions of meaning among words that appear to be spelled out far more naturally in terms of spatial structure than in terms of conceptual structure. A good example (brought to my attention by Thomas Kuhn) is distinguishing among ducks, geese, and swans. . . . Clearly, one of the most salient differences . . . is how ducks, geese, and swans look—their relative sizes and the proportions and shapes of their respective parts. . . . notice that descriptions of size, proportion, and shape of parts, being purely geometric notions, are quite naturally expressed in the 3-D model.

We hypothesise that DM has either lost these geometric structures or the ability to access these structures.[11] Consequently, he is more impaired on tests of concrete word knowledge relative to abstract word knowledge.

The present results also point to a gap in the psychological literature on semantic representation, which has little to say about the manner in which abstract concepts are represented. Although we will not attempt to elaborate a model of abstract representations here, we will point out some of the differences between abstract and concrete concepts that may help in the eventual development of such a model.

[11]The integrity of DM's structural descriptions will be addressed in another paper (Srinivas, Breedin, Coslett, & Saffran, in preparation).

Differences in the representations for abstract and concrete concepts are likely to reflect differences in the manner in which they are acquired and the roles that they play in language. Much of one's knowledge of concrete concepts is acquired through input from some number of the five senses. Studies by Landau, Smith, and Jones (1988; 1992) have shown that object shape plays a crucial role in the acquisition of count nouns. Both young children and adults show a "shape bias" when learning novel objects in that they tend to generalise a label to objects that share the same shape. Labels for other perceptual features, like colour and texture, are acquired later in development and appear to become salient via linguistic context. Note, however, that all of these perceptual features (e.g. shape, colour, and texture) correspond directly with entities in the physical world. In contrast, knowledge of abstract concepts seems to be acquired in the context of language, with little or no direct physical support. That is, we learn the meaning of many abstract concepts through their use in sentences and in relationship to other concepts, often concrete ones. As Saffran, Bogyo, Schwartz, and Marin (1980, p. 400) noted: "While the core meaning of a reference term is relatively fixed (a rose *is* a rose), the meaning of an abstract word depends to a large extent on the linguistic context in which it is embedded (e.g., the *phase* of the moon, the *phase* of development, and so on)."

Given the importance of linguistic context in the acquisition and specification of abstract concepts, it may be that exposure to multiple sentence contexts plays a predominant role in the development of representations for abstract concepts. Talmy (1988) makes a distinction between grammatical and lexical elements in the development of a cognitive representation of sentences, arguing that the grammatical elements provide the structure for the cognitive representation whereas the lexical elements provide the context. Schmauder (1992) has proposed a similar argument for the distinction between open- and closed-class words. She hypothesises that what she calls "conceptual features" (e.g. human–nonhuman, rigid–flexible, animate–inanimate) are critical for the representation of open-class words, whereas what she calls "grammatical features" (e.g. proximal–distal, collective–distributive, affirmative–negative) are important for the representation of closed-class words. It may be, in this respect, that abstract words belong somewhere in between open- and closed-class words. They differ from the other classes in the flexibility with which they fit into many different sentence contexts and the way in which their meaning adapts itself to that context. The following two examples from Talmy (1987) demonstrate how the meaning of relatively abstract concepts like *get* and *break* is altered by grammatical elements in the case of *get* and by lexical elements in the case of *break*.

1. a. She's got to go to the park.
   b. She gets to go to the park.
2. a. The heat broke the guitar.
   b. The falling radio broke the guitar.

In example (1), the grammatical structure of the sentence alters the meaning of *get* from a chore in the case of (a) to a treat in the case of (b). In example (2), one's knowledge of heat, radios, and guitars changes one's interpretation of *breaking* from warping in the case of (a) to smashing in the case of (b). Whereas concrete terms are also subject to some modulation of meaning as a function of linguistic context, there is certainly a difference in degree.

There is another respect, more subtle and more difficult to specify, in which the representations of abstract words are likely to differ from those of concrete words. It is a reasonable supposition that the representations of concrete words are organised, as Allport (1985) has suggested, as associative networks, with distributed features interconnected as a function of the frequency of their co-occurrence. In the case of apple, for example, features such as red, round, crisp (though an increasingly rare property in some locales), each represented in an appropriate sensory "attribute-domain," along with more abstract properties such as "grows on trees" and "wards off doctors," are likely to be strongly interconnected. Activity in one portion of the associated net is likely to induce activity in the remainder. In contrast, many abstract words are likely to have more structured representations of the sort that Gentner (1981), Jackendoff (1990), Pinker (1992), and others have proposed for verbs. These representations specify not only the semantic features of the verb but also the relationships among those features, as well as arguments to be filled by other words in the linguistic context. A simplified example of this type of structured representation, taken from Pinker (1989) for the verb *remind*, is shown in Fig. 5. Items in parentheses are *not* part of the stored representation, but are filled when the verb is used. The representation indicates that *remind* is a psychological event involving the action of an object (picture) that has the property of being representative (of Mary) on an object (Bob) that has the property of being animate; in effect, the picture causes a representation of Mary to "go" into the consciousness of Bob. This representation also indicates the verb's arguments and argument structure. In Fig. 5 arguments are indicated by brackets. Thus, the argument structure for the verb *remind* is: [argument$_1$] reminds [argument$_2$] of [argument$_3$]. Note the association of argument slots with particular components of the verb's meaning; this argues for a good deal of specificity in the internal organisation of verbs (and is, incidentally, a feature that appeared to be well presented in DM,

