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CATEGORY SPECIFIC SEMANTIC IMPAIRMENTS

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SUMMARY

We report a quantitative investigation of the visual identification and auditory comprehension deficits of 4 patients who had made a partial recovery from herpes simplex encephalitis. Clinical observations had suggested the selective impairment and selective preservation of certain categories of visual stimuli. In all 4 patients a significant discrepancy between their ability to identify inanimate objects and inability to identify living things and foods was demonstrated. In 2 patients it was possible to compare visual and verbal modalities and the same pattern of dissociation was observed in both. For 1 patient, comprehension of abstract words was significantly superior to comprehension of concrete words. Consistency of responses was recorded within a modality in contrast to a much lesser degree of consistency between modalities. We interpret our findings in terms of category specificity in the organization of meaning systems that are also modality specific semantic systems.

INTRODUCTION

Neuropsychological and neurological data provide an important source of evidence on the cerebral organization of visual perception, in identifying not only the component processes in the attainment of a meaningful percept, but also the categories into which meaningful percepts are to be classified. It is now generally accepted that a failure of visual identification that cannot be accounted for by impaired sensory processes (or other confounding factors) can occur as a selective deficit. Not only can visual agnosic deficits at the level of perceptual analysis—apperceptive agnosia—be distinguished from those of semantic analysis—associative agnosia—there is also evidence of differentiation at a semantic level. Thus visual agnosia for objects, colours, faces, topography, parts of the body, letters and numbers have all been identified as mutually dissociable deficits and hence it can be inferred that the neural substrates of these categories are also different (*see* Hécaen and Albert, 1978).

There have been pointers to suggest that such classification might be taken a stage further and that a more fine grain categorical organization can be observed within the broad category of visual object agnosia. As yet the evidence is sparse and mainly anecdotal. Nielson (1946) described a patient (C.H.C.) who he claimed had considerably greater difficulty in identifying inanimate objects by sight or touch, and foods except by taste, than in identifying all living things (including flowers). He also observed the converse pattern of deficits in a patient (Flora D) who had greater difficulty in identifying 'animate objects' than inanimate objects. Hécaen and de Ajuriaguerra (1956) reported a single case study of a patient with a left hemisphere lesion in whom they observed a category specific visual agnosia; identification of inanimate objects was more impaired than identification of animals. Konorski (1967) extrapolated from such dissociations between cognitive deficits, to distinguish nine 'gnostic fields', one of which was living things. He also speculated that small manipulable objects form a separate category from nonmanipulable objects. More recently Warrington (1981) provided quantitative evidence of a patient (C.A.V.) who had a significantly greater impairment in the identification of the visual representation of concrete concepts as compared with abstract concepts using a word/picture matching test (T. Shallice and J. McGill, unpublished) in which the abstract words were represented by pictures of concrete objects (e.g. *aptitude*—man playing a bassoon) of approximately equivalent familiarity and complexity as the pictures representing concrete concepts (e.g. a *donkey*). The evidence for category specific deficits is more firmly established for auditory-verbal than visual information. Impaired comprehension of colour names and body part names has long been recorded in the neurological literature. Indeed Goodglass *et al.* (1966), in the first quantitative investigation of semantic word categories, concluded that the selective impairment or preservation of semantic categories occurred not infrequently in an aphasic population. In a single case study Warrington (1975) demonstrated a significantly greater auditory comprehension impairment for concrete words than abstract words and more recently, quantitative evidence of the selective impairment of the comprehension of inanimate object names has been reported (Warrington and McCarthy, 1983).

Category specificity, then, has been documented in both the visual and verbal domains, but the relationship between the two is rarely considered. Typically visual object agnosia is viewed only from the perspective of visual processing. Yet the relationship between visual 'semantics' (i.e. knowledge of things), and their verbal equivalent, could well have far reaching theoretical implications. It seems fairly certain that there is not a one to one correspondence between one domain and the other. For instance, it is accepted (and it has occasionally been documented) that verbal comprehension can be intact in patients with a visual object agnosia (Rubens and Benson, 1971; Hécaen *et al.*, 1974). Conversely, patients with word comprehension difficulties—transcortical sensory aphasia—are not necessarily agnosic for visual stimuli (Benson, 1979; Warrington and McCarthy, 1983).

Such observations have usually been interpreted in terms of a unitary semantic system that has been specifically disconnected from 'lower level' modality specific perceptual systems (Geschwind, 1965). There are, however, a number of agnosic phenomena which are difficult to interpret in terms of a single semantic system disconnected from particular input modalities, and more easily interpreted in terms of modality specific semantic systems. Thus certain semantic memory impairments leave the patient with a stable but impoverished semantic processing ability. Only a limited set of items can be identified and for other items, at best, only superordinate information is retained (Warrington, 1975; Coughlan and Warrington, 1981). Such a pattern of impairment can occur together with lack of concordance between modalities; it is then most easily accounted for in terms of the degradation of the stored information within two semantic systems rather than a disconnection. Moreover other observations also suggest the existence of independent modality specific semantic systems. Beauvois *et al.* (1978) have argued that the observations of patients with optic aphasia and tactile aphasia indicate that separate semantic systems for verbal, visual and tactile information exist (*see also* Beauvois, 1982).

In this paper we report 4 patients recovering from a herpes simplex encephalitis in whom clinical observations suggested the selective preservation of the identification of inanimate objects. Our aim in these investigations was to obtain further evidence for the categorical organization and modality specificity of semantic systems.

CASE HISTORIES

Case 1

J.B.R., a 23-year-old electronics undergraduate, was admitted to the National Hospital on January 24, 1980. Two days previously he had had a grand mal seizure following which he became progressively drowsy. On examination he was pyrexial, his neck was stiff and Kernigs' sign was positive. He was confused and disorientated. EEG showed repetitive complexes bilaterally and a CT scan showed widespread low attenuation, maximal in both temporal lobes, that was considered consistent with herpes simplex encephalitis (*see* fig.). He gradually became more active and alert but he remained very confused and for a period of one week, three weeks after the onset of his illness, he was observed to eat and drink indiscriminately, including nonfood items. He continued to improve slowly and by August 1980 there were no neurological signs of note other than the cognitive deficits described below (a detailed neurological account of this patient has been given by Greenwood *et al.*, 1983).

Psychological test findings. J.B.R.'s scores on intelligence tests are given in Table 1. He was totally disorientated in time and place and he was densely amnesic for ongoing events and for events prior to his illness. On recognition memory tests for words and faces he scored at a chance level (Table 1). He was unable to identify contemporary famous faces or names. His perceptual skills were considered

TABLE 1. COGNITIVE TEST RESULTS

	J.B.R		S B Y.	K.B.	I.N.G.
	14.4.80	7.8.80	28.6.80	28.4.81	11.6.82
Verbal IQ	102	101	95	70	70
Performance IQ	78	103	93	76	58
Arithmetic	12	15	9	4	4
Similarities	11	10	7	3	6
Digit Span	9	7	7	7	6
Vocabulary	9	8	12	3	4
Picture Completion	7	8	7	6	2
Block Design	9	11	10	5	6
Picture Arrangement	4	7	5	6	0
Matrices IQ	99	100	NT	90	70
Recognition Memory					
Words (n = 50)	29	—	29	NT	23
Faces (n = 50)	30	—	18	27	25

Performance on WAIS, Matrices and Warrington's (1984) Recognition Memory Tests.

