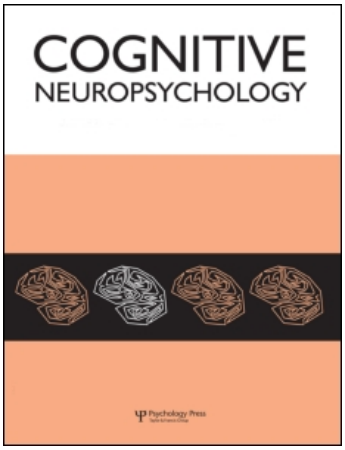

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A CASE OF IMPAIRED KNOWLEDGE FOR FRUIT AND VEGETABLES

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A CASE OF IMPAIRED KNOWLEDGE FOR FRUIT AND VEGETABLES

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In this paper, we report the case of RS, a brain-damaged patient presenting with a disproportionate conceptual impairment for fruit and vegetables in comparison to animals and artefacts. We argue that such a finer-grained category-specific deficit than the living/nonliving dichotomy provides a source of critical evidence for assessing current alternative theories of conceptual organisation in the brain. The case study was designed to evaluate distinct expectations derived from the categorical and the knowledge-specific accounts for category-specific semantic deficits. In particular, the integrity of object-colour knowledge has been assessed in order to determine whether the patient's deficit for fruit and vegetables was associated with a deficit for that kind of knowledge, which has been claimed to be highly diagnostic for fruit and vegetables. The results showed that the patient's pattern of performance is consistent with theories assuming a topographical category-like organisation of conceptual knowledge in the brain.

INTRODUCTION

The fact that brain damage can impair conceptual knowledge for some categories of entities while leaving knowledge of other categories relatively spared has found widespread empirical support in the last 20 years. The most often-reported pattern (e.g., Forde, Francis, Riddoch, Rumiati, & Humphreys, 1997; Laiacona, Capitani, & Barbarotto, 1997; Lambon Ralph, Howard, Nightingale, & Ellis, 1998; Moss, Tyler, Durrant-Peatfield, & Bunn, 1998; Samson, Pillon, & De Wilde, 1998) is certainly that of patients showing a loss of conceptual knowledge for living entities (animals, fruit and vegetables, flowers) in the face of relatively spared knowledge for nonliving ones (tools, vehicles, furniture), but there is now an increasing number of case reports of patients showing the reverse pattern of dissociation (e.g., Cappa, Frugoni, Pasquali, Perani, & Zorat, 1998; Gaillard, Auzou, Miret, Ozsancak, & Hannequin, 1998; Laiacona & Capitani, 2001; Moss & Tyler, 2000; Sacchett & Humphreys, 1992; Silveri, Gainotti, Perani, Cappelletti, Carbone, & Fazio, 1997; Warrington & McCarthy, 1983, 1987).

Such patterns of conceptual impairment have been used to inform theories of the organisation of conceptual knowledge in the brain/mind. Given the prevalence of selective or disproportionate deficits for either living or nonliving entities, current theoretical proposals and debates mainly focused on the issue of which organising principle of conceptual knowledge could be responsible for patterns of deficits conforming to the living/non-

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living distinction (see Caramazza, 1998; Forde & Humphreys, 1999, for a review). However, there is some evidence suggesting that the living/nonliving dimension is not the relevant one to account for the occurrence of category-specific deficits. Patients have been reported who were impaired in some but not all living categories. Thus, in several cases, the body part category has been found to be spared relative to the animal and fruit and vegetable categories (e.g., De Renzi & Lucchelli, 1994; Forde et al., 1997; Shelton, Fouch, & Caramazza, 1998; Silveri & Gainotti, 1988). In other cases, the animal category appeared to be more impaired than the fruit and vegetable category (e.g., Caramazza & Shelton, 1998; De Renzi & Lucchelli, 1994; Gainotti & Silveri, 1996; Hart & Gordon, 1992), while, in some others, fruit and vegetables were more impaired than animals (e.g., Farah & Wallace, 1992; Forde et al., 1997; Hart, Berndt, & Caramazza, 1985; Hillis & Caramazza, 1991; Pietrini, Nertempi, Vaglia, Revello, Pinna, & Ferro-Miloni, 1988).

In this paper, we will report an additional case of a brain-damaged patient presenting with a pattern of dissociation within the living category, namely, a disproportionate conceptual impairment for fruit and vegetables in comparison to animals and artefacts, and we will argue that such a finer-grained category-specific semantic deficit than the living/nonliving dichotomy provides a source of critical evidence for assessing current alternative theories of conceptual organisation in the brain/mind.

Among the previous case reports suggesting that all categories of living things are not necessarily equally impaired in case of a living things impairment, those of EW (Caramazza & Shelton, 1998), KR (Hart & Gordon, 1992), MD (Hart et al., 1985), TU (Farah & Wallace, 1992), and JJ (Hillis & Caramazza, 1991) present the clearest evidence that the animal category, on the one hand, and the fruit and vegetable category, on the other hand, can be damaged independently from each other. EW and KR both showed marked difficulty in naming animals, while they performed at ceiling when naming fruit and vegetables as well as manufactured objects. This pattern of dissociation was further observed in semantic tasks that did not require the production of the name of the object. Thus, in attribute verification tasks, EW performed very poorly with animals whether visual or nonvisual attributes were tested, but normally with inanimate objects, which comprised fruit and vegetables and artefacts. Likewise, KR performed at ceiling in attribute verification tasks both for fruit and vegetables and artefacts while his performance for animals was clearly impaired (the deficit was, however, confined to the retrieval of visual attributes). Hence, in both cases, the pattern of performance indicated a dissociation *within* the living things category, with impaired conceptual knowledge for animals and spared conceptual knowledge for fruit and vegetables.

On the other hand, the patients MD (Hart et al., 1985) and TU (Farah & Wallace, 1992) showed a selective impairment for fruit and vegetables, which appeared, however, to be restricted to naming. Thus, MD showed selective difficulty for fruit and vegetables as compared to other items in picture naming, naming from a verbal description, and verbal fluency tasks. He nevertheless showed quite good scores for fruit and vegetables in word categorisation, word/picture matching, and attribute verification tasks. The only task not requiring the production of the object's name, and for which MD showed a mild selective impairment for fruit and vegetables as compared to other items, was a picture categorisation task. TU's pattern of performance was quite similar. This patient was selectively impaired with fruit and vegetables in naming (from a picture or from a verbal description) and verbal fluency tasks. However, he performed well for fruit and vegetables in a word/picture matching task and could accurately define fruit and vegetables from a spoken name. Hence, in MD and TU, the selective difficulties in processing the category of fruit and vegetables seemed to be located at the name retrieval processing level.[1] Although there is no evidence in these cases that retrieving conceptual knowledge for fruit and vegetables is impaired per

[1] In the case of MD, an additional impairment at the visual recognition level cannot be excluded.

se, the selective naming difficulties might suggest that entries in the output lexicon are addressed by semantically categorised information in such a way that access to the name of fruit and vegetables from semantics can be selectively disrupted.

Finally, JJ (Hillis & Caramazza, 1991) showed marked difficulty with fruit and vegetables as well as manufactured objects in a picture naming task, while he was relatively accurate in naming animals. JJ also showed difficulties with nonanimal items when asked to provide definitions of them from spoken words, a pattern suggesting that semantic knowledge was impaired for these items. However, no separate scores were provided for fruit and vegetables and manufactured objects in this task, so that the extent to which semantic knowledge for fruit and vegetables was impaired relative to other item categories is unknown.

How could current theories of conceptual knowledge organisation explain that the animal and the fruit and vegetable categories can jointly be impaired (or spared) but, in some cases, can also selectively be impaired (or spared)? Current theories advanced to account for category-specific semantic deficits can be broadly classified into three classes.

The first class of theories assumes that category-specific semantic deficits reflect a topographical category-like organisation of conceptual knowledge within the brain: Conceptual knowledge associated with objects belonging to a particular category would be grouped in specific brain regions. Three proposals have been advanced within this framework, each of them making different assumptions as to the organising principle that would have led to such a topographical organisation of conceptual knowledge in the brain. The first proposal, the OUCH model (Caramazza, Hillis, Rapp, & Romani, 1990), adopts the view of a unitary semantic system whose internal organisation is determined by the strength of association between the various semantic properties. It is assumed that properties that are highly correlated tend to be represented in close proximity within the "semantic space." Given that members of a given category share many properties in common that are highly intercorrelated, the semantic properties of objects belonging to a given category tend to cluster together within the "semantic space." Selective semantic deficits for either animals or fruit and vegetables can hence be accounted for by assuming that the semantic properties associated with fruit and vegetables, on the one hand, and the semantic properties associated with animals, on the other hand, form two distinct clusters within the semantic space. Brain damage could then disrupt processing of both categories or only one of them, depending on the regions of the semantic space that happened to be damaged.