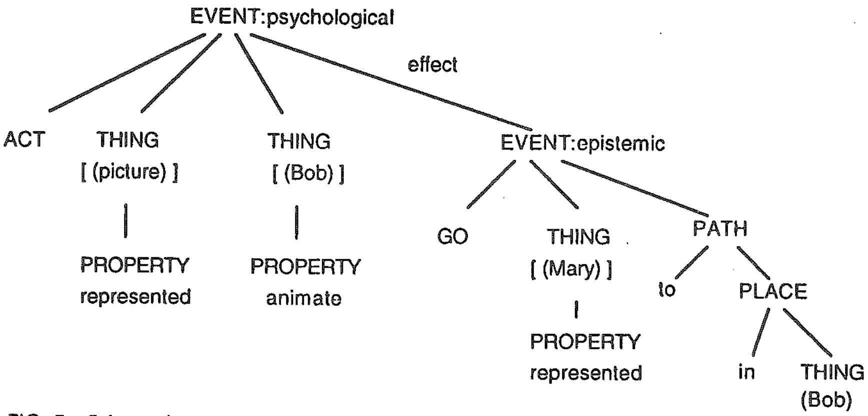

FIG. 5 Schematic representation of the verb *remind*.

as indicated by his good performance on the relational triplets in the verb synonymy task, which specifically probed this aspect of verb meaning). We do not want to suggest that the representations of object concepts are entirely lacking in internal organisation; part-whole relationships and the specific relationships of properties to parts, for example, must be represented. But it would seem a different matter to incorporate one more property into the representation of a concrete term (e.g. that the platypus has primitive mammary glands) than to modify the meaning of an abstract word like *remind*.[12] Indeed, to build on the earlier suggestion that abstract words may be intermediate between function words and concrete words, this consideration suggests another dimension for the term "open class:" At the level of semantic representation, concrete words may be more "open" than abstract words. Representational differences along the lines proposed here could potentially account not only for the reverse concreteness effect but also for a range of other phenomena described in the neuropsychological literature, including the verb retrieval deficits found in some aphasic patients (e.g. Breedin, 1991; McCarthy & Warrington, 1985; Zingeser & Berndt, 1990).

In the case of DM, we would argue that although there is widespread semantic loss, the linguistic/relational aspects of semantic representation are better preserved than perceptual attribute-domains, giving rise to a relative advantage for abstract words. Presumably, it is the opposite pattern that accounts for the more typical effect of left hemisphere damage, in which the concreteness effect is greatly magnified.

[12]Some might want to argue that there is a distinction between semantic representations as core definitions of terms that are essential for their correct linguistic usage and encyclopaedic knowledge. As far as we know, however, there is no psychological evidence for such a distinction.

DM and Other Patients with Percept Semantics

Most of the patients who appear to have sust
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to the perceptual aspect of semantic repr
McCarthy, 1987), have not shown the reve
strated in DM. How can these different pa
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Localisation of the Deficit

DM's neuroimaging studies demonstrate
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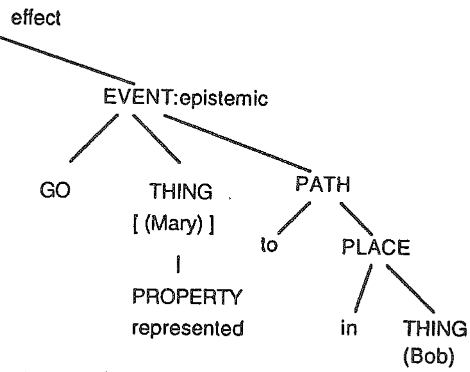

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DM and Other Patients with Perceptual Loss to Semantics