to be intact (e.g. on the Warrington and Taylor (1978) test of matching usual and unusual view photographs he scored 20/20 correct and 19/20 correct on the Warrington and James (1967) fragmented letter test). His spontaneous speech was fluent although he used a somewhat limited and repetitive vocabulary; occasional word-finding difficulty was noted and he tended to use circumlocutory expressions. Articulation, phrase length and syntax were considered to be normal. His score on the modified Token Test (Coughlan and Warrington, 1978) was satisfactory (15/15). He failed to score on a graded difficulty naming test (GNT) (McKenna and Warrington, 1983) and on a test of naming common objects he scored 11/15 (Coughlan and Warrington, 1978). He failed to score on the NART (Nelson, 1982) and on the Schonell reading test he made dyslexic errors (regularizations) with the lower frequency irregularly spelt words. He had no difficulty in naming or identifying colours, shapes and letters. However, his ability to identify inanimate objects by sight or by touch was impaired and he appeared to have more difficulty in identifying pictures of animals than pictures of inanimate objects and in comprehending animal names than object names. He performed at a very defective level on the Peabody Picture Vocabulary Test (score 26). Similarly on the Shallice and McGill Concrete/Abstract Picture Word Matching Test his comprehension of both categories of word was severely impaired (*see* Table 2).

TABLE 2. CONCRETE/ABSTRACT WORD/PICTURE MATCHING

	Concrete $n = 30$	*Abstract* $n = 30$
J.B.R. (7.4.80)	14	19
S.B.Y. (28.6.82)	15	11
L. hemisphere lesion group	1.6	7.6

Error scores for J.B.R. and S.B.Y. and the mean error score for a consecutive series of patients with left hemisphere lesions ($n = 45$) (chance = 22.5).

In summary, J.B.R. was able to function at an overall average level on tests of intelligence. He was densely amnesic. His language skills, especially his spontaneous speech, were relatively intact. He had significant difficulties, however, both with visual identification and word comprehension.

Case 2

S.B.Y., a 48-year-old naval officer (engineer), was admitted to a private hospital in Hong Kong on February 15, 1982. He was febrile and confused. He became comatose and was treated with cytosine arabinoside and dexamethasone. A CT scan was normal but there was a raised protein content in the CSF. His level of consciousness gradually returned to normal and on May 7, 1982 he was transferred to the Queen Elizabeth Military Hospital, Woolwich. On examination there were no neurological signs other than the cognitive deficits described below. A repeat CT scan in May 1982 showed areas of low attenuation in both temporal lobes that were considered to be compatible with the diagnosis herpes simplex encephalitis (*see* fig.).

Psychological test findings. S.B.Y.'s intelligence test results are given in Table 1. He was almost totally disorientated in time and place and his memory for ongoing events was very impaired. He scored at a chance level on recognition memory tests for words and faces. His perceptual skills appeared to be intact insofar as he made no errors on the fragmented letters test and on matching usual and unusual view objects. His spontaneous speech was very fluent and apart from a tendency to repeat himself, only occasional word-finding difficulties were noted. His phrase length, syntax and articulation appeared to be entirely normal. His performance on the modified Token Test was very satisfactory (15/15). However, his comprehension of individual words appeared to be impaired and on tests of object naming his performance was very poor (GNT 0/30) as was naming from description (1/15) (Coughlan and Warrington, 1978). He was still able to identify and name colours and letters and he was able to read at a high average level (NART 31/50). Identification of inanimate objects by sight and by touch was impaired and he appeared to have more difficulty with animal and food names than object names. His performance on the Peabody Picture Vocabulary Test was very weak (score 73). On the Shallice and McGill Concrete/Abstract Picture Matching Task, although his score was only slightly weak compared with patient controls for the abstract words, it was very significantly impaired for the concrete words (Table 2).

In summary S.B.Y.'s overall level on intelligence tests was just within the average range. It is assumed that he would have been able to function at least within the high average range premorbidly and that these scores indicate some generalized intellectual deterioration. In addition he had a dense amnesic syndrome, a visual identification deficit and impaired word comprehension.

Case 3

K.B., a 60-year-old housewife, was admitted to the National Hospital on April 27, 1981 for further assessment of her cognitive deficits following a herpes simplex encephalitis diagnosed in June 1979. During the acute illness she developed a frontal headache, fever and increasing confusion over a 48 h period. During the early stages of recovery she was reported to be very amnesic, dysphasic and agnosic. She was also observed to eat food and nonfood items indiscriminately.

On examination there were no neurological signs of note other than cognitive dysfunctions (described *below*). An EEG was normal. A CT scan showed marked residual low attenuation bitemporally most marked on the left (*see* fig.). (A detailed neurological account of this patient has been given by Greenwood *et al.*, 1983.)

Psychological test findings. Intelligence test results are given in Table 1. She was completely disorientated for time and place and appeared to be almost totally unable to recall or recognize ongoing events. On a recognition memory test for faces she scored at a chance level. Her spontaneous speech was very sparse as to word choice and word-finding difficulties were very evident. On the Boston Diagnostic Aphasia Battery the pattern of deficit was that of a global dysphasic with articulation spared. She was only able to name 1/15 common objects and she failed to score on a test of naming from description. Her performance on the Peabody Picture Vocabulary Test was extremely poor (score 26). It was noted that she was unable to name or identify objects by touch. She was fairly accurate in identifying and naming letters, actions, body part names and colours. Her reading and spelling were impaired (she failed to score on the NART). In the course of clinical assessment it was observed that K.B. had more difficulty in identifying animals and foods than inanimate objects and a similar pattern of difficulty was observed for her word comprehension.

Case 4

I.N.G., a right-handed housewife aged 44 years, was admitted to the National Hospital between June 10 and 27, 1982 for assessment of her suitability for rehabilitation. A herpes simplex encephalitis had been diagnosed in November 1978 on the basis of a three day history of vomiting, pyrexia and seizures. A CT scan then showed a low attenuation lesion deep in the right hemisphere and a brain biopsy demonstrated necrotic tissue. At the time of her discharge in June 1979 she was severely amnesic, aphasic and agnosic and she had been observed to attempt to eat nonfood items. She was still incontinent and continued to have generalized seizures which were preceded by left-sided clumsiness and turning of her head to the right. On admission to the National Hospital, neurological examination was normal apart from higher cerebral function deficits. A repeat CT scan showed areas of bilateral temporal low attenuation and marked atrophy which were considered consistent with her known herpes encephalitis (*see* fig.).

Psychological test findings. Intelligence test results are given in Table 1. She was disorientated in time and place and was completely unable to recall or recognize ongoing events or hospital personnel. On recognition memory tests for words and faces she scored at a chance level (Table 1). Her spontaneous