The second proposal assuming a topographical category-like organisation of knowledge is the one put forward by Damasio and his collaborators (e.g., Damasio, 1990; Tranel, Damasio, & Damasio, 1997). According to these authors, the retrieval of conceptual knowledge is achieved by "convergence zones" within the brain. These "convergence zones" are dedicated to reconstructing the various object properties that were pertinently associated in experience, which are represented across multiple sensory and motor cortices. Stemming from the assumption that the object properties that were pertinently associated in experience differ in kind across the various categories, the authors propose that the retrieval of conceptual knowledge associated with the various categories of objects is achieved by partially segregated convergence zones. Each of these convergence zones would indeed be located in the best suited anatomical region to permit the most effective interactions with those brain areas which represent the object properties they were designed to integrate. Although the empirical evidence advanced in support of this proposal mainly focused on the animal/tool/familiar person distinction (Tranel et al., 1997; Tranel, Logan, Frank, & Damasio, 1997), it could be extrapolated that the retrieval of conceptual knowledge for fruit and vegetables also relies on the activation of specific convergence zones. Thus, processing animals or fruit and vegetables or both categories could be impaired, depending on the particular brain region that is damaged.

The third proposal related to the notion that conceptual knowledge for the various categories of objects is represented and processed in distinct

brain areas is known as the domain-specific knowledge hypothesis (Caramazza & Shelton, 1998). Within this hypothesis, the driving force leading to such a topographical organisation is believed to be an evolutionary one. The organisation of conceptual knowledge in the brain would reflect neural adaptations in response to evolutionary pressures for the rapid and successful identification of evolutionary salient categories of objects. These were identified as animals, plant life, and conspecifics. From this point of view, category-specific deficits reflect either a defect to one (or several) of the specialised neural systems (i.e., the systems sustaining knowledge about animals, plant life, or conspecifics) or a selective preservation of these neural systems in the case of a category-specific deficit for nonliving things. This third proposal is certainly the one that most explicitly expects a dissociation between the animal and the fruit and vegetable categories.

The second class of theories also takes category-specific semantic deficits as evidence for a topographical structuration of conceptual knowledge in the brain. However, semantic properties would not be grouped within the brain according to the category of object they are associated with, but rather on the basis of the kind of object properties to which they refer. Initially, it has been proposed that the semantic system is subdivided into a visual and a functional subsystem, storing knowledge about visual and functional properties of objects, respectively (Farah & McClelland, 1991; Warrington & Shallice, 1984). Stemming from the assumption that the distinction between objects from the various semantic categories covaries with the kind of semantic properties that are the most diagnostic for these objects, category-specific deficits were attributed to selective damage either to the visual or the functional semantic subsystem. Thus, as living things were assumed to be primarily defined by visual properties, category-specific deficits for living things were seen as resulting from damage to the visual semantic subsystem. Conversely, as the semantic representation of nonliving things was assumed to be highly weighted on functional properties, category-specific deficits for nonliving things would result from damage to the functional semantic subsystem. This account could only explain category-specific deficits that conform to the living/nonliving distinction. However, subsequently, other authors enlarged the visual vs. functional dichotomy and proposed that conceptual knowledge is stored across more distributed knowledge stores (Humphreys & Forde, 2001; Warrington & McCarthy, 1987). Thus, visual knowledge would be represented across distinct shape, colour, and texture knowledge stores, other sensory knowledge across distinct auditory, tactile, and olfactory knowledge stores, and functional knowledge across encyclopaedic and action-related knowledge stores. This modified theoretical framework leaves room to explain finer-grained dissociation within the broad living and nonliving categories. According to this "knowledge-specific" account, a selective deficit for animals or a selective deficit for fruit and vegetables would result from selective damage to the knowledge store representing information assumed to have high weighting in the representation of animals or fruit and vegetables, i.e., the shape or the colour knowledge store, respectively (Humphreys & Forde, 2001; Warrington & McCarthy, 1987).

A third class of accounts attributes category-specific deficits to some object or concept properties that systematically covary with semantic category. The most frequently invoked properties are structural similarity (Gaffan & Heywood, 1993; Humphreys, Riddoch, & Quinlan, 1988) and the structure of correlations among the concept's features (Devlin, Gonnerman, Andersen, & Seidenberg, 1998; Tyler, Moss, Durrant-Peatfield, & Levy, 2000). Up to now, these accounts were mainly articulated in relation to category-specific deficits for living or nonliving things; they are nevertheless based on assumptions that might be extended to account for finer-grained specific deficits.

The structural similarity account highlighted the fact that exemplars belonging to living categories are more structurally similar than exemplars belonging to nonliving categories, so that more competition needs to be resolved throughout the

identification processes of living things. Accordingly, living things would be more vulnerable to brain damage than nonliving things. The hypothesis of greater structural similarity between living than nonliving things found empirical support in a study by Humphreys et al. (1988), which also found that fruit and vegetables were slightly more structurally similar than animals. Thus, the structural similarity account could explain why brain damage impairs fruit and vegetables more than animals. However, the reverse pattern, that is, a selective impairment for animals with spared knowledge for fruit and vegetables, could not find an explanation within this framework.

The correlational structure account is based on the assumption that concepts are represented as patterns of activation over many semantic features within a unitary distributed conceptual system and that category-specific deficits emerge as a result of differences in the internal structure of concepts across categories. The internal structure of concepts is determined by the set of features activated and the degree of correlations among these features, which reflect the extent to which they co-occur together in concepts (for example, the feature "having a head" and "having eyes" are very strongly correlated as they always occur together). Feature correlations are thought to have significant consequences in the condition of brain damage. It is assumed that correlated features support each other with mutual activation, so that strongly correlated features should be more resilient to damage within the semantic system than features that are more weakly correlated. One of the variants of the correlational account, that of Devlin et al. (1998), proposes that features of the concepts in the living category are more strongly intercorrelated than those in the nonliving category so that living concepts should be more resilient to mild damage within the semantic system than nonliving ones. As the level of damage increases, however, the intercorrelated features would collapse en masse so that living concepts would be far more impaired than nonliving concepts. The variant of the correlational account proposed by Tyler and her colleagues (Moss et al., 1998; Tyler et al., 2000; Tyler & Moss, 2001) makes the reverse prediction, namely, living concepts should be less robust to damage than nonliving ones; nonliving deficits will only be seen when damage to the semantic system is particularly severe (Moss & Tyler, 2000; Tyler et al., 2000). This expectation derives from the additional notion that successfully identifying an individual concept relies heavily on activating its *distinctive* features, i.e., those features that are necessary for accurate discrimination among similar members of a category. Thus, individual concepts will be preserved, following brain damage, insofar as they have strong correlations among their more distinctive properties. It is further claimed that concepts of living things have distinctive properties that tend to be weakly correlated, or not correlated at all, with other properties and so are particularly vulnerable to damage. In contrast, because artefacts have distinctive forms that are consistently associated with the distinctive functions for which they were created, concepts of artefacts are characterised by strong correlations between their distinctive properties, which makes the individual concepts of artefacts more resistant to damage than those of living things.

In principle, correlational structure accounts could be able to explain finer-grained category-specific impairments, such as a specific impairment for fruit and vegetables or a specific impairment for animals, on the basis of the additional assumption that the internal structure of both these kinds of living thing concepts differs in a systematic way. The available empirical estimates of feature relations do reveal some differences within the living thing category. Thus, estimates by Devlin et al. (1998) indicate that concepts of fruit and vegetables have a higher number of correlated features than animals. Under the Devlin et al. approach, such a pattern should make the concepts of fruit and vegetables more robust to damage than the concepts of animals. This implies that fruit and vegetables should be spared in case of mild damage and, furthermore, when fruit and vegetables are impaired, animals should be impaired too. As regards the pattern of correlations among distinctive features, the available data seem less consistent.

Tyler and Moss (2001; Moss, Tyler, & Devlin, 2002) stated that fruit and vegetables have very few, poorly correlated distinctive features. On this basis, the authors predict that concepts in the category of fruit and vegetables will be the most vulnerable at all levels of damage. However, estimates by McRae and Cree (2002) indicate that fruit and vegetables tend to have more, rather than fewer, distinctive features than animals, and a similar, if not a higher, number of correlated features. Unfortunately, the degree of intercorrelation among distinctive features is not provided in this study. Thus it appears that one must wait for more complete estimates of feature relations before being able to draw firm predictions concerning finer category-specific deficits within the correlational structure accounts. It is worth underlining, however, that even if the results of these estimates supported the notion that the concepts of fruit and vegetables systematically differ from the concepts of animals in their internal structure, both variants of the correlational structure account would still have great difficulty accounting for a pattern of a *double* dissociation between animals and fruit and vegetables reported in the context of a *mild* semantic impairment.

