Category-specific naming deficit following cerebral infarction

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Studies aimed at characterizing the operation of cognitive functions in normal individuals have examined data from patients with focal cerebral insult. These studies assume that brain damage impairs functions of the cognitive processes along lines that honour the 'normal' pre-morbid organization of the cognitive system[1]. For example, detailed study of individual brain-damaged patients has revealed apparently selective disruption of cognitive functions such as auditory/verbal working memory[2], phonological processing ability[3], grapheme-to-phoneme translation procedures[4] and semantic processing[5]. Warrington *et al.* have studied patients with even more fine-grained selective disturbances of the semantic system[6,7]. The most selective deficits have been reported for four patients who were significantly better at identifying inanimate objects than they were at identifying living things and foods[8]. These patterns of selective deficit after localized brain damage provide important information about the normal organization of the lexicon, and ultimately about how components of the lexical system are related to particular neural substrates. Here, we report a case study of a patient demonstrating a very selective disturbance of the ability to name items from two related semantic categories. Despite normal performance on a large battery of lexical/semantic tasks, the patient shows a consistent and striking disability in naming members of the semantic categories of 'fruits' and 'vegetables'. The selectivity of this deficit supports a category-specific organization of the mental lexicon, and suggests independence of the processing routes involving naming and name recognition.

The patient studied here (M.D.) is a 34-year-old, right-handed male college graduate who works as a systems analyst for a large United States government agency. In August of 1981 he suffered a left-hemisphere cerebrovascular accident, which resulted acutely in a global aphasia and right hemiparesis. Within 1 month, he recovered to a mild expressive aphasia and mild hemiparesis. M.D. subsequently experienced several transient ischaemic attacks, and a left internal carotid artery occlusion was diagnosed. In December 1981, he was treated with extra-cranial/intra-cranial bypass surgery, which has been successful in averting further ischaemic episodes. A computerized tomography scan obtained at 1 month post-onset revealed an infarction involving the left frontal lobe and basal ganglia.

Early in 1983 M.D. was referred as a potential candidate for a research project on naming deficits in aphasia. His initial performance on all subtests of a standard language battery[9] indicated that he was not clinically aphasic, although he had some difficulty naming objects. He maintained that he was experiencing considerable difficulty with certain words. Further experimental testing suggested that these difficulties were focused on the semantic categories of 'fruits' and 'vegetables'. M.D. showed a striking inability to name such common items as Peach and Orange while able to name easily less frequent items such as Abacus and Sphinx.

To chart the boundaries and stability of this unusual deficit, M.D. was tested over 1 year with a variety of materials that were designed to evaluate the structure of his lexical/semantic system. Performance on a large battery of tests was excellent. This battery included: visual and auditory lexical decision; oral reading; word-picture matching (nouns and verbs); semantic categorization (words and pictures); and picture naming (oral and written). Unless some member of the semantic categories of fruits and vegetables were a stimulus item, M.D.'s scores were almost perfect.

Special tests were designed to focus on the problematic categories. M.D. was asked to name a large number of items (line drawings, coloured drawings, colour photographs and actual objects) from several semantic classes; Table 1 summarizes his performance for all stimulus types.

M.D. showed considerable difficulty in naming individual fruits and vegetables, but was able to name easily a large range of other pictures and objects. His seven naming errors outside the fruits/vegetables category involved two household items, four geometric shapes (for example, diamond) and one tree. He named correctly a total of 13 food products outside the categories of fruits and vegetables. The 'other' items given to M.D. for naming were chosen to cover a wide range of semantic categories. Some of these categories (for example, 'body parts') have members with a very high frequency of usage in the language, hence the mean frequency of occurrence[10] for the fruit/vegetable items (11.8 per million) was considerably lower than the mean for the other items (32.8 per million). This disparity does not explain M.D.'s selective impairment, however, as 73% of items in the other group were in the same frequency range as the fruit/vegetable items and were named without difficulty.