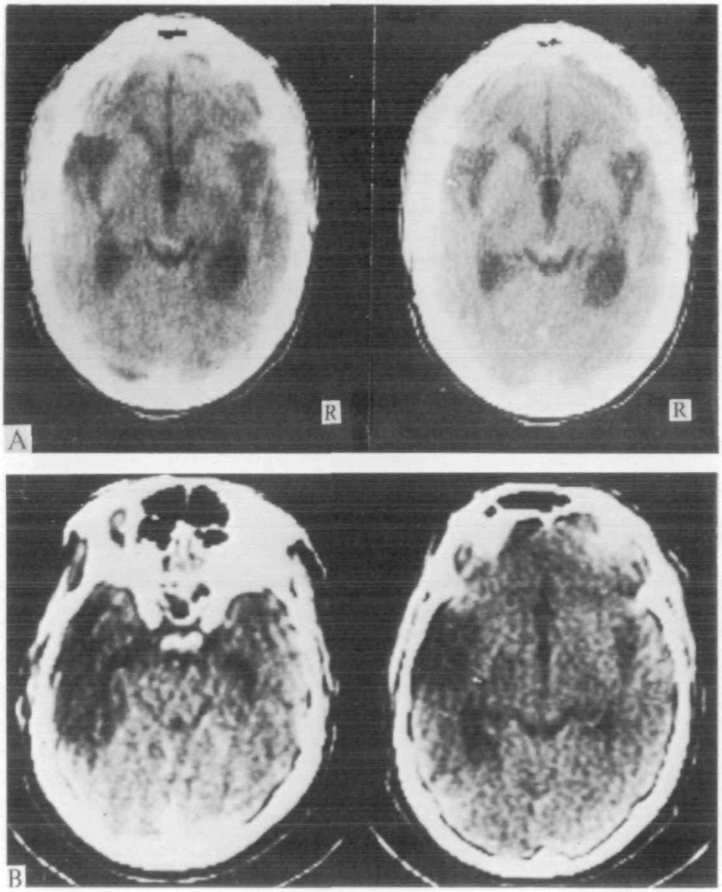


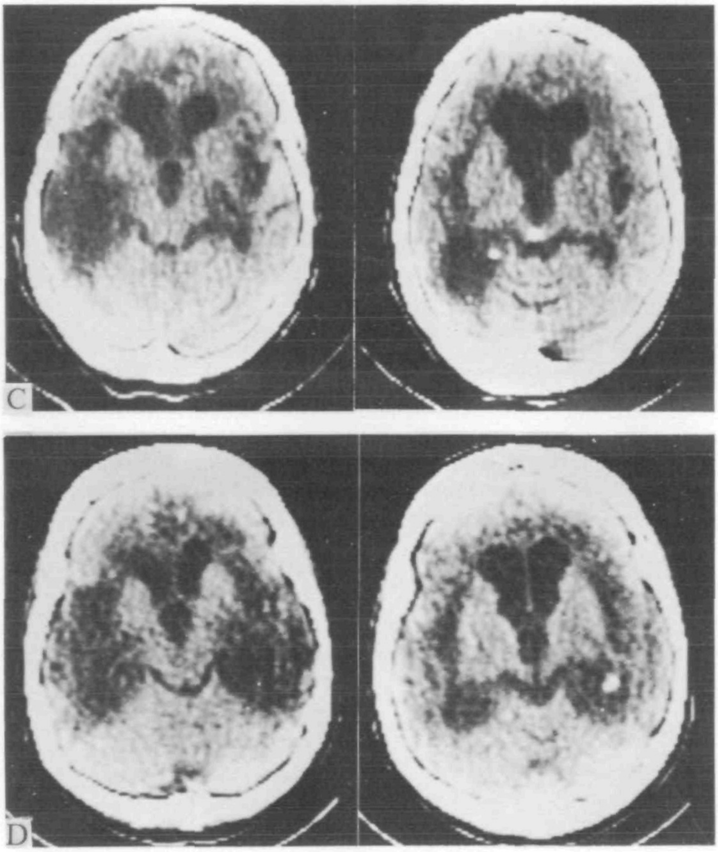
FIG. CT scans of A, J.B.R. (October 1980). B, S.B.Y. (May 1982). C, B.A.R. (April 1981) and D, I.N.G. (June 1982).

speech was exceptionally sparse; she tended to repeat automatic phrases and very rarely attempted propositional speech. Within these limitations her phrase length, syntax and articulation appeared to be normal. Her performance on object naming tests was very impaired (e.g. 5/15 common objects correct) as was her performance on the modified Token Test (9/15). However, she could name the primary colours and common shapes. Her reading and spelling skills were extremely defective. Her ability to identify common inanimate objects by sight or touch was impaired and she appeared to have even greater difficulty in identifying foods and animals. She performed at a very defective level on the Peabody Picture Vocabulary Test (score 44). I.N.G. was very distractable in the test situation and it was somewhat difficult to hold her attention for sufficient time to complete tests without interruption.

In summary, there was evidence of a fairly marked degree of generalized intellectual impairment. In addition she was markedly amnesic, dysphasic, dyslexic, dysgraphic and agnosic.

Summary of Case Reports

These 4 patients were at various stages of recovery from a herpes simplex encephalitis. The clinical course of their illness, the neurological findings and the residual cognitive deficits were qualitatively



similar in the 4 cases. CT scans demonstrated predominantly bitemporal damage in all 4 patients. In addition to varying degrees of dementia and expressive speech functions, these patients all had a severe global amnesic syndrome and a comprehension deficit which encompassed both visual and verbal knowledge. In all 4 cases clinical observation suggested that within the domain of 'concrete' concepts, knowledge of inanimate objects was spared relative to knowledge of living things and food. Their residual comprehension capacities were documented in more detail.

EXPERIMENTAL INVESTIGATIONS

Difficulties in visual identification had been observed in all 4 patients on clinical assessment and in addition difficulties in verbal comprehension were apparent. Our aim in this series of experiments was to document and explore these impairments and in particular, to consider the possible categorical specificity of their deficits and the correspondence between the visual and verbal deficit. The main clinical difference between these 4 patients was in their expressive speech capacities. Neither K.B. nor I.N.G. were able to give coherent word definitions or verbal descriptions of pictures and they were therefore tested in one experiment only (Experiment 8) in which a matching to sample technique was adopted. J.B.R. and S.B.Y. were both able to express themselves fairly lucidly and fluently within the constraints imposed by their impoverished verbal vocabulary. It was therefore possible to investigate their comprehension capacities in much more detail using picture description and word definition tasks (Experiments 1-7).

In these experiments each verbal response was scored correct or incorrect by three independent judges and the analyses were based on the consensus rating. A lenient scoring criterion was adopted, the judges being instructed to accept as correct 'reasonable evidence that the core concept is conveyed'. In addition they were required (1) to make allowance for dysphasic word-finding difficulties, (2) to credit any correct homonym, (3) to ignore the evidence of gesture, (4) not to give credit for superordinate information alone, (5) to ignore verbal description of features present in a picture (e.g. tail, legs) and (6), in the case of picture description, identification was assumed to be correct if the stimulus was correctly named.

Experiment 1: Identification of Visual and Verbal Stimuli

Our aim in this experiment was to document the relative severity and concordance of J.B.R. and S.B.Y.'s impaired identification of visual and verbal stimuli. The test stimuli consisted of 40 clear line drawings (mostly of inanimate objects) selected from the Zinkin and Birtchnell set (1968). All items were well within the visual/verbal vocabulary of the average adult. The patients first attempted to identify the pictures by naming or description. After each response, irrespective of quality, the patient was asked to elaborate *once*. After a short interval the patients attempted to define the object names presented auditorially. S.B.Y. attempted this task a second time ten days later and J.B.R. was retested on the visual version only, a second time, later on the same day.

The percentage of responses judged correct for the visual and verbal version of this task for each patient, together with the number of visual stimuli correctly named, is given in Table 3. There was a small but insignificant advantage of auditory presentation for both patients (McNemar test $P > 0.2$ for all comparisons).