From this brief overview of the main theoretical accounts for category-specific deficits, it appears that the first two classes of accounts, the topographical category-like and knowledge-specific organisation accounts, provide a theoretical framework that most naturally explains the deficits affecting selectively either the animal or the fruit and vegetable category. It also appears that the inspection of the kind of semantic properties that are impaired in such cases might be a basis on which both types of accounts can be put to the test. The accounts assuming a category-like organisation of knowledge predict that all kinds of semantic properties associated with objects from the impaired category should be impaired while all kinds of semantic properties associated with objects from the spared categories should be spared. In contrast, the accounts assuming an organisation of knowledge by kind of semantic properties predicts that a selective impairment of a given category should be associated with a selective impairment in retrieving knowledge that is particularly diagnostic for that impaired category, namely, shape knowledge for animals and colour knowledge for fruit and vegetables, as proposed by the defenders of the knowledge-specific accounts (Humphreys & Forde, 2001; Warrington & McCarthy, 1987). Moreover, this particular kind of knowledge should be impaired across all categories (but see Humphreys & Forde, 2001, for a challenge of this latter prediction, and Pillon & Samson, 2001, for a discussion).

The previous case studies of patients presenting with a selective deficit for either the animal or the fruit and vegetables category provide little, if any, evidence with respect to these expectations. Among the case studies of patients presenting with a selective deficit for animals (EW: Caramazza & Shelton, 1998; KR: Hart & Gordon, 1992), only the KR study provided data relative to the patient's ability to retrieve the specific kind of visual knowledge that would be particularly diagnostic for animals, such as shape as opposed to colour information. It was found that KR was impaired at retrieving both shape and colour knowledge about animals, with her performance being nevertheless better for shape than colour knowledge probes (scoring 74% and 47% correct, respectively). In contrast, KR's performance was perfect when asked to retrieve both shape and colour knowledge about fruit and vegetables, as well as shape knowledge about vehicles. This pattern is inconsistent with the one expected in case of a selective loss of shape knowledge, which should lead to impaired retrieval of shape knowledge and spared retrieval of colour knowledge for all categories of items. However, the shape attributes that were probed in this study only related to very general shape properties, such as having or not having four legs for the animal items and having or not having wheels for the vehicle items. (The type of shape questions probed for fruit and vegetables was not specified.) Had the patient's knowledge been assessed with more specific or distinctive shape properties of objects, this study would have provided stronger evidence against the knowledge-specific accounts for category-specific deficits. As for the case studies of patients presenting with a selective deficit for fruit and vegetables

(JJ: Hillis & Caramazza, 1991; TU: Farah & Wallace, 1992; MD: Hart et al., 1985), the ability to retrieve different kinds of properties has been assessed only in the case of MD. MD was asked to give judgements about size, colour, shape, and texture for the eight fruit and vegetables he had previously misnamed and for four animals. His responses were 100% accurate for all the properties, which suggests spared access to both shape and colour knowledge. However, the item set used to probe the different kinds of objects' properties was very limited in size and the relevance of these data for the theories of conceptual knowledge organisation might be questioned on the grounds that MD appeared to suffer from a name-retrieval rather than a conceptual impairment for fruit and vegetables.

Other cases are potentially informative about the actual relationship between processing fruit and vegetables and object-colour information. These are cases of patients presenting with a deficit in retrieving object-colour knowledge (Della Sala, Kinnear, Spinnler, & Stangalino, 2000; Luzzatti & Davidoff, 1994; Miceli, Fouch, Capasso, Shelton, Tomaiuolo, & Caramazza, 2001). Within the framework of the knowledge-specific accounts, such a deficit should result in disproportionate difficulties in identifying and naming fruit and vegetables in comparison to other categories. Luzzatti and Davidoff (1994) reported the case of two patients, GG and AV, having difficulties in retrieving the colour of objects. The patients were presented with a picture naming task including natural and manufactured objects, with the natural items set comprising fruit and vegetables items (12 items among 44). GG was slightly more impaired with natural (61% correct) than manufactured objects (70% correct), whereas AV showed no category effect (86% and 88% correct for natural and manufactured items, respectively). Unfortunately, no separate scores were provided for the fruit and vegetables items within the natural set and it is thus unclear whether naming of fruit and vegetables was spared or not in these patients. More recently, Della Sala et al. (2000) investigated the retrieval of object-colour knowledge in a group of 33 patients with probable Alzheimer's disease. Among them, three patients were found to be impaired in retrieving the colour of objects pictured as black and white drawings, while being perfectly able to name the same objects as well as colours. The small number of items used in this study (i.e., nine items, among which were four fruit and vegetable items) does not allow us to draw a firm conclusion from this finding. However, it is worth noting that these patients failed to retrieve the colour of at least two of the fruit and vegetables they were able to name. This suggests that impaired access to object-colour knowledge does not necessarily result in impaired identification and naming of items from the fruit and vegetable category. Additional evidence pointing to that conclusion comes from the study of Miceli et al. (2001). The authors reported the case of a patient, IOC, who had impaired knowledge of the colour of objects in face of spared knowledge of other objects' properties like form, size, and function. This selective impairment of object-colour knowledge was not associated with disproportionate impairment in processing the meaning of fruit and vegetables items in comparison to other item categories like animals and artefacts. Thus, in a word-to-picture verification task, the patient scored 63% for animals, 69% for artefacts, and 75% for fruit and vegetables (Shelton et al., 1998), a pattern that is clearly inconsistent with what is expected under the knowledge-specific account for category-specific deficits.

In sum, the previous case studies of patients presenting with a disproportionate deficit for either the animal or the fruit and vegetable category, or with a deficit in retrieving object-colour knowledge, did not investigate in a systematic way the issue of the particular association of deficits predicted by the knowledge-specific account for category-specific deficits, namely the association of a selective deficit in retrieving a particular kind of object's knowledge (shape vs. colour knowledge) with a selective or disproportionate deficit in processing a particular category of objects (animals vs. fruit and vegetables). Some of these studies (Della Sala et al., 2000; Hart & Gordon, 1992; Miceli et al., 2001) nevertheless provide some indirect evi-

dence that seem inconsistent with this expectation. The main purpose of the following case study was to seek for more direct evidence pertaining to that issue. In particular, the integrity of object-colour knowledge has been assessed in a patient presenting with a category-specific deficit for fruit and vegetables, in order to determine whether this deficit was associated with a deficit for that particular kind of knowledge.

The following study had two additional purposes. The first one was to show that brain damage could result in *conceptual* knowledge of fruit and vegetables being disproportionately impaired in comparison to knowledge of animals. As we have previously mentioned, there was no evidence that conceptual knowledge for fruit and vegetables was impaired in the cases of selective naming deficit for fruit and vegetables reported so far (MD: Hart et al., 1985; TU: Farah & Wallace, 1992; and JJ: Hillis & Caramazza, 1991), which makes unclear the significance of such patterns for theories of conceptual knowledge organisation. The second additional purpose of this case study was to ascertain that the dissociation in the patient's performance could not be caused by potentially confounding factors, such as word frequency and, more particularly, concept familiarity. In the cases of JJ (Hillis & Caramazza, 1991) and MD (Hart et al., 1985), the items from the various categories were not controlled for factors such as word frequency and concept familiarity. At first sight, concept familiarity alone could not explain the patients' disproportionate deficit for fruit and vegetables since, arguably, fruit and vegetables are much more familiar in our daily life than animals. However, personal or gender-specific experience must also be taken into consideration. For instance, Hart et al. reported that MD confessed "to knowing little about cooking or food in general". Studies with normal subjects found that males rated fruit and vegetables as less familiar than did females (Albanese, Capitani, Barbarotto, & Laiacona, 2000) and that, with fruit and vegetables, males perform worse than females in naming (McKenna & Parry, 1994) and verbal fluency tasks (Capitani, Laiacona, & Barbarotto, 1999). Strikingly, the two patients who were reported to have a selective impairment for animals (EW: Caramazza & Shelton, 1998; and KR: Hart & Gordon, 1992) were both females, whereas TU (Farah & Wallace, 1992), MD (Hart et al., 1985) and JJ (Hillis & Caramazza, 1991), who showed an impairment for fruit and vegetables, were all males. Accordingly, the dissociation along the animal/fruit and vegetable distinction reported so far might be an artefact of gender-specific familiarity. Given that the present report also concerns a male patient, an attempt was made to control for personal and gender-specific familiarity in assessing the patient's knowledge about fruit and vegetables.

CASE REPORT

RS is a right-handed and French-speaking civil engineer, who worked as General Secretary in an international company. In December 1997, at the age of 63, he suffered from an ischaemic stroke in the territory of the left posterior cerebral artery (PCA). Clinically, he showed a right homonymous hemianopia as well as some mild sensitive deficit on the right side of the body. The brain MR performed 24 hours after the onset of troubles showed a recent ischaemic-type lesion involving the whole arterial territory of PCA: the medial and inferior temporal lobe (hippocampus, parahippocampal gyrus, fusiform and lingual gyrus), the occipital lobe on its medial side, the left side of the splenium, as well as part of the left thalamus (see Figure 1).