Most of the patients who appear to have sustained greater loss of their knowledge of living than non-living things, a pattern attributed to selective damage to the perceptual aspect of semantic representation (e.g. Warrington & McCarthy, 1987), have not shown the reverse concreteness effect demonstrated in DM. How can these different patterns of performance be reconciled? It should be noted, first of all, that in many cases patients may not have been adequately tested (if at all) for differences in the retention of abstract versus concrete concepts. (Note that the definition test administered to DM included more than 350 words.) Of the 13 cases showing selective impairment to living things, reviewed by Saffran and Schwartz (1994), only 2 were tested on abstract-concrete word knowledge. One of the cases, SBY, showed a reverse concreteness effect (Warrington & Shallice, 1984). The other case, JBR, did not show a significant reverse concreteness effect, although he did define more abstract words than concrete words (Warrington & Shallice, 1984). A third patient, who demonstrated both effects (FB), has been reported by Sirigu et al. (1991). Alternatively, it may be that the patients who do not show a reverse concreteness effect do not have as much damage to the perceptual component of semantics as DM; however, this seems unlikely in that many of them show a much stronger dissociation between living and non-living things than does DM. A third possibility is that, whereas the other patients may have lost perceptual attributes, other aspects of semantic knowledge are more intact than they are in DM. These alternatives need to be explored in future studies.

Localisation of the Deficit

DM's neuroimaging studies demonstrate relatively circumscribed regions of abnormality involving anterior portions of the inferior temporal and occipito-temporal gyri bilaterally but asymmetrically, with greater involvement on the left. Although limited, data for other patients with evidence of a reverse concreteness effect also demonstrate damage to one or both temporal lobes (Sirigu et al., 1991; Warrington 1981; Warrington & Shallice, 1984). The localisation data are of particular interest in light of evidence from humans and monkeys that implicates the inferior temporal lobe in object recognition (Ungerleider & Mishkin, 1982) and language (Burnstine et al., 1990). PET studies in humans, for example, reveal that the inferior temporal lobe (area 20), is activated in object recognition tasks, particularly on the left (Haxby et al., 1991). On the basis of evidence that visual object recognition mechanisms are localised more posteriorly in humans than in monkeys, presumably as a result of displacement by the development of phylogenetically newer cortical areas (Haxby et al., 1991), we speculate that anterior regions of inferior temporal cortex are involved in networks at the interface between perception and language. This contention is consistent with evidence that DM's impairment with concrete words is attributable, at least in part, to a loss of perceptual information.

On the account developed here, one might expect to observe reverse concreteness effects in other patients with lesions involving the anterior inferior temporal lobe (e.g. in cases of temporal lobectomy or herpes simplex encephalitis), yet reports of this pattern are rare. This may reflect the fact that the tests required to demonstrate the effect are seldom administered. Another possibility is that this phenomenon, like a number of other striking clinical syndromes, such as prosopagnosia, may typically be associated with bilateral temporal lobe lesions (Damasio, Damasio, & Van Hoesen, 1982). Finally, it may be that the reverse concreteness effect emerges only when extensive loss of perceptual components is coupled with some degree of impairment to other components of semantic representation. In this context, one should note that, although disproportionately impaired with concrete words, DM exhibited a deficit with abstract words as well.

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APPENDIX A

DM's Performance on Repeated Measures of Background Tests

Test	*Date Administered*	*Score*
Dementia Rating Scale	11-92	120/144
	7-93	127/144
WAIS-R Verbal IQ	4-90	84
	9-92	83
WAIS-R Performance IQ	4-90	84
	9-92	92
Boston Naming Test	7-91	11/60
	1-92	13/60
Picture Sequences—Spatial	4-91	100
	11-92	100
	5-94	100
Picture Sequences—Semantic	4-91	72
	11-92	89
	5-94	72

APPENDIX B

Time Line for Main Experiments

Date	*Test*
3-92	Set I of Verb–Noun Synonymy Task
4-92	Set I of Abstract–Concrete Synonymy Task
8-92	Set II of Verb–Noun Synonymy Task
	Set II of Abstract–Concrete Synonymy Task
	Defining Abstract and Concrete Words
	First Administration of Semantic Category Synonymy Triplets
9-92	Defining Abstract and Concrete Words
	Auditory Lexical Decision Test
11-92	MRI
	Second Administration of Semantic Category Synonymy Triplets
	Living–Non-living Attribute Test
2-93	SPECT
	Concrete/Abstract Word/Picture Matching
	Third Administration of Semantic Category Synonymy Triplets
	Perceptual Features of Verbs

APPENDIX (

Examples of DM's Naming Errors

Test	*Target*	*Resp*
Boston Naming Test	saw	knif
	wheelchair	mot
	harmonica	stor
		a m
	igloo	a tu
	mushroom	lam
Naming to Sounds	whistling	trur
	cat meowing	alm
	birds chirping	a d
	harmonica	tryi
		a h
	cow mooing	tha
		you
Naming Verb Pictures	sharpening a pencil	inse
	ripping a dress	ext
	sewing a button	inse
	licking a lollipop	tas
	melting snowman	dry