In this and succeeding experiments stability in performance over repeated testing was assessed using the contingency coefficient (Siegel, 1956) with the proviso that

TABLE 3 EXPERIMENT 1.
IDENTIFICATION OF VISUAL AND VERBAL STIMULI

	Visual	*Auditory*
J.B.R.		
(20.6.80)	68	78
(20.6.80)	68	NT
S.B.Y.		
(28.6.82)	50	53
(6.7.82)	48	55

Percentage correct for each presentation condition on each occasion.

performance for both sets of data lay between 20 and 80 per cent (this avoids artefacts arising from floor and ceiling effects). Comparing responses within a modality, for J.B.R. there was a significant degree of consistency between the two sets of responses in the visual modality ($C = 0.61$, $P < 0.001$) and S.B.Y. showed the same consistency effect in both modalities (visual, $C = 0.48$, $P < 0.001$; verbal, $C = 0.33$, $P < 0.05$). It should be noted that the maximum value for a 2×2 contingency coefficient (C) is 0.71. By contrast, the pattern of consistency scores between modalities was on the whole weaker. For J.B.R. there was an insignificant degree of consistency between his ability to identify an item presented visually and the same item presented auditorially ($C = 0.26$, $P > 0.05$). This was also the case for S.B.Y. on the first test session ($C = 0.15$, $P > 0.2$); on the second occasion, however, there was a significant degree of concordance ($C = 0.49$, $P > 0.01$).

Performance on this simple task would be expected to be at ceiling level in any normal average adult. Given the patients relatively intact expressive speech, the high error rate observed on both the visual and verbal version of this task provides quantitative evidence of a moderately severe visual and verbal agnosia in both patients (very comparable in severity to the patients reported by Warrington, 1975).

Experiment 2: Identification of Inanimate Objects and Living Things

It had been observed that the ability of these patients to identify certain categories of both picture stimuli and 'concrete' words, namely, animals and plants, was particularly poor whereas inanimate objects appeared to be relatively spared. The aim of this experiment was to explore the possibility of a category specific identification deficit for both visual and verbal stimuli.

The test stimuli consisted of 96 coloured pictures: 48 animals and plants and 48 inanimate objects. The two sets did not differ significantly in spoken word frequency (*see* Appendix). J.B.R. and S.B.Y. first attempted to identify by naming or describing each stimulus picture, alternating between the two major categories. Secondly, they attempted to define each picture name, presented in the same order, auditorially.

The percentage correct for each category for each mode of presentation for each patient is given in Table 4. For both J.B.R. and S.B.Y. there was a striking discrepancy between their ability to identify inanimate objects either with pictures or words and their inability to identify living things. J.B.R. was almost at ceiling level on the visual inanimate object condition, yet he virtually failed to score on the visual living things condition. It was also shown that his ability to name objects that he succeeded in identifying was relatively well preserved and far superior to his ability to name living things; but this was not the case for S.B.Y. whose naming skills were very impaired (*see* Table 4). Although S.B.Y.'s overall level was somewhat worse than J.B.R.'s both patients were usually able to identify the superordinate category with auditory presentation (*see* Table 4). The small difference in favour of picture identification compared with name definition for

TABLE 4. EXPERIMENT 2. IDENTIFICATION OF PICTURES, NAMES, LIVING THINGS AND INANIMATE OBJECTS

	Living things				*Inanimate objects*			
	Visual		*Auditory*		*Visual*		*Auditory*	
	Identified	*Named*	*Identified*	*Superordinate*	*Identified*	*Named*	*Identified*	*Superordinate*
J.B.R. (5.8.80)	6	6	8	90	90	67	79	94
S.B.Y. (27.7.82)	0	0	0	75	75	0	52	85

Percentage correct identification score, naming score and superordinate score.

inanimate objects was significant for S.B.Y. (McNemar test A = 16, D = 5, $P < 0.05$) but not for J.B.R. (McNemar test A = 9, D = 4, $P > 0.1$).

Qualitatively the difference between the major categories was very striking. Some examples of their responses to the inanimate object words were as follows.

J.B.R. Tent—temporary outhouse, living home.
Briefcase—small case used by students to carry papers.
Compass—tools for telling direction you are going.
Torch—hand-held light.
Dustbin—bin for putting rubbish in.

S.B.Y. Wheelbarrow—object used by people to take material about.
Towel—material used to dry people.
Pram—used to carry people, with wheels and thing to sit on.
Submarine—ship that goes underneath sea.
Umbrella—object used to protect you from water that comes.

In contrast some examples of their responses to living things were as follows.

J.B.R. Parrot—don't know.
Daffodil—plant
Snail—an insect animal.
Eel—not well.
Ostrich—unusual.

S.B.Y. Duck—an animal.
Wasp—bird that flies.
Crocus—rubbish material.
Holly—what you drink.
Spider—person looking for things, he was a spider for a nation or country.

As there were both floor and ceiling effects it was only possible to compute the concordance of visual and auditory presentation for S.B.Y.'s responses to the inanimate objects category. The contingency coefficient was not significant (C = 0.12, $P > 0.2$).

Experiment 3: Definition of Names of Living Things and Inanimate Objects

In the previous experiments we documented a particularly striking dissociation of the ability to identify pictures and names of inanimate objects compared with pictures and names of living things. Our aim in this experiment was to assess the reliability of these observations by using a completely different set of words.

The test items consisted of names of 40 living things (animals and plants) and 40 inanimate objects matched for frequency. J.B.R. was required to define each name, alternating between the two major categories. This task was attempted twice on the same day (June 20, 1980). S.B.Y. did not attempt this task.

TABLE 5. EXPERIMENT 3. IDENTIFICATION OF NAMES OF LIVING THINGS AND INANIMATE OBJECTS

Living things				*Inanimate objects*			
1st attempt		*2nd attempt*		*1st attempt*		*2nd attempt*	
Identified	*Superordinate*	*Identified*	*Superordinate*	*Identified*	*Superordinate*	*Identified*	*Superordinate*
15	50	10	63	85	93	75	93

Percentage correct identification score and superordinate score for J.B.R.

The percentage correct score for each category for each mode of presentation is given in Table 5. Again there is a very striking discrepancy in the quality of his responses to stimuli in the two categories. Of the living things, he identified only a very few of the high frequency items and was able to indicate the superordinate category for approximately half the stimuli. Identification for most of the inanimate objects was remarkably good and he almost always knew the superordinate category (*see* Table 5). His ability to indicate the superordinate for the inanimate object category was significantly better than for living things ((i)$\chi^2 = 17.64$, $P < 0.01$; (ii) $\chi^2 = 10.32$, $P < 0.01$). Our findings in this experiment replicate the verbal condition of Experiment 2. Consistency measures could not be computed because of the floor and ceiling effects.

Experiment 4: Identification of Foods and Inanimate Objects

In addition to the selective impairment in the identification of living things, it had been observed that J.B.R.'s comprehension of food names appeared to be very poor. The aim of this experiment was to compare his ability to identify pictures and names of foods and inanimate objects. S.B.Y. was not tested on this experiment.

The test stimuli consisted of 30 coloured pictures of foods and 30 coloured pictures of inanimate objects (*see* Appendix). J.B.R. first attempted to identify each picture by naming or description, the foods and the inanimate object items being alternated. He then attempted to identify each food and object name. The percentage correct for each category for each presentation mode together with his naming and superordinate identification score is given in Table 6. Some days later he attempted to mime an action appropriate to 20 foods and 20 inanimate objects (e.g. banana, spaghetti—actual object presented) that partially overlapped with those items previously used. His miming performance was scored jointly by T.S. and E.K.W.