Neuropsychological disorders were confined to the language area. On evaluation at 2 to 3 months post-stroke, RS's spontaneous speech was grammatical and fluent, without articulatory difficulties, but suggested a mild anomia. Anomia was also evidenced in a picture naming task (Bachy-Langedoc, 1988), in which the patient named only 22 of the 41 items correctly. The patient was impaired in a word-to-picture matching task (*LEXIS*: De Partz, Bilocq, De Wilde, Seron, & Pillon, 2001), scoring 63/80 (controls' mean = 79.3, *SD* = 0.46). However, his performance was within the normal range in a semantic matching task where he had to choose which of two pictures of object was semantically

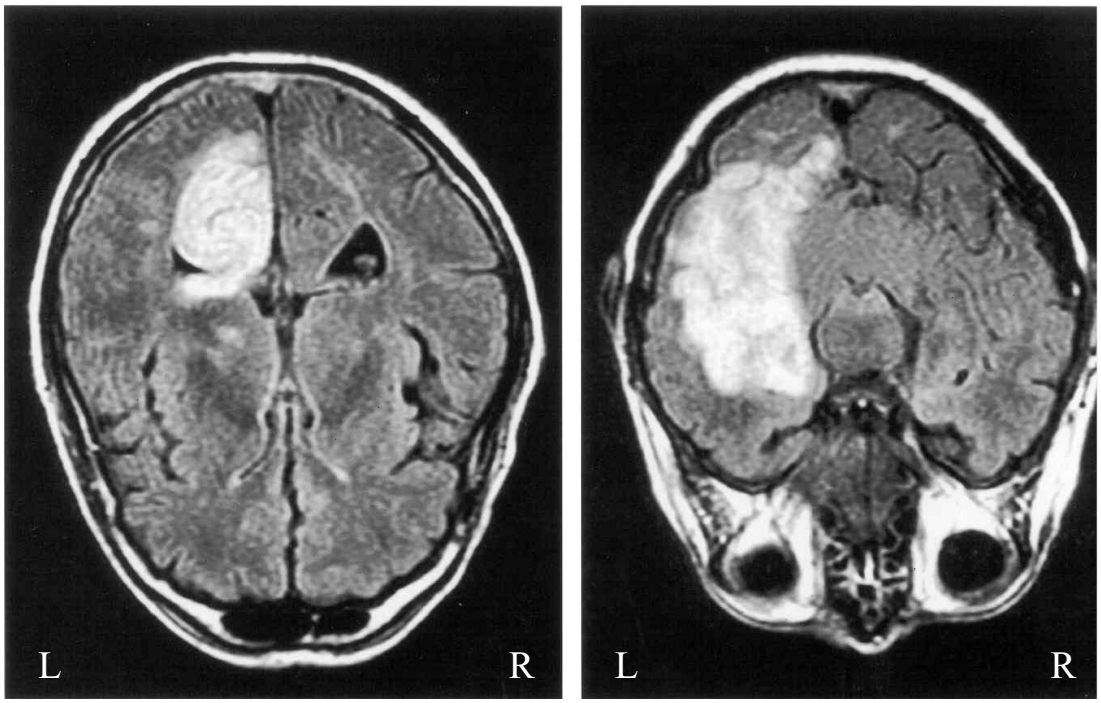

Figure 1. *MRI scan of RS, 24 hours post-onset.*

related to a target picture (*LEXIS*) and in a synonym matching task with concrete and abstract words (*Batterie d'épreuves évaluant la reconnaissance, la compréhension et la production de verbes et substantifs concrets et abstraits*, Pillon, Samson, & Gilmont, 1995). The reading and writing assessment revealed an alexia without agraphia for letters and words but not for numbers. Finally, at the BORB battery (Riddoch & Humphreys, 1993), RS performed within the normal range in the length, size, orientation, and position in gap matching tasks. His performance was also within the normal range on the different view matching tasks as well as in the object decision task.

RS was aware of his word-finding problems and appeared to be particularly dismayed by his difficulty in handling fruit, vegetables, and food items. He reported, for instance, that he never knew what he would find on his plate when ordering a meal in a restaurant. This apparently specific difficulty in identifying fruit and vegetables as well as food items was the focus of the study reported here. All the tests reported in this paper were carried out between March and December 1998.

EXPERIMENTAL INVESTIGATION

General assessment of RS's category-specific deficit

Test 1. Naming the items of the living/nonliving battery

Method. RS was presented with the living/nonliving battery (Samson et al., 1998), which includes 72 items: 18 animals, 18 fruit and vegetables, 18 implements, and 18 means of transport. The mean word frequency across all four categories did not differ significantly, but the mean rated concept familiarity and visual complexity (for the pictures) differed across the different semantic categories (see Samson et al., 1998, for more details and Table

Table 1. *RS's number and percentage of correct responses in naming tasks*

	Mean familiarity[a]	*Mean male familiarity*[a]	*Mean visual complexity*[b]	*Mean word frequency*[c]	*Oral picture naming*		*Oral naming to description*	
					N	%	*N*	%
Fruit and vegetables	3.64	3.48	2.16	430	3/18	17	7/18	39
Animals	1.65	1.67	3.55	1249	5/18	28	10/18	56
Implements	3.35	3.34	2.34	648	16/18	89	13/18	72
Transport	2.57	2.65	3.51	2516	17/18	94	14/18	78

[a]Familiarity as rated on a 5-point scale (1 = low familiarity; 5 = high familiarity).
[b]Visual complexity as rated on a 5-point scale (1 = low visual complexity; 5 = high visual complexity).
[c]Frequency value per 100×10^6 taken from Content, Mousty, and Radeau (1990).

1 for the mean values). Importantly, however, fruit and vegetables had the highest mean value of concept familiarity and the lowest mean value of visual complexity. Note that familiarity was rated by a group of 15 normal subjects, 6 of whom were males. When taking into account the ratings of the male subjects only (cf. the gender-specific familiarity effect, Albanese et al., 2000; Capitani et al., 1999), the fruit and vegetable category was still the most familiar category of items (see Table 1). The 72 items were presented in two naming conditions: oral picture naming and oral naming to verbal description. The verbal descriptions provided information about category-membership of the target, its physical appearance and functional properties, as well as encyclopaedic information.

Results. RS's scores in the two naming conditions are displayed in Table 1. Strikingly, despite the fruit and vegetable category being both the most familiar and the less visually complex category of items, RS's score was the lowest for that category in both naming conditions. It is therefore unlikely that concept familiarity (either general or gender-specific) and visual complexity alone could explain RS's low performance in naming fruit and vegetables. However, although the four item categories did not significantly differ in word frequency, fruit and vegetable items appeared to have the lowest word frequency values. A logistic regression analysis was therefore performed in order to control for this potentially confounding factor. Another aim of this analysis was to evaluate the significance of RS's poor performance in naming animals, by controlling for the factors of visual complexity and concept familiarity. Both these factors could indeed make animal items more difficult to name than the items of the other categories since animal items were the less familiar and among the most visually complex items used in the battery.

The performances in the two naming tasks were analysed separately by means of a logistic regression analysis with the number of correct responses in each naming condition as the dependent variable and category (animals/fruit and vegetables/implements/means of transport), concept familiarity (either general familiarity, i.e., obtained from both male and female judges, or gender-specific familiarity), word frequency, and visual complexity (this latter factor being added for the picture naming condition only) as the independant variables. For the picture naming task, the analysis showed no significant effect of word frequency or visual complexity (both $\chi^2 < 1$); the effect of concept familiarity did not reach significance (general familiarity: $\chi^2 = 2.94$, $p = .09$; gender-specific familiarity: $\chi^2 = 2.10$, $p = .15$). However, the analysis showed a highly significant category effect once the three potentially confounded factors were controlled for (with general familiarity: $\chi^2 = 40.41$, $p < .001$; with gender-specific familiarity: $\chi^2 = 38.63$, $p < .001$). Planned contrasts showed that naming accuracy was significantly lower for fruit and vegetables as compared to the two nonliving categories (with general familiarity: $\chi^2 = 27.27$, $p < .001$; with gender-specific familiarity: $\chi^2 = 27.12$, $p < .001$). Naming accuracy was also significantly lower for animals as compared to the two nonliving categories (with general

familiarity: $\chi^2 = 4.51$, $p < .04$; with gender-specific familiarity: $\chi^2 = 4.88$, $p < .03$). However, despite RS's naming accuracy for fruit and vegetables being lower than that for animals, this difference failed to reach significance (with general familiarity: $\chi^2 = 3.58$, $p = .06$; with gender-specific familiarity: $\chi^2 = 2.79$, $p = .09$).

For the naming to description task, the analysis revealed a significant effect of concept familiarity (general familiarity: $\chi^2 = 4.59$, $p < .04$; gender-specific familiarity: $\chi^2 = 4.96$, $p < .03$) but no significant effect of word frequency ($\chi^2 < 1$). The category effect was again significant once concept familiarity and word frequency were controlled for (with general familiarity: $\chi^2 = 10.20$, $p < .02$; with gender-specific familiarity: $\chi^2 = 10.13$, $p < .02$). Planned contrasts showed that RS's score for fruit and vegetables was significantly lower than his score for the two nonliving categories (with general familiarity: $\chi^2 = 10.08$, $p < .01$; with gender-specific familiarity: $\chi^2 = 9.90$, $p < .01$) and significantly lower than his score for animals (with general familiarity: $\chi^2 = 5.06$, $p < .03$; with gender-specific familiarity: $\chi^2 = 5.30$, $p < .03$). In contrast, RS's performance for animals was not significantly different from his score for the two nonliving categories (with general familiarity: $\chi^2 < 1$; with gender-specific familiarity: $\chi^2 < 1$).