To investigate M.D.'s knowledge of the semantic category of these items, he was shown pictures of 75 items from the categories fruits, vegetables, animals, vehicles and food products and he was asked to sort them into piles on the basis of their semantic classification. He was then asked to label the categories thus produced; his errors consisted entirely of confusions involving the categories of fruits and vegetables. He categorized 3 out of 24 fruits as vegetables and 6 out of 23 vegetables as fruit. He also incorrectly classified two food products (butter, cheese) as vegetables, although he named them correctly. Although the absolute number of errors committed on this task was not very large, M.D. had considerable difficulty with it, performing slowly and complaining of uncertainty.

In another attempt to determine M.D.'s knowledge of the members of semantic categories, he was asked to generate as many names as possible from 17 categories. The mean number of fruits and vegetables generated in 1 min was 6.5, with an additional four vegetable names generated incorrectly as fruits. The mean number of items generated for the other 15 categories was 12.4, including 12 instances in the category food products.

M.D.'s ability to name and to categorize pictures of fruits and vegetables is compromised relative to his ability to name and to categorize members of other categories. A further set of tasks was designed to assess the possibility that this impairment is limited to stimuli processed through the visual modality. A set of 20 verbal definitions, containing perceptual, functional and category information, was developed for 10 fruit/vegetable items and 10 other items (animals, furniture and clothing). M.D. named two out of 10 fruits and vegetables and all of 10 other items from their definitions. Next, M.D. was asked to name a

Table 1 Number of correct naming responses

	Semantic category		
	Fruit	Vegetables	Other
Line drawings	5/11	7/11	11/11
Coloured drawings	4/6	5/7	18/18
Photographs	11/18	12/18	222/229
Real objects	10/13	13/23	11/11
Total	30/48 (0.63)	37/59 (0.63)	262/269 (0.97)

The 'other' category includes vehicles, toys, tools, animals, body parts, food products, school, bathroom, kitchen and personal items, clothing, colours, shapes and trees.

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set of objects that he could feel with either the left or right hand, but could not see. Fruit/vegetable items were selected on the basis of their tactile discriminability from other similar items. M.D. named 6 of 13 fruits, 11 of 21 vegetables and 11 of 12 other items (he failed on tea bag). There was no difference in performance based on the hand used.

M.D.'s selective naming deficit for fruit/vegetable items is not modality-specific, and therefore may be the result of a selective disturbance within the semantic system itself, rather than a problem with access to the semantic system. To assess this possibility, a series of tasks was designed to probe M.D.'s comprehension of the names that he has difficulty producing. A 45-item word/picture matching task was developed in which M.D. was required to point to one of two pictures in response to an aurally presented word. Fruit and vegetable items were represented, as well as vehicles, food products and animals. For half the items, the incorrect pictures were closely semantically related to the target. M.D.'s one error (confusion between rhinoceros and hippopotamus) was not within the fruits/vegetable category; he pointed immediately and with certainty to pictured fruits and vegetables on hearing their names.

M.D.'s comprehension of the properties of objects was assessed by asking him for judgements about the category, size, colour, texture and shape of eight fruit/vegetable items that he had previously misnamed, and four animals. Item names were presented aloud. Although some responses on this task were hesitant for the fruits/vegetables categories, they were correct for all properties.

Note that M.D. could categorize items correctly as fruits or vegetables when their names were presented aurally, suggesting that his difficulty in categorizing pictures of fruits and vegetables was related to his inability to name them. This possibility was supported by his ability to categorize correctly all the written names of the fruits and vegetables whose pictures he had found difficult to classify. On two separate occasions approximately 6 months apart, M.D. easily sorted 14 printed fruit/vegetable names into their proper categories, together with the names of 21 items from other categories.

The impairment to the semantic system revealed in this patient appears to be limited to two specific and related semantic categories and to situations that require him to name the objects or to categorize them without having first been given their names. M.D. is aware of this problem, and expresses some frustration with it. Although he confesses to knowing little about cooking or food in general, it is clear that his difficulty with these items is not consonant with his ability to name many other types of foods and food-related items; in this respect he differs from the patients studied by Warrington and Shallice[8], who had difficulty identifying all types of food products. Further, his failure to learn the names of these items after many test sessions that focused on this deficit suggests that this phenomenon does not reflect a simple pre-morbid lack of interest in these categories.