TABLE 6. EXPERIMENT 4. IDENTIFICATION OF FOODS AND INANIMATE OBJECTS

Foods				*Inanimate objects*			
Visual		*Auditory*		*Visual*		*Auditory*	
Identified	*Named*	*Identified*	*Superordinate*	*Identified*	*Named*	*Identified*	*Superordinate*
20	20	30	93	87	40	77	87

Percentage correct identification score, naming score and superordinate score for J.B.R.

His score was 20 per cent correct for foods and 65 per cent correct for inanimate objects. His ability to identify inanimate objects for both modes of presentation is significantly better than his ability to identify foods (visual $\chi^2 = 26.8$, $P < 0.001$, 1 d.f.; verbal $\chi^2 = 13.1$, $P < 0.001$, 1 d.f.) and an identical pattern of scores was obtained on the mime condition ($\chi^2 = 8.29$, $P < 0.01$, 1 d.f.). The miming result provides further evidence that this category specific impairment cannot be attributed to any difficulty of expression, eliminating the possibility that food stimuli are more difficult to describe than inanimate object stimuli. In this experiment we have obtained as striking a dissociation between identification of food and inanimate objects as was obtained for living things and inanimate objects in the previous two experiments. Consistency measures could not be computed because of floor and ceiling effects.

Experiment 5: Identification of Animate, Inanimate Objects and Foods

A problem in comparing categories in the visual mode is that items may differ in familiarity just as words do in their frequency of usage. Although word frequency counts are available for all test stimuli used in these experiments, this may not be an adequate control for visual familiarity. The Snodgrass and Vanderwart (1980) stimuli were specifically standardized to provide visual familiarity ratings and were thus considered particularly suitable for investigating both category and mode of presentation effects.

The test stimuli consisted of a subset of the Snodgrass and Vanderwart drawings: 40 animals, 40 inanimate objects and 20 foods. S.B.Y. (July 27, 1982) first attempted to name or identify each of the 100 drawings, presented in pseudorandom order. Secondly, he attempted to identify each stimulus name (these stimuli were not available to us at the time we tested J.B.R.). The percentage correct scores for each category for each mode of presentation are given in Table 7.

TABLE 7. EXPERIMENT 5. SNODGRASS AND VANDERWART PICTURES TEST

Animals		*Foods*		*Inanimate objects*	
Visual	*Auditory*	*Visual*	*Auditory*	*Visual*	*Auditory*
13	10	25	25	60	65

Percentage correct for each category for each mode of presentation for S.B.Y.

For both types of stimuli an analysis of covariance using the linear logistic model was performed. For the visual results there was a highly significant effect of category ($\chi^2 = 17.5$, $P < 0.001$, 2 d.f.) with inanimate objects being identified significantly better than both animals (z = 3.3, $P < 0.001$) and food (z = 2.65, $P < 0.01$); there was no significant difference between animal and food categories (z = 0.41, $P > 0.3$). For the auditory modality the results were very similar; there was an overall effect of category ($\chi^2 = 23.2$, $P < 0.001$, 2 d.f.) with inanimate objects being identified better than both animals (z = 3.64, $P < 0.01$) and foods (z = 3.13, $P < 0.001$) with no difference between comprehension of animal and food names (z = 0.41, $P > 0.3$).

The consistency of his visual and verbal responses for the inanimate objects category for the two presentation modes was computed: the contingency coefficient was insignificant (C = 0.04, $P > 0.5$).

In this experiment we have taken into account not only word frequency but also visual familiarity and clear evidence of significant category effects is still obtained. The lack of concordance between the two modes of presentation is again a feature of the data.

Experiment 6: Abstract and Concrete Word Comprehension

In the previous experiments three specific categories were explored and evidence for category specific deficits within the 'concrete' domain were documented for both a visual and auditory mode of presentation. Identification of living things and foods appeared to be selectively impaired. Our aim in this experiment was to explore the ability of J.B.R. and S.B.Y. to comprehend a wider range of verbal stimuli that spanned the full abstract/concrete range.

The test stimuli consisted of two subsets of the Brown and Ure (1969) word list. J.B.R. attempted to define 323 words of which 132 were of AA and A frequency, the remaining 191 were in the frequency range 1 to 50. Half of the total pool had a concreteness rating above the median value of 4.47. S.B.Y. attempted to define 190 words of which 50 were A or AA frequency and 140 in the 1 to 50 frequency range; half of each frequency range had a concreteness rating above the median. In order to ensure correct perception of each word the patients were asked to repeat it correctly before attempting a definition.

The percentage correct for each level of concreteness and frequency for each patient is given in Table 8. For both patients there was a significant effect of

TABLE 8. EXPERIMENT 6.
ABSTRACT/CONCRETE WORD COMPREHENSION

	Frequency	*Concrete* > 4.47	*Abstract* < 4.47
J.B.R.			
(4.8.80)	A and AA	89	93
(28.6.82)	< 50	65	71
S.B.Y.	A and AA	76	91
(6.7.82)	< 50	50	94

Percentage correct for each level of frequency and concreteness.

frequency (J.B.R., $\chi^2 = 20.79$, $P < 0.001$, 1 d.f. and S.B.Y., $\chi^2 = 5.90$, $P < 0.02$, 1 d.f., respectively). There was a highly significant effect of concreteness for S.B.Y. ($\chi^2 = 35.3$, $P < 0.001$, 1 d.f.) with performance on abstract words being much superior to that on concrete. This was not the case for J.B.R. ($\chi^2 = 1.57$, $P > 0.2$). S.B.Y.'s ability to define abstract words was particularly impressive; some examples of his responses are as follows.

Debate	Discussion between people, open discussions between groups.
Malice	To show bad will against somebody.
Deceive	To let people down—give them the wrong ideas and wrong impression.
Caution	To be careful how you do something.

By contrast some examples of his responses to concrete words are as follows.

Ink	Food—you put on top of food you are eating—a liquid.
Frog	An animal—not trained.
Cabbage	Use for eating, material it's usually made from an animal.
Tobacco	One of your foods you eat.

The patient's incorrect responses were rated by three judges according to the same classification adopted by Coughlan and Warrington (1981) as follows.

Omission	Made no attempt at definition.
Vague	Imprecise, residual comprehension indicated (e.g. puppy—'young animal').
Phonological	Responses in which the subject appears to be defining a word phonologically similar to the target word (e.g. *sap*—'kitchen tool device for turning the water on').
Miscellaneous	(e.g. *mutton* 'some sort of rubbish').

TABLE 9. EXPERIMENT 6. ERROR ANALYSIS

	Omission	*Vague*	*Phonological*	*Miscellaneous*
J.B.R.	4	22	27	47
S.B.Y.	0	60	11	30

Percentage correct for each type of error.

The percentage for each type of error is given in Table 9. The most interesting aspect of the error analysis is the occurrence of phonological errors, a phenomenon previously reported by Coughlan and Warrington (1981). As in the case of the previous study these errors cannot be attributed to impairment at an early stage of auditory perception as the subject was required to repeat each target word. The main finding of this experiment is, however, the evidence for selective impairment of the knowledge of concrete concepts, which has been recorded twice previously (Warrington, 1975, 1981). S.B.Y. showed this dissociation particularly clearly. It should also be noted that he exhibited this same dissociation in picture-word matching (*see* Case Report).

Experiment 7: Comparison of Multiple Verbal Categories

With verbal stimuli it is feasible to investigate a wide range of categories and so obtain a selection which has not been predetermined by clinical observation. Battig and Montague (1969) have obtained frequency norms for 56 verbal categories; 26 of these were considered appropriate for more detailed investigation of possible category specificity. For the most part exclusion was determined by cultural factors (e.g. US colleges), the lack of sufficient high frequency items (e.g. units of time) or their being proper names (e.g. girls' names).