As regards the nature of RS's errors in both naming tasks, they were nonresponses (81% and 68% of the errors in the picture naming and naming to description tasks, respectively) and semantic errors (19% and 32% of the errors, respectively). Semantic errors all consisted of providing a semantic coordinate of the target, e.g., *girafe* (giraffe) → *zèbre* (zebra); *fraise* (strawberry) → *orange* (orange); *pioche* (pickaxe) → *bêche* (spade); *mobylette* (motor cycle) → *vélo* (bike). Another striking feature of RS's responses in the picture naming task is that he frequently used verbal and nonverbal self-cueing strategies in order to cope with his word-finding problem. He tried to describe the entity (e.g., for *hippopotamus*, he said "it lives in the south, in a herd, near rivers, its head emerges from the water, it is peaceful"), made pantomimes, attempted to cue the target name by self-generating a sentence context (e.g., for "donkey," he said "stubborn as a . . ."), or by excluding other names (e.g., for "chain saw", he said "not a drill, not a saw . . ."). As can be seen in Table 2, RS mainly used naming approaches for fruit and vegetables, animals, and implements. (For means of transport, his responses were mostly straightforward and correct.) However, the quality of the naming approaches differed according to the category of the target item. Naming approaches more often contained precise and correct semantic information when produced for a target in the implement category than for a target in the animal or fruit and vegetables categories, with the naming

Table 2. *Distribution of RS's responses in the picture naming task according to whether they were produced after a naming approach or not*

	Fruit and veg	*Animals*	*Implements*	*Transport*	*Total*
Without naming approach					
Correct response	2	3	7	14	26 (81%)
Semantic error	1	1	0	1	3 (9%)
Nonresponse	0	3	0	0	3 (9%)
After a naming approach providing precise and correct semantic information[a]					
Correct response	1	2	7	2	12 (55%)
Semantic error	1	0	0	0	1 (5%)
Nonresponse	4	4	1	0	9 (41%)
After a naming approach providing only vague and/or incorrect semantic information					
Correct response	0	0	2	1	3 (17%)
Semantic error	1	1	0	0	2 (11%)
Nonresponse	8	4	1	0	13 (72%)

[a]Semantic approaches containing at least one specific semantic property and no false semantic property.

approaches produced for fruit and vegetables containing the least frequently precise and correct semantic information. Moreover, naming approaches led to a successful name retrieval mostly for items in the implement category. For the items in the fruit and vegetable and animal categories, even the few approaches containing some precise/correct information seldom led to a successful name retrieval. These qualitative observations not only suggest that the severity of RS's word-finding difficulties differ across the four categories, they also suggest that, for fruit and vegetables and, to a lesser extent, for animals, RS had additional difficulties in accessing the underlying semantic representations.

Test 2. Naming fruit and vegetables, manufactured food items, and domestic implements

In the previous naming tasks, we have shown that RS's poor performance in naming fruit and vegetables could not be explained by a familiarity effect, even when taking into account gender-specific familiarity ratings. Still, the possibility that RS shows a particularly low idiosyncratic familiarity with fruit and vegetables should be considered. RS actually stated that he almost never cooked nor bought food in stores. RS also claimed that he was not familiar with household activities. We therefore explored RS's naming abilities on a second set of items that was aimed at contrasting RS's performance for fruit and vegetables with his performance for domestic implements, i.e., a nonliving category which we believed would match fruit and vegetables more closely in idiosyncratic familiarity. The set of items also included manufactured food items, in order to determine if RS's problem was limited to fruit and vegetables or if it extended to the broader category of food.

Method. One hundred and fifty-three photographs depicting fruit and vegetables, manufactured food items, and domestic implements were presented to a group of five normal subjects (three males and two females). The subjects were instructed to name each item and rate on a 5-point scale how familiar the item was in their daily life (we used the same familiarity instructions as those used by Snodgrass & Vanderwart, 1980). From the 153 items, we chose 21 fruit and vegetables, 21 food items, and 21 domestic implements, which were closely matched for familiarity and could be correctly named by the control subjects. The selected items were also presented to a control subject matching RS in gender, age, educational level, and occupation. Note that the control subject also stated he was not expert in cooking and was almost never in charge of household activities.

Results. The performance of both RS and the control subject is displayed in Table 3. RS's performance for implements was comparable to that of the control subject (Fisher exact probability = .5); his performance for fruit and vegetables was however significantly lower than that of the control subject (Fisher exact probability = .0002) and the same pattern was found for manufactured food items (Fisher exact probability = .004). RS's deficit thus seemed to extend to the food category. RS's good performance for domestic implements in the face of his low familiarity with household activities is also interesting. It suggests that RS's poor performance for fruit and vegetables as well as for food

Table 3. *RS's and the control subject's naming performance (number and percentage of correct responses) for fruit and vegetables, manufactured food items, and domestic implements*

		RS		*Control subject*	
	Mean familiarity[a]	*N*	*%*	*N*	*%*
Fruit and vegetables	3.09	11/21	52	21/21	100
Food	3.1	14/21	67	21/21	100
Domestic implements	3.09	17/21	81	18/21	86

[a]Familiarity as rated on a 5-point scale (1 = low familiarity; 5 = high familiarity).

items did not result simply from his low idiosyncratic familiarity with such items.

Test 3. Object decision task

RS's performance in the object decision task of the BORB (Riddoch & Humphreys, 1993) was within the normal range. However, since RS's naming for fruit and vegetables and animals appeared to be slightly more impaired in the picture naming condition than in the naming to description condition, mild damage to the structural processing level could not be dismissed at this stage. Thus, in order to assess further the patient's structural processing abilities, another object decision task, which included items drawn from the four categories tested in the naming tasks, was presented.

Method. Seventy-two line drawings were presented. The items belonged to four semantic categories: animals, fruit and vegetables, implements, and means of transport. Half of the line drawings for each semantic category depicted real objects; the other half depicted unreal objects. Unreal objects were a combination of parts of two objects belonging to the same category (see Samson et al., 1998, for more details). RS was presented with the line drawings in a random order and was asked to say, for each line drawing, whether he recognised the entity depicted in the drawing as something that existed in real life.

Results. RS performed quite well in this task as he scored 67/72 (93%, a score within the normal range of the young controls used in a previous study, Samson et al., 1998). All errors consisted of accepting unreal objects. Four errors involved fruit and vegetables and one error involved an implement.

Test 4. Picture and word categorisation

Method. RS was presented with the 72 items of the living/nonliving battery, once as picture stimuli and once as word stimuli, and was asked to classify these items into four broad semantic categories: animals, fruit and vegetables, implements, and means of transport.

Results. RS performed this categorisation task easily and faultlessly, both with the pictures and with the words.

Test 5. Word/picture verification

Method. RS was given the picture of each of the 72 items of the living/nonliving battery simultaneously with a spoken word. He was asked to say if the word was the correct name for the pictured object. Each picture was presented once with the correct word, once with a word that was a "close" coordinate of the correct word (i.e., the picture of a donkey with the word *horse*) and once with a word that was a "far" coordinate of the correct word (i.e., the picture of a donkey with the word *hippopotamus*). An item was scored as correct when for a given picture, RS both accepted the correct word and rejected the two coordinate words.

Results. RS's performance was poorer for fruit and vegetables than for animals and the two nonliving categories (see Table 4). Errors in all four categories of items mostly consisted of accepting the close coordinate word (RS only once rejected the correct name of an animal, twice rejected the correct name of an implement, and twice accepted the name of a far coordinate for fruit and vegetables).

A logistic regression analysis with the same factors as those described in Test 1 revealed a significant effect of concept familiarity (general familiarity: $\chi^2 = 11.33$, $p < .001$; gender-specific familiarity: $\chi^2 = 10.23$, $p < .01$) but no significant effect of visual complexity or word frequency (all $\chi^2 < 1$). The category effect was significant even when the three potentially confounded factors were controlled for (with general familiarity: $\chi^2 = 12.41$, $p < .01$; with gender-specific familiarity: $\chi^2 = 11.15$, $p < .02$). Planned contrasts showed that RS's performance for fruit and vegetables was significantly lower than for animals (with general familiarity: $\chi^2 = 11.79$, $p < .001$; with gender-specific familiarity: $\chi^2 = 10.69$, $p < .01$) and the two nonliving categories (with general familiarity: $\chi^2 = 9.75$, $p < .01$; with gender-specific familiarity: $\chi^2 = 8.09$, $p < .01$). In contrast, RS's performance for animals was significantly better than his performance for nonliving

Table 4. *RS's number and percentage of correct responses in the word/picture verification and verbal description tasks*

	Word/picture verification		*Verbal description from a word*		*Verbal description from a picture*	
	N	%	*N*	%	*N*	%
Fruit and vegetables	9/18	50	8/18	44	7/18	39
Animals	16/18	89	13/18	72	13/18	72
Implements	13/18	72	14/18	78	16/18	89
Transport	16/18	89	18/18	100	15/18	83

things (with general familiarity: $\chi^2 = 4.42$, $p < .04$; with gender-specific familiarity: $\chi^2 = 4.59$, $p < .04$).