APPENDIX

Examples of DM's Definitions

Word	*Mean Rating*	*Definition*
Dead	7	no longer alive
Old	7	the opposite of being you
Father	7	one who is a parent of chi
Woman	7	female person, opposite c
Applaud	6	clap your hands
Command	6	to tell somebody to do so
Hat	6	something you wear on y wear one so the sun doesı
Window	6	a part of a house that you or out or even the sun car
Shy	5	feeling somewhat embar
Unjust	5	not fair
Carpet	5	that which covers the floo
Doctor	5	one who helps people wh
Table	5	something you can put fo off of it

PENDIX A

ated Measures of

Date ninistered	Score
11-92	120/144
7-93	127/144
4-90	84
9-92	83
4-90	84
9-92	92
7-91	11/60
1-92	13/60
4-91	100
11-92	100
5-94	100
4-91	72
1-92	89
5-94	72

ENDIX B

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Task
onymy Task
Task
onymy Task
Words
c Category Synonymy Triplets
Words

ntic Category Synonymy Triplets
st

e Matching
tic Category Synonymy Triplets

APPENDIX C

Examples of DM's Naming Errors

Test	*Target*	*Response*
Boston Naming Test	saw	knife, to cut back and forth, scissors
	wheelchair	mobile chair
	harmonica	store stuff in those things . . . almost like a mailbox
	igloo	a tunnel . . . you can drive into it can't you?
	mushroom	lamp of some kind
Naming to Sounds	whistling	trumpet
	cat meowing	almost like a child crying
	birds chirping	a duck up in a tree
	harmonica	trying to picture what is is being played—a horn?
	cow mooing	that's familiar . . . I saw it when I was younger . . . almost sounds like a horn
Naming Verb Pictures	sharpening a pencil	inserting, cutting
	ripping a dress	extending or expanding
	sewing a button	inserting or cutting
	licking a lollipop	tasting or blowing
	melting snowman	drying or clearing

APPENDIX D

Examples of DM's Definitions

Word	*Mean Rating*	*Definition*
Dead	7	no longer alive
Old	7	the opposite of being young, a person who has lived many years
Father	7	one who is a parent of children, a male
Woman	7	female person, opposite of man
Applaud	6	clap your hands
Command	6	to tell somebody to do something and insist that they do
Hat	6	something you wear on your head to cover your head . . . often I wear one so the sun doesn't hit me while I'm on vacation
Window	6	a part of a house that you can raise up or down so air can come in or out or even the sun can shine through
Shy	5	feeling somewhat embarrassed or not expressing yourself
Unjust	5	not fair
Carpet	5	that which covers the floor
Doctor	5	one who helps people who are sick . . . to have a degree
Table	5	something you can put food or other things on . . . often you eat off of it

Word	Mean Rating	Definition
Tree	5	that which grows outside and has a lot of coverage on it—leaves
Maintenance	4	to keep something going
Art	4	something that is drawn, to draw something
Stomach	4	that's where your food goes . . . goes through your mouth down to your stomach
Altar	4	a place to bow or kneel
Fear	3	being afraid something is going to hurt you
Jolly	3	something that's enjoyable
Butterfly	3	it's a little animal that flies
Dog	3	it's an animal that's a little bigger than cats
Star	3	star that shines from the sky
Wild	2	something that's doing unnormal things
Fuss	2	to attack or disagree
Cabbage	2	something to eat
Cheese	2	something sweet to eat
Needle	2	something to insert
Caress	1	accept
Coward	1	not positive
Cushion	1	something you put things into
Hay	1	it's something that covers things
Jelly	1	put it on things you like to eat
Statue	1	something that is made visible

Remembering Norman S
Evidence for Two Distin
Fact Learning Mec

Narinder Kap
Wessex Neurological Centre, S

We report two patients who showed distincti
performance relating to their ability to remem
sustained a missile injury to the mammillary b
left with a marked memory disorder. He ne
having acquired long-term factual knowledg
information about Norman Schwarzkopf—i
matched test of name-occupation learning
standard paired-associate learning test. By c
bilateral non-medial temporal lobe pathology
reverse pattern of performance—he could not
Schwarzkopf, but he performed well on t
learning test. These data point to two anato
dissociable long-term fact learning mechani
served by limbic-diencephalic structures and
the neocortex.

INTRODUCTI

It is now well established that memory fo
are functionally distinct and dissociable (e.
memory system(s) responsible for learni
further, and can we gather anatomical poin
that may provide a basis for such fractiona

Our ability to learn facts about the real
ledge about people, has traditionally been
of explicit, "declarative" learning mechan

Requests for reprints should be addressed to Dr.
Southampton General Hospital, Southampton, SO9
796085.)

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