Although a unified lexical/semantic theory cannot be formulated on the basis of this one case, there are three important implications of these findings for the ultimate development of such a theory. First, the selective impairment of information in specific superordinate categories suggests that the organization of the semantic system in some sense honours those categorical distinctions. These results support and considerably extend previous neuropsychological investigations which have indicated a category-specific organization of the semantic system[6,8]. Second, the dissociation in categorization ability between performance with lexical instances (which is normal) and with pictorial instances (which is impaired) suggests that lexical categorization could be accomplished on the basis of strictly lexical, as opposed to semantic, information. Third, although a general dissociation between 'name recognition' and 'name retrieval' has been supported previously by results from aphasic patients[9], the category-specific dissociation found in M.D. indicates that the output lexicon is addressed by semantically categorized information that can be disrupted highly selectively.

The results reported here suggest that the lexical/semantic system is organized categorically and specifically at the level of the input and output processes to and from the system.

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1. Saffran, E. M. *Br. J. Psychol.* **73**, 317 (1982).
2. Warrington, E. K. & Shallice, T. *Brain* **92**, 885 (1969).
3. Caramazza, A., Berndt, R. S. & Basili, A. *Brain Language* **18**, 128 (1983).
4. Beauvois, M. F. & Derousne, J. *J. Nerurol. Neurosurg. Psychiat.* **42**, 1115 (1979).
5. Schwartz, M. F., Marin, O. S. M. & Saffran, E. M. *Brain Language* **7**, 277 (1979).
6. Warrington, E. *Br. J. Psychol.* **72**, 175-196 (1981).
7. Warrington, E. & McCarthy, R. *Brain* **106**, 859 (1983).
8. Warrington, E. & Shallice, T. *Brain* **107**, 829 (1984).
9. Goodglass, H. & Kaplan, E. *The Assessment of Aphasia and Related Disorders* (Lea & Febiger, Philadelphia, 1972).
10. Francis, N. & Kucera, H. *Frequency Analysis of English Usage* (Houghton Mifflin, Boston, 1982).

Three types of neuronal calcium channel with different calcium agonist sensitivity

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How many types of calcium channels exist in neurones? This question is fundamental to understanding how calcium entry contributes to diverse neuronal functions such as transmitter release, neurite extension, spike initiation and rhythmic firing[1-3]. There is considerable evidence for the presence of more than one type of Ca conductance in neurones[4-13] and other cells[14-18]. However, little is known about single-channel properties of diverse neuronal Ca channels, or their responsiveness to dihydropyridines, compounds widely used as labels in Ca channel purification[19-21]. Here we report evidence for the coexistence of three types of Ca channel in sensory neurones of the chick dorsal root ganglion. In addition to a large conductance channel that contributes long-lasting current at strong depolarizations (L), and a relatively tiny conductance that underlies a transient current activated at weak depolarizations (T), we find a third type of unitary activity (N) that is neither T nor L. N-type Ca channels require strongly negative potentials for complete removal of inactivation (unlike L) and strong depolarizations for activation (unlike T). The dihydropyridine Ca agonist Bay K 8644 strongly increases the opening probability of L-, but not T- or N-type channels.

Figure 1 shows evidence for three distinct components of Ca channel current in whole-cell recordings obtained under ionic conditions that minimize contamination by other currents. The components were distinguished kinetically by applying depolarizing test pulses at various levels from different holding potentials (h.p.). With h.p. = −40 mV (uppermost traces in each panel), strong depolarizations (−10, +10, +20 mV) are required to activate any inward current; the peak current-voltage relation (Fig. 1*b*, squares) is typical for a single-current component. Because this inward current component decays very slowly ($t_{1/2}$ of hundreds of milliseconds), we designate it 'L' (for long-lasting). Weak depolarizations from h.p. = −100 mV evoke a different Ca channel current (Fig. 1*a*), seen as a prominent shoulder at negative test potentials in the associated peak current-voltage plot (Fig. 1*b*, circles). The additional current becomes noticeable at −60 mV, and is nearly constant in amplitude between −40 and −10 mV, consistent with a very negative range of activation. As this component decays relatively rapidly

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