Test 6. Picture and word description task

Method. RS was given the 72 items of the living/nonliving battery, once as a picture and once as a word, and was asked to describe the object they referred to. Instructions stressed the fact that he should give as much relevant information as possible so that a subject, unaware of the picture RS was looking at or the word he heard, would be able to find out which entity he was defining. All his verbal descriptions were tape-recorded and then transcribed to be submitted to two groups of six independent judges. One group was asked to identify the items described in the "word" condition, and the other group was asked to identify the items described in the "picture" condition. An item was scored as correct if at least one judge had identified it with certainty from the patient's description. The patient's descriptions leading to correct but unsure identifications or for which the judges considered that part of the provided information was wrong were scored as incorrect. In that way, we considered as correct responses the descriptions that contained not only correct, but also sufficiently relevant semantic information to allow one to identify the entity described with certainty.

Results. In both the picture and the word description tasks, a similar pattern to that found in the word/picture verification task emerged (see Table 4), with the patient's performance being poorer for fruit and vegetables than animals and the two nonliving categories. Qualitatively, we noted that RS's descriptions of nonliving items as well as animals were strikingly precise (including both visual and nonvisual attributes) as compared to his descriptions of fruit and vegetables. For instance, RS described a camel (from a picture input) as "an exotic animal with two humps on its back; it is used as transport with people sitting between the two humps; it is a peaceful animal widely used by nomads who cross the desert" or a giraffe (from a word input) as "an animal of a big size with a long neck and a handsome head; it lives in a herd and its coat has white and black spots. Its long neck allows it to eat the leaves from the trees, a food it really likes." Similarly, RS described a balloon (from a picture input) as "an air transportation that transports humans but also cameras or other things; it moves in the sky because it is filled with a light gas; its height can be adjusted by changing the proportion of gas" or a screwdriver (from a word input) as "a tool with a handle and an active part which is flat and relatively pointed, it allows to enter into a body through a rotary movement." In contrast, RS's descriptions of fruit and vegetables were more hesitant and less precise. He described a cherry (from a word input) as "a nice fruit, it grows in our country" or a carrot (from a word input) as "a vegetable, longer than large, its colour is gray-green; you cut it into small pieces; it gives taste to the dishes." In the picture condition, RS often only described what he saw on the picture. For instance, in front of the picture of a tomato, he said "it is a vegetable, it has an appendage, an envelope, it is maybe of a kind of rose colour and inside . . . it depends, I think it could be two or three different vegetables" or, for watermelon (the picture shows the internal part of the fruit), he said "it is a condiment, a fruit, surrounded with a shell, it is more or less 20 cm big,

it is elongated, inside there is a mixture of seeds and things to eat."

A logistic regression analysis was conducted separately for the picture and word conditions with the same factors as those described earlier (with visual complexity being introduced into the analysis for the picture condition only). For the picture condition, the analysis showed no significant effect of concept familiarity, word frequency or visual complexity ($1.24 < \chi^2 < 0.11$, $0.26 < p < .74$), but a significant category effect once all these three factors were controlled for (with general familiarity: $\chi^2 = 12.05$, $p < .01$; with gender-specific familiarity: $\chi^2 = 11.41$, $p < .01$). Planned contrasts showed that RS's performance was significantly lower for fruit and vegetables than for nonliving items (with general familiarity: $\chi^2 = 9.18$, $p < .01$; with gender-specific familiarity: $\chi^2 = 8.30$, $p < .01$), but the difference between his performance for fruit and vegetables and for animals was not statistically significant (with general familiarity: $\chi^2 = 2.01$, $p = .16$; with gender-specific familiarity: $\chi^2 = 1.10$, $p = .30$). Again, RS's performance for animals was comparable to his performance for nonliving items (with general familiarity: $\chi^2 < 1$; with gender-specific familiarity: $\chi^2 < 1$).

In the word condition, the logistic regression analysis showed a significant effect of concept familiarity (general familiarity: $\chi^2 = 5.11$, $p < .03$; gender-specific familiarity: $\chi^2 = 7.73$, $p < .01$) but no significant effect of word frequency ($\chi^2 < 1$). The category effect was significant once concept familiarity and word frequency were controlled for (with general familiarity: $\chi^2 = 19.16$, $p < .001$; with gender-specific familiarity: $\chi^2 = 21.70$, $p < .001$). Planned contrasts revealed a significant difference between RS's score for fruit and vegetables and his score for nonliving things (with general familiarity: $\chi^2 = 17.91$, $p < .001$; with gender-specific familiarity: $\chi^2 = 19.97$, $p < .001$) as well as a significant difference between RS's score for fruit and vegetables and his score for animals (with general familiarity: $\chi^2 = 7.25$, $p < .01$; with gender-specific familiarity: $\chi^2 = 9.77$, $p < .01$). RS's performance for animals was however not significantly different from his performance for nonliving things (with general familiarity: $\chi^2 < 1$; with gender-specific familiarity: $\chi^2 < 1$).

Test 7. Attribute verification task

The aim of this test was to assess RS's ability to retrieve a set of semantic properties of fruit and vegetables as well as of items from the other categories. Although the task was not designed to properly evaluate possible differences in retrieving visual vs. nonvisual knowledge, both kinds of knowledge were probed, so that it could provide some information on this issue.

Method. Fifteen animals, 15 fruit and vegetables, 16 implements, and 16 means of transport were used for this task. These items were a subset of the items used in the naming and other semantic tasks. The name of each of the 62 items was presented in four sentences, two stressing a correct semantic attribute (one visual, one nonvisual) and two stressing a wrong semantic attribute (one visual, one nonvisual). The visual attributes consisted of describing a part of the object, its global appearance or its colour. The nonvisual attributes referred, for animals, to eating habits, moving habits, living environment or human use; for fruit and vegetables, they referred to taste, cooking, or growing environment; for implements, to their functional use; and for means of transport, stated what is transported, the context in which it is used, or the specific place where it is used. False statements were constructed by assigning a true attribute of an item to another item of the same category. The 248 verbal statements were submitted in questionnaire form to 10 control subjects (age 19 to 27 years) who were asked to verify the statements and to rate on a 5-point scale how easy it was to answer (1 = *very easy*; 5 = *very difficult*). The mean rated difficulty was 1.66 ("true" statements) and 2.11 ("false" statements) for fruit and vegetables, 1.92 ("true" statements) and 2.16 ("false" statements) for animals, 1.92 ("true" statements) and 1.97 ("false" statements) for implements, and 1.65 ("true" statements) and 2.00 ("false" statements) for means of transport. False statements were judged more difficult than true statements, $F(1, 240) = 9.00$, $p < .01$, but there was no significant difference in the mean difficulty of

statements between the four item categories, $F(3, 240) = 1.03$, $p = .38$. No significant item category × truth value interaction was found either, $F(3, 240) < 1$. RS was presented with each statement and asked to say if it was true or false.

Results. An item was scored as correct when the two true statements were accepted and the two false statements rejected. The performance of RS and the control subjects is displayed in Table 5(a).[2] Similarly to the pattern observed in the word/picture verification and the description tasks, RS's performance was the lowest for fruit and vegetables whereas his performance for animals was close to his performance for the two nonliving categories. In fact, RS performed below the normal range of the control subjects' performance for the fruit and vegetable category only. RS's score was entered in a logistic regression analysis with the same factors as those described earlier (excluding visual complexity). The analysis showed no significant effect of concept familiarity or word frequency ($0.64 < \chi^2 < 3.16$, $0.43 < p < .07$) but a significant effect of category once both these factors were controlled for (with general familiarity: $\chi^2 = 8.80$, $p < .04$; but with gender-specific familiarity: $\chi^2 = 7.18$, $p = .07$). Planned contrasts showed that RS's score for fruit and vegetables was significantly lower than his score for nonliving things (with general familiarity: $\chi^2 = 6.81$, $p < .01$; with gender-specific familiarity:

Table 5. *RS's and the controls' number and percentage of correct responses in (a) the attribute verification task and (b) for the visual vs. nonvisual attributes in the attribute verification task*

		RS		*Controls*		
	Mean rated difficulty[c]	*N*	*%*	*Mean N*	*Mean %*	*Range*
(a) *Attribute verification task*[a]						
Fruit and vegetables	1.89	7/15	47	11.9/15	79	10–14
Animals	2.04	12/15	80	12/15	80	10–14
Implements	1.94	14/16	88	13.8/16	86	12–15
Transport	1.82	13/16	81	13.7/16	86	11–16
(b) *Visual vs. nonvisual attributes in the attribute verification task*[b]						
Visual attributes						
Fruit and vegetables	1.72	8/15	53	13/15	87	12–14
Animals	1.91	12/15	80	13/15	87	12–14
Implements	2.43	14/16	88	14/16	88	12–16
Transport	1.88	14/16	88	14.1/16	88	11–16
Total	1.99	48/62	77	54.1/62	87	50–59
Nonvisual attributes						
Fruit and vegetables	2.05	12/15	80	13.9/15	93	12–15
Animals	2.17	15/15	100	13.8/15	92	13–15
Implements	1.45	16/16	100	15.7/16	98	15–16
Transport	1.77	15/16	94	15.6/16	98	14–16
Total	1.85	56/62	90	58.9/62	95	57–62

[a]One item has been scored as correct when a correct response was provided for all the four statements related to it (true and false visual and nonvisual).
[b]One item has been scored as correct when a correct response was provided for both the true and the false statements related to it.
[c]Difficulty as rated on a 5-point scale (1 = very easy; 5 = very difficult).