The test stimuli consisted of 12 items of fairly high category-frequency from each of the 26 categories. J.B.R., tested on two days, attempted to define one item from each category in turn and this procedure was repeated until he had attempted all 312 words. (It was not possible to test S.B.Y. on this experiment.) Since this word pool included categories with items that might be difficult for normal subjects to define precisely (e.g. *metals*, *fish*), a control subject matched for age and occupation with J.B.R. was also tested.

The number correct for each category for J.B.R. and the control subject is given in Table 10.

In order to control for word frequency effects an expected score for each category

TABLE 10 EXPERIMENT 7. BATTIG AND MONTAGUE CATEGORY TEST

	Obtained score	*Expected score*	*Difference score*	*Control score*
1. Clothing	10	8.6	+1.4	12
2. Dwelling	10	9.5	+0.5	11
3. Furniture	10	8.5	+1.5	11
4. Kitchen utensil	10	8.6	+1.4	12
5. Occupation	10	8.6	+1.4	11
6. Body part	10	10.3	−0.3	11
7. Vehicle	10	9.4	+0.6	9
8. Sport	9	8.1	+0.9	9
9. Weather	9	8.8	+0.2	9
10. Crime	8	4.7	+3.3	9
11. Earth formation	8	9.6	−1.6	12
12. Tools	8	8.5	−0.5	11
13. Animals	6	9.5	−3.5	11
14. Science	5	7.1	−2.1	11
15. Insect	3	8.5	−5.5*	10
16. Metal	4	9.6	−5.6*	6
17. Drink	2	6.1	−4.1*	11
18. Cloth	2	8.5	−6.5*	8
19. Musical instrument	2	8.1	−6.1*	12
20. Disease	1	6.7	−5.7*	9
21. Fish	1	7.7	−6.7*	9
22. Precious stone	1	6.1	−5.1*	8
23. Flower	0	5.9	−5.9*	7
24. Fruit	0	7.7	−7.7*	9
25. Tree	0	7.5	−7.5*	8
26. Vegetable	0	6.9	−6.9*	11

J.B.R.'s (5.8.80–8.8.80) and control subject's performance for each category. * Significant difference at $P < 0.05$ between J.B.R.'s obtained and expected scores.

was estimated from J.B.R.'s level of performance in Experiment 6 on five frequency bands of the Brown and Ure pool which span the full concrete/abstract range (AA, A, 10 to 49, 1 to 9, < 1). Each individual word was given an 'expected' score depending upon its frequency band; for instance a word in the frequency band 1 to 9 received a score of 0.58, the probability correct for that band in the previous experiment. The sum of these scores was taken as the expected value for that category (*see* Table 10). For each category the significance of the obtained score and the expected score was computed using an χ^2 test. For the most part J.B.R. either scored at a level commensurate with his overall level on the mixed abstract/concrete pool or at a very low level indeed. Thus on his ten best categories his score averaged more than 80 per cent correct whereas for his ten worst his score averaged less than 10 per cent correct, far worse than the control subject. These categories do include some that the control subject also found somewhat difficult (e.g. *metal*, *tree*). It appeared that the control subject's poor performance on these categories could be attributed to characteristics of this word pool that result in their being somewhat difficult to define other than in terms of the superordinate (e.g. fish) or containing a considerable number of low frequency items (e.g. precious stone). Even allowing for these variations in category difficulty, J.B.R.'s pattern of performance would appear to offer strong evidence for the selective preservation and selective impairment of particular verbal categories.

On this account, the distribution of difference scores would be expected to be bimodal, which it appears to be by inspection. To assess this possibility more formally, Dr I. Nimmo-Smith applied Silverman's (1981) simulation procedure for estimating the number of modes in a distribution. The hypothesis that the obtained scores came from a unimodal distribution could be rejected at $P < 0.005$ significance level.

Turning to the individual categories, the findings of this experiment are in general in accord with the category effects reported in Experiments 2, 3 and 4. There are a number of somewhat anomalous findings that will be discussed below.

Experiment 8: Recognition of Animals, Foods and Inanimate Objects

Clinical assessment of K.B. and I.N.G. indicate fairly marked nominal and expressive difficulties. It was therefore inappropriate to investigate picture and word identification by verbal description. Instead a matching to sample technique was adopted. J.B.R. was also tested. Identification of animals, foods and inanimate objects was tested using a spoken word/picture matching test. The test stimuli consisted of arrays of 5 coloured pictures which were 5 animals, 5 foods or 5 inanimate objects (all taken from the Ladybird books series for young children) and the task was to match the spoken word to one of the 5 items in the array. The patients were tested in blocks of 20 trials; within a block the array remained the same and each of the 5 test stimuli was presented four times in pseudorandom order. The patients were under no pressure to respond quickly; the intertrial interval was approximately 2 s and the interblock interval approximately 2 min. The three stimulus categories were tested in a 3×3 Latin Square design, a different set of 5 items being used for each array, giving in all 15 items in each category (*see* Appendix).

The percentage correct for each category for each patient is shown in Table 11. For each patient 3×2 contingency tables were drawn up comparing across categories the number of items for which performance was perfect across all four trials with the number where performance was impaired. The contingency tables were then analysed using the Lancaster/Irwin method for partitioning the χ^2 statistic (Everitt, 1977). For all 3 patients there was no significant difference between performance with animals and foods (J.B.R., $\chi^2 = 1.21$, $P > 0.2$, 1 d.f.; K.B. and I.N.G., $\chi^2 = 0$). For all 3 patients performance on inanimate objects was significantly better than the other two categories (J.B.R., $\chi^2 = 13.01$, $P < 0.001$, 1 d.f.; K.B., $\chi^2 = 18.41$, $P < 0.001$, 1 d.f.; I.N.G., $\chi^2 = 5.41$, $P < 0.05$, 1 d.f.). Matching to sample therefore gives completely analogous results to the verbal description procedure.

TABLE 11. EXPERIMENT 8. WORD/PICTURE MATCHING

	Animals	*Foods*	*Inanimate objects*
J.B.R. (25.2.83)	67	60	98
K.B. (7.5.81)	45	55	85
I.N.G. (14.6.82)	80	85	97

Percentage correct for each category (Chance = 20 per cent).

DISCUSSION

In this series of experiments we have attempted to document the visual identification and auditory comprehension deficits of 4 patients who had made a partial recovery from herpes simplex encephalitis. These patients were selected for more detailed investigation on the basis of clinical observations that suggested that their knowledge of certain categories of visual objects appeared to be selectively impaired. It had been noted that they all had much greater difficulty in identifying living things than inanimate objects.

The patients differed in one major respect. Two of the patients, J.B.R. and S.B.Y., had fluent spontaneous speech with normal articulation, phrase length and syntax. The other 2 patients, K.B. and I.N.G., however, had marked expressive speech difficulties; only a single experiment using the matching to sample technique was therefore possible. In other respects the pattern of performance of all 4 patients was remarkably similar. Two minor exceptions were noted: (1) the selective preservation of abstract word comprehension in S.B.Y., and (2) the relative preservation of nominal skills in J.B.R. In this discussion we will make the assumption that had it been feasible to test K.B. and I.N.G. using verbal description procedures, their performance would in all critical respects have been similar to that of J.B.R. and S.B.Y.

The major findings of this investigation are as follows.