[2] The data from one of the control subjects had to be excluded because that subject had an overall accuracy score of only 52% (i.e., 5.2 *SD*s below the mean score of the other nine subjects). The subject's score was poor for all four categories: he was 60% correct for fruit and vegetables, 47% for animals, 44% for implements, and 56% for means of transport.

$\chi^2 = 5.13$, $p < .03$), whereas his score for animals was comparable to his score for nonliving things (both $\chi^2 < 1$). There was also a significant difference between RS's score for fruit and vegetables and his score for animals, which did not, however, reach significance once gender-specific familiarity was controlled for (with general familiarity: $\chi^2 = 4.85$, $p < .03$; with gender-specific familiarity: $\chi^2 = 2.74$, $p = .10$).[3] It is also worth noting that RS's performance was below the range of the controls' performance for the fruit and vegetable category only; his performance for animals and the two categories of nonliving things fell entirely inside the controls' range.

Although the task was not designed to evaluate possible differences in retrieving visual vs. nonvisual knowledge, it could be indicative to also look at RS's pattern of performance for the statements stressing visual vs. nonvisual attributes. Thus, in an additional analysis, we considered separately the statements stressing visual and nonvisual attributes and scored as correct an item for which both the true statement was accepted and the false one rejected. Note, however, that in doing this, the mean rated difficulty of the statements was no longer equated across conditions. While the mean difficulty of the statements did not significantly differ between the four item categories, $F(3, 232) = 1.17$, $p = .32$, nor between visual and nonvisual attributes, $F(1, 232) = 2.29$, $p = .14$, there was a significant attribute type × category interaction effect, $F(3, 232) = 12.73$, $p < .001$. Separate analyses performed for each category showed that, for the implement category, the statements stressing visual attributes were rated as more difficult than the statements stressing nonvisual attributes, $t(47.2) = 6.34$, $p < .001$. An opposite trend was noted for fruit and vegetables, but this difference failed to reach significance, $t(51.3) = 1.92$, $p = .06$. However, there was no significant difference in the mean rated difficulty of the statements stressing visual vs. nonvisual attributes for animals, $t(58) = 1.38$, $p = .17$, and means of transport, $t(62) < 1$.

As can be seen in Table 5(b), RS's performance was worse, on the whole, for the visual than the nonvisual attributes (77% vs. 90% correct, respectively). The logistic regression analysis performed with attribute type (visual/nonvisual), category membership (fruit and vegetables/animals/implements/means of transport) as well as concept familiarity and word frequency as independent variables revealed that this attribute effect was significant (with general familiarity: $\chi^2 = 8.14$, $p < .01$; with gender-specific familiarity: $\chi^2 = 7.99$, $p < .01$) once all the other variables were controlled for. However, a similar trend was noted for the control subjects, whose performance was 87% vs. 95% correct for the visual and nonvisual attributes, respectively. In fact, RS's performance was below the range of controls only for the visual attributes of fruit and vegetables.[4]

Moreover, the results in Table 5(b) once again indicate that, for both visual and nonvisual statements, RS's performance was worse for fruit and vegetables than for any other category, while no similar trend was noted for the control subjects.

[3] Among the visual statements used to assess knowledge of fruit and vegetables, seven of them stressed a colour attribute. RS gave a wrong response to three of them. As we will show later, RS seemed to have lost the link between a colour name and the corresponding colour concept. These three errors could therefore be due to a failure to comprehend the colour name rather than a failure to access the concept or the attribute probed. However, these errors do not by themselves explain RS's lower performance for fruit and vegetables. The three colour statements for which RS made a wrong response related to two items for which he also provided a wrong response to another, noncolour, statement. Given the scoring procedure adopted here (i.e., one item being considered as correct when all four statements were correctly judged), the general score would thus remain unchanged if the three colour statements were excluded from the analysis.

[4] The scoring procedure adopted here does not allow us to examine separately RS's scores for the visual statements stressing colour and noncolour attributes because, for a given item, the "true" and "false" statements did not necessarily stress the same kind (colour vs. noncolour) of attribute. By scoring separately the response accuracy for each individual "true" or "false" statements stressing visual attributes of fruit and vegetables, scores were as follows: for the statements stressing a colour attribute, RS made 4/7 (57%) correct responses (controls' mean score: 6.9/7, 99%; range: 6–7); for the statements stressing a noncolour attribute, RS had 17/23 (74%) correct responses (controls' mean score: 21.1/23, 92%; range: 20–22). Thus, it appears that RS's performance was below the normal range for both the colour and noncolour attributes of fruit and vegetables.

This category effect was significant once all other variables, including attribute type, were controlled for (with general familiarity: $\chi^2 = 11.44$, $p < .01$; with gender-specific familiarity: $\chi^2 = 9.45$, $p < .03$), which indicates that the category effect is not reducible to an attribute type effect. Planned contrast showed that RS's scores for fruit and vegetables were significantly lower than his scores for nonliving items (with general familiarity: $\chi^2 = 9.11$, $p < .01$; with gender-specific familiarity: $\chi^2 = 7.04$, $p < .01$), and significantly lower than his score for animals (with general familiarity: $\chi^2 = 6.04$, $p < .02$; but with gender-specific familiarity: $\chi^2 = 3.43$, $p = .06$). On the other hand, RS's scores for animals were not significantly different from his scores for nonliving things (both $\chi^2 < 1$).

Discussion

In all the naming tasks, RS's lowest scores were for the fruit and vegetable category as compared to the other categories of items. This was particularly striking when RS was asked to name the items of the living/nonliving battery, despite fruit and vegetables being the most familiar (even when only the male familiarity ratings were taken into account) and the less visually complex items. RS's naming impairment also extended to the food category and the animal category. Access to category membership, from a word or from a picture, appeared to be preserved for all the categories of items tested. However, when access to specific semantic attributes was required without necessitating the production of the target word (i.e., word/picture verification, word and picture description, and attribute verification tasks), RS's disproportionate deficit for fruit and vegetables was more apparent than in the naming tasks: RS's scores for fruit and vegetables were indeed lower than his scores for nonliving items *and* for animals but no difference could be observed between the animal category and the two nonliving categories (see Figure 2 for a summary of the results). That RS's impairment for fruit and vegetables appeared in all semantic tasks, whatever the modality in which the items were presented (pictures or words) and even when no name production was required, points to the semantic processing level as the likely locus of RS's deficit for fruit and vegetables.

RS's slightly lower score for animals and fruit and vegetables in the picture naming task relative to the

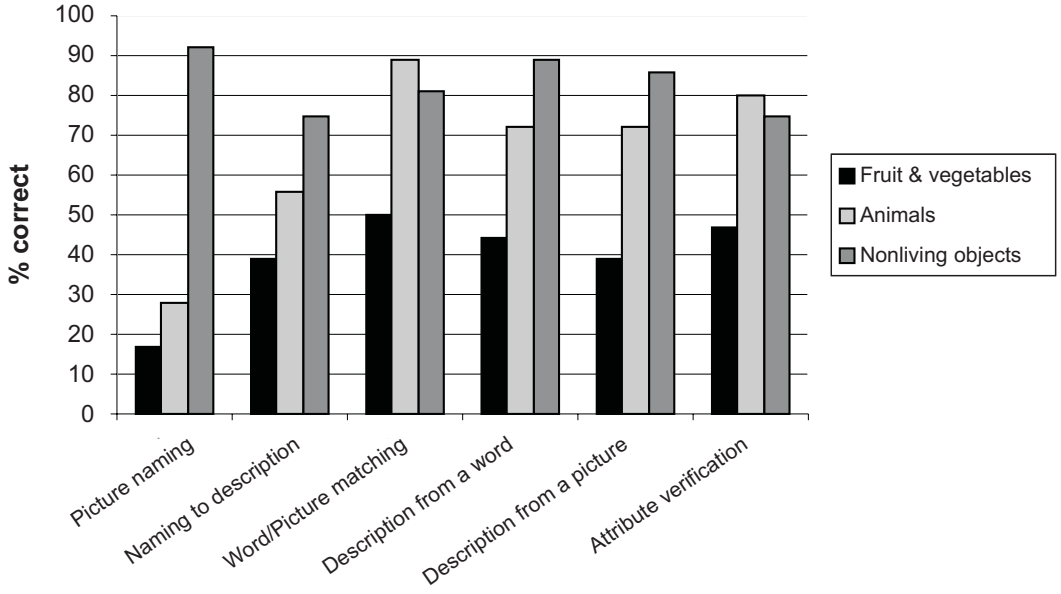

Figure 2. *RS's percentage of correct responses in the naming and semantic tasks for the fruit and vegetable, animal, and nonliving object categories.*

naming from description task could suggest greater difficulty in accessing semantic knowledge from a picture than from a verbal input. However, it seems unlikely that the difference resulted from a structural processing impairment, since RS's performance in the two object decision tasks (cf. BORB in Case Report and Test 3) was within the normal range. Nor did the difference seem to result from a disruption of the processes by which the semantic system is accessed from the structural description store, since no similar discrepancy was found when RS had to describe animals and fruit and vegetables from a picture vs. from a spoken word. Therefore, we propose that the discrepancy between RS's score in the picture naming and the naming from description tasks results from differences in the kind and amount of information being provided directly in both tasks. The verbal description of an object by the examiner indeed provides more detailed and selected semantic information (category membership and *only relevant* visual, functional, and encyclopaedic information) than the picture of that object (which yields only structural/visual information directly). Thus verbal descriptions might facilitate semantic processing by enhancing the activation of the relevant semantic properties of the objects within the semantic system.