1. *Category Specificity*

The identification of inanimate objects was remarkably well preserved when compared with the identification of living things and foods. Experiments 2 and 3 established a very striking dissociation between identification of objects and living things. In Experiment 4 it was found that the identification of foods was very impaired as compared with inanimate objects. In Experiments 5 and 8 the same dissociation between inanimate objects and foods and living things was observed. Furthermore our evidence for category specificity is derived from four different methods of assessment, namely, verbal description, naming, mimed responses and picture/word matching. Other aspects of category specificity were explored in Experiments 6 and 7. Comprehension of abstract words was remarkably well preserved in one patient (S.B.Y.) when contrasted with his comprehension of concrete words (Experiment 6). In Experiment 7 a much wider range of categories was probed using the Battig and Montague (1969) stimulus lists. J.B.R.'s knowledge of this range of categories appeared to be distributed bimodally, both when compared with an 'expected' score and with the performance of a matched control subject; knowledge of most categories was either relatively spared or grossly impaired. The significance of these findings is discussed below.

2. *Comparison of Verbal and Visual Modalities*

Although these patients were selected on the basis of visual identification difficulties they were found to have very comparable difficulties in comprehending the spoken word. Experiment 1, which provided a baseline measure of the severity of their visual identification difficulties for comparison with previously reported patients (Warrington, 1975, 1981), also permitted a direct comparison of knowledge within the visual and verbal domains. Their performance was at a very similar level on both tasks. In the three experiments (2, 4 and 5) which explore category specificity in both domains, an identical pattern of selective preservation and impairment was observed.

3. *Response Consistency*

Somewhat different patterns of responses were obtained for presentation of the same stimulus item on separate occasions within a modality and between modalities. In general, with one exception, there was an insignificant degree of consistency for comparison of responses between modalities (4/5). In contrast there was a significant degree of response consistency for all comparisons within a modality (3/3).

4. *Semantic and Phonological Errors*

In Experiments 3 and 4 superordinate (categorical) information was preserved for a high proportion of the items on which subordinate information could not be retrieved. In Experiment 6 that investigated knowledge of the full abstract/concrete range of content words there was also a high incidence of error responses which indicated preservation of superordinate information. In addition a small but significant number of the 'phonological' errors previously observed by Coughlan and Warrington (1981) were recorded.

Our discussion of these findings will concentrate on their relevance for understanding the organization of the semantic systems. But first, we must consider whether any of our findings could be attributed (1) to artefacts of stimulus selection or (2) to other cognitive deficits.

Word frequency is a critical parameter for a wide range of verbal skills in the brain-damaged population (e.g. Howes, 1964; Poeck and Stachowiak, 1975). In our experiments, the test stimuli within each category were as far as possible balanced for word frequency. It is more difficult to balance for visual familiarity, but in Experiment 5 that compared food, animal, and inanimate object pictures, the effects of visual familiarity were partialled out by using the norms of Snodgrass and Vanderwart (1980); category effects were still obtained. Furthermore in a subsidiary experiment on normal subjects we found that the type of food stimuli used were rated the most familiar for a given word frequency (T. Shallice and R. McCarthy, unpublished). Thus one of the categories showing a robust and reliable deficit is also the most familiar.

It is of course possible that past experience might also influence word frequency and visual familiarity for a particular individual. However, the present series consisted of patients of both sexes, with a wide age range (23 to 55 years), who had very varied educational and occupational histories. Furthermore they all suffered from the same viral illness that is known to affect temporal lobe structures bilaterally (Illis and Gostling, 1972) and this was the case for these patients. We would therefore reject any explanation of our central findings in terms of stimulus selection bias or individual variations of cerebral organization.

Secondly, it is necessary to consider the possible confounding effects of associated deficits, in particular amnesia, dysphasia and perceptual impairments. There was evidence of a moderately severe amnesic syndrome in all 4 patients and it might be suggested that their retrograde deficit was so severe that information acquired in early life was not preserved. If, however, loss of knowledge acquired in childhood resulted from the same functional impairment as amnesia then any patient with a severe semantic memory deficit would also have to have a severe amnesic syndrome. This is not the case (*see* Warrington, 1975; Coughlan and Warrington, 1981). Furthermore, the category specificity findings themselves make the retrograde amnesia hypothesis untenable; any suggestion that food names were learned after names of inanimate objects would be absurd. Similarly, the category specificity findings are very difficult to explain in terms of some form of visual processing deficit.

In view of the associated aphasic impairments recorded in all four of these patients it is necessary to consider whether our results were confounded by word-finding difficulties. It is, however, unclear how the impoverished residual expressive vocabularies of our patients would bias their responses against living things and foods and in the case of S.B.Y. in favour of abstract words. In this regard it is worth noting that both J.B.R. and S.B.Y., in addition to being able to recognize colours, had an adequate colour name vocabulary. More critically on the picture/word matching tasks in which no verbal responses were required, equally clear evidence of category specificity was obtained for both the dissociation between the abstract and concrete categories (S.B.Y.) and that between inanimate objects, animals and foods (J.B.R., K.B., I.N.G.). In short, we claim that our findings are not secondary to an amnesic syndrome or to deficits of visual perception or expressive speech. It would appear therefore that the observed comprehension deficits arise within the semantic domain.

Before considering in more detail the significance of category specific impairments we will discuss briefly whether the deficits should be attributed to a degradation of the semantic entries themselves or alternatively to difficulty in the process of accessing the full semantic representation of the concept. It has previously been argued by ourselves (Warrington and Shallice, 1979) that the hallmarks of a degradation deficit are consistency of responding across multiple presentations of the same stimulus, especially the vulnerability of subordinate information and marked frequency effects. These properties were recorded in the present investigation. The relative invariance of identified and unidentified stimuli we interpret as reflecting a static impoverished knowledge base. Our data suggests that there is less correspondence between their knowledge of pictures and words—their visual and auditory vocabularies. Thus a particular concept can be consistently known from its visual representation and consistently *not* known from its verbal representation or of course the converse (the severity of the verbal and visual deficits being much the same). Strictly our arguments apply to the inanimate object category only, as floor and ceiling effects prevented a meaningful consistency analysis (both within and between modalities) for the other categories. Our inference is that two semantic systems—visual and verbal—are implicated and both are impaired in these patients. This conclusion is in accord with the findings reviewed in the Introduction that point to the existence of separate visual and verbal semantic systems.

The major finding of interest in this study is the evidence for category specificity. We have argued that our findings provide compelling evidence for the specific impairment and preservation of semantic information. It then becomes necessary to specify and explain the observed dissociations between preservation of knowledge of inanimate objects and impairment of knowledge of living things and foods. In fact the converse dissociation has already been documented for the auditory modality in a patient (V.E.R.) in whom comprehension of inanimate object names was impaired, food, animal and plant names being preserved (Warrington and McCarthy, 1983). If the categories sampled both in that investigation and the present study are considered, the overall pattern of performance appears to be the same except that the preserved and the impaired categories are reversed. The existence of this double dissociation eliminates any explanation in terms of general task difficulty or the increased vulnerability of particular categories.

In the case of V.E.R. it was argued that the preserved categories were those in which the identification of a particular category member depended upon a differentiation which stressed sensory features. To distinguish between a strawberry and a raspberry depends critically upon fine differences in colour, shape, size and texture. Similarly such information must also be accessed to achieve precise verbal comprehension.

Inanimate objects unlike, say, most animals and plants, have clearly defined functions. The evolutionary development of tool using has led to finer and finer functional differentiations of artefacts for an increasing range of purposes. Individual inanimate objects have specific functions and are designed for activities appropriate to their function. Consider, for instance, chalk, crayon and pencil; they are all used for drawing and writing, but they have subtly different functions. Their crucial defining characteristic is their use with a particular writing surface, for example, blackboard, drawing paper, writing paper. Similarly, jar, jug and vase are identified in terms of their function, namely, to hold a particular type of object, but the sensory features of each can vary considerably. By contrast, functional attributes contribute minimally to the identification of living things (e.g. lion, tiger and leopard), whereas sensory attributes provide the definitive characteristics (e.g. plain, striped, or spotted). We would suggest that identification of an inanimate object crucially depends on determination of its functional significance, but that this is irrelevant for identification of living things. We would therefore speculate that a semantic system based on functional specifications might have evolved for the identification of inanimate objects. The other major categories we have considered might well have some representation in such a system, but this, we assume, would be inadequate for precise identification. To achieve precise identification for foods and living things, other semantic systems based on sensory features would be required (*see* Warrington and McCarthy, 1983). Such semantic systems would presumably have different patterns of associative links with other cognitive systems such as those underlying action and intention and associative links with other sensory modalities.

This distinction between functional significance and sensory features is clearly applicable to the major categorical dissociation we have observed, namely, those between inanimate objects on the one hand and living things and foods on the other. How does this distinction relate to our findings on the wider range of categories sampled in Experiment 7? The observation of a bimodal distribution of performance between those categories that are relatively spared and those that are grossly impaired supports the concept of category specific preservation and impairment. Although the findings for many of the individual categories selectively preserved or impaired are in good accord with our major distinction, this formulation may well be incomplete. For instance the distinction is hardly applicable to categories such as weather and land formation (both preserved categories). We note that impaired categories include cloths and precious stones, which are inanimate objects. We would argue, however, that these categories have only a 'generic' function and that such stimuli might be more easily differentiated by their sensory features. A more abstract category—diseases—can perhaps also be understood in these terms.

The major anomalies to emerge are the findings that J.B.R. obtained a very poor score indeed on the musical instrument category and a relatively good score on body parts. Whether these results reflect the confounding effects of word frequency or whether there is a more fine grain categorical organization of semantic systems than has hitherto been supposed needs to be clarified by further studies. Nevertheless evidence for category specificity, *per se*, would appear to be robust. The dissociations are striking and generalize over a wide range of stimuli.

Further support for a more general level of category specificity within the semantic systems is provided by the findings on the comprehension of abstract words. The relative preservation of the comprehension of abstract concepts compared with concrete concepts has been previously reported (Warrington, 1975). S.B.Y. (Experiment 6) provides a very clear second instance of this unexpected syndrome. His comprehension of low frequency abstract words was nearly perfect, far superior to his comprehension of concrete words of equivalent frequency. (For further discussion of the significance of category specificity, *see* Warrington and McCarthy, 1983.)

Neurological Considerations

All 4 patients described here were diagnosed as cases of herpes simplex encephalitis. In each, there was evidence of bilateral brain disease affecting in particular the temporal lobe structures. The severe global amnesic sydrome present in all 4 patients has frequently been described in herpes simplex encephalitis and is well recognized to be associated with bilateral temporal lobe disease. The neuropsychological syndrome we have described in this investigation—a specific impairment of visual and verbal identification—would generally be accepted as lateralized to the left hemisphere, the temporal and ventral occipital regions being considered critical structures (Hécaen and Albert, 1978; Coughlan and Warrington, 1978). The lesions in our patients were widespread but included these regions.

Of particular neurological interest is that features of the Klüver-Bucy syndrome are a not infrequent feature in the acute phase of herpes simplex encephalitis (*see* Hierons *et al.*, 1978). Greenwood *et al.* (1983) have discussed this aspect of the illness in more detail and conclude that a more frequently observed symptom is bizarre eating and drinking behaviour. Three of our 4 patients were indeed observed to eat and drink indiscriminately in the acute phase. As we have documented a severe difficulty in identifying foods and comprehending food names in these patients the question arises as to whether their agnosia is causally related to the Klüver-Bucy syndrome or is an associated deficit.

We have described a new constellation of deficits in which, broadly speaking, visual identification and verbal comprehension of living things and foods appear to be selectively impaired and inanimate objects selectively preserved. Further investigation will establish whether or not this is a commonly occurring syndrome in patients with herpes simplex encephalitis.

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(*See overleaf for Appendix*)

APPENDIX

Stimuli used in Experiment 2

Animate stimuli

	Freq.		Freq		Freq
Peacock	33	Hedgehog	11	Panda	9
Deer	316	Lobster	29	Palm	119
Rose	461	Daffodil	6	Buttercup	4
Chestnut	24	Frog	171	Crab	62
Duck	216	Ladybird	2	Acorn	10
Camel	72	Holly	24	Wasp	32
Giraffe	40	Owl	137	Sheep	464
Kangaroo	43	Bear	557	Rabbit	209
Crocodile	61	Tulip	20	Ostrich	33
Parrot	94	Mouse	207	Beetle	41
Butterfly	77	Foxglove	0	Rhino	14
Tortoise	17	Eel	24	Shark	92
Fox	163	Poppy	15	Seaweed	41
Donkey	156	Toadstool	4	Squirrel	88
Crocus	0	Snail	47	Swan	29
Flamingo	7	Lizard	54	Spider	229

Inanimate stimuli

	Freq		Freq.		Freq.
Car	1752	Lighthouse	51	Scales	185
Submarine	122	Tent	208	Spade	7
Spanner	0	Decanter	0	Mittens	3
Thermometer	154	Kettle	88	Briefcase	3
Torch	28	Stool	58	Tankard	2
Violin	106	Towel	48	Wallet	13
Vice	14	Mincer	0	Axe	27
Piano	418	Toaster	16	Typewriter	43
Ladder	127	Scissors	72	Calculator	4
Saw	2900	Barometer	42	Binoculars	20
Drill	136	Canoe	164	Hammer	155
Tennis racket	24	Trumpet	77	Compass	210
Wheelbarrow	21	Windmill	33	Tricycle	10
Dustbin	0	Slippers	38	Headphones	3
Hoover	22	Guitar	101	Pram	0
Mop	16	Umbrella	51	Drums	128

The word frequencies were taken from the Carroll *et al* (1971) count. Where appropriate the frequency of the American equivalent is given

Stimuli used in Experiment 4

Food	*Freq.*	*Inanimate*	*Freq.*
Grapefruit	18	Rollerskates	2
Mixed nuts	143	Paint box	3
Cabbage	139	Swing	89
Pineapple	39	Balloon	233
Cake	244	Mirror	209
Cucumber	6	Camera	166
Beer	24	Crayon	83
Bread	515	Bicycle	182
Eggs	785	Cotton reel	12
Chocolate	143	Umbrella	51
Meat	617	Wheelbarrow	21
Tomatoes	49	Clothes peg	4
Orange	221	Pram	3
Biscuits	45	Button	130
Cheese	236	Mitten	3
Pear	32	Sandal	5
Ice cream	33	Belt	174
Soup	184	Double bass	2
Milk	849	Skipping rope	1
Sprouts	8	Trumpet	77
Lemon	44	Tankard	2
Strawberry	26	Basin (sink)	149
Baked beans	199	Radiator	25
Lolly	8	Shears	30
Onion	42	Electric fire	—
Mushroom	43	Scales	185
Chips	42	Jigsaw	8
Peas	70	Slide	182
Jelly	87	Drums	128
Apples	284	Tie	234