Finally, the results of the attribute verification task indicated that RS's performance in verifying visual attributes of fruit and vegetables was below the range of the control subjects, while his performance for both visual and nonvisual attributes of the other categories of items was within the normal range. This observation is inconsistent with the hypothesis of a selective deficit in retrieving visual knowledge as a source of RS's difficulties with fruit and vegetables, which should lead to below-normal performance in verifying visual statements for *all* categories of items. Evidence that RS was not impaired in retrieving visual knowledge in general was also found in the picture and word description tasks. For animals and manufactured items, RS's descriptions were very detailed and precise (see earlier), not only as regards the nonvisual attributes, but also the visual appearance of the objects, in spite of the fact that describing the visual appearance of animals, implements or means of transport might be far more difficult than describing their function.

Assessing object-colour knowledge

The following tests were aimed at testing RS's object-colour knowledge, as colour knowledge has been claimed to be a kind of knowledge that is particularly diagnostic for fruit and vegetables. These tests were designed to contrast RS's object-colour knowledge for fruit and vegetables with object-colour knowledge for another category of items, matched for familiarity with fruit and vegetables and for which RS showed a less marked deficit in naming and semantic tasks.

The criteria chosen for the selection of items was that the objects had a typical colour and that, altogether, they allowed us to cover the widest range of colours in each category. Thus, only fruit and vegetables and manufactured items have been selected in this test. Items from the animal category could not be included due to the difficulty in finding animal items covering a range of different (typical) colours and liable to match fruit and vegetables in terms of familiarity. For the fruit and vegetables category, only 10 out of the 18 items used in the previous tasks were kept and 10 additional items were selected. For the manufactured objects, 20 new items had to be selected, because almost none of those from the living/nonliving battery had a typical colour. These manufactured items were taken from various subcategories, such as cloth, vehicles, sport items, and urban items.

The tasks usually used to assess object-colour knowledge require a colour-related response, either by pointing to a colour patch, colouring a line drawing, choosing among coloured line drawings the one that is correctly coloured, producing the colour name, or pointing to a colour name. Hence, the results of these tasks are informative about object-colour knowledge retrieval provided that the patient can adequately report to the examiner the colour he believes to be associated with a particular object. For instance, a patient might know that a tomato is red, but at the same time, because of a colour anomia, he might be unable to select and produce the word *red*. In order to determine the most reliable response modality that could be used to assess RS's object-colour knowledge, the patient was thus first presented with several tasks assessing

his colour perceptual processing and naming. All the tests described below were also presented to RS's matched control subject who participated in Test 2.

Test 8. Colour discrimination
RS and the control subject were presented with the Ishihara (1974) plates. Both correctly and easily identified all items.

Test 9. Colour matching
Method. RS and the control subject were given an array of 11 target colour patches randomly positioned (the colours were: white, yellow, orange, red, purple, green, blue, black, brown, pink, and grey). They were then presented with 38 colour patches consisting of three or four different shades of each target colour, one at a time, and asked to associate these patches with one of the colour patches of the array.

Results. Both RS and the control subject scored 35/38 (92%) on this task. All the errors consisted of choosing a closely related colour patch. RS's performance thus indicates that he was able to perceptually categorise colours into the 11 selected basic colours.

Test 10. Colour naming
Method. RS was presented with 44 colour patches and asked to name each of them. The items consisted of four different shades of each of the 11 basic colours presented in Test 9. The same procedure was used for the control subject.

Results. RS scored 28/44 (64%). He made no errors for the different shades of white, green, and yellow, but never provided the correct name for the different shades of purple (which were three times named as pink and once as blue) and orange (which were all named as pink). For all the other colours, he gave the correct name at least twice (errors were the following: black patch → *blue*, *brown*; pink patch → *red*; blue patch → *green*; brown patch → *green*; grey patch → *green*, *green*; red patch → *brown*, *brown*). The patient's performance was significantly lower than the control subject's performance (39/44, 89%; Fisher exact probability = .006). The control subject must also have found it difficult to name the purple patches, as he only provided the correct name once (he twice misnamed it as blue and once as grey). The control subject made also one error for the brown and the pink colour patches, which were misnamed as black and red, respectively.

Test 11. Spoken word/colour matching
Method. RS was presented with an array of 11 colour patches, each patch corresponding to one of the 11 basic colours. He was asked to point to the colour patch that corresponded to the auditory presented words. The test was performed four times, each time with different shades of the 11 basic colours. The control subject was also tested.

Results. RS scored 37/44 (84%), a score again lower than that of the control subject (41/44, 93%), although the difference was not statistically significant (Fisher exact probability = .16). RS made errors when pointing to the colour patch corresponding to the following names: brown (pointing three times to the grey patch), purple (pointing once to the green and once to the brown patches), orange (pointing once to the pink patch), and grey (pointing once to the purple patch). The control subject's errors involved the following colour names: purple (associated with the pink patch), grey (associated with the purple patch), and blue (associated with the purple patch).

Test 12. Spoken word/colour verification
Method. RS was presented simultaneously with a colour name and a colour patch. He was asked to tell if the word was the correct name for the colour patch. Each colour was presented three times, once with the correct name, once with the name of a closely related colour (e.g., the word "orange" for the yellow colour patch), and once with a less closely related colour (e.g., the word "purple" for the yellow colour patch). An item was scored as correct when, for a given colour patch, the patient both accepted the correct name and rejected the two distractors. The same procedure was used for the control subject.

Results. RS scored 7/11 (64%), a performance significantly lower than the control subject's level (11/11; Fisher exact probability = .05). RS made errors for the following colour patches: brown (accepted as purple), blue (accepted as green), purple (rejected as not being purple), and yellow (accepted as orange).

Test 13. Colour name fluency

Method. RS and the control subject were asked to produce as many colours as possible in 2 min. (This test was administered before all the other tests involving colour processing.)

Results. RS provided 17 names (control subject: 22). Both produced the names of the 11 basic colours used in the previous tests.

Discussion

RS showed no colour discrimination difficulties and was quite accurate when asked to classify colour patches into the 11 basic colours. He also performed quite well in the colour name fluency task. However, he was not able to correctly associate a given colour with the appropriate name or vice versa. Within current models of colour processing (see, for instance, Davidoff, 1991), RS's pattern of performance suggests a preservation of the internal colour space (as evidenced by his good performance in classifying visually presented colours). However, he seemed to suffer from a disruption of the links between the input verbal lexicon and the internal colour space (as evidenced by his poor performance when asked to match a name with the corresponding colour) and from a disruption of the links between the internal colour space and the output verbal lexicon (as evidenced by his colour naming impairment). As RS seemed to have lost the link between a colour and its name, we avoided the use of the colour names in the tasks assessing object-colour knowledge and instead asked the patient to point to a colour patch.

Test 14. Retrieval of object-colour knowledge about fruit and vegetables from a visual input

Method. RS was asked to point to the appropriate colour of 20 fruit and vegetables presented as black-and-white drawings. For each item, he had a choice of three patches of colours. All the distractor patches displayed a plausible colour for the fruit and vegetable category. The shade of almost all the correct colour patches differed from the shade of the actual colour of the object. The control subject did the same test.

Results. RS scored 17/20 (85%), a performance similar to the control subject's level (16/20).

Test 15. Retrieval of object-colour knowledge from a verbal input

Method. We used the same 20 fruit and vegetables items and the same colour patches as in Test 14. But instead of being presented with the picture of the target item, RS was given its name. RS was also asked to point to the appropriate colour (among three colour patches) of 20 manufactured objects that have a salient and typical colour (e.g., a pillar box, a golf ball, a tyre). The number of items for a given colour were matched as closely as possible across the two categories of items. All 40 items used in that task were submitted to six control subjects (half of which were males), who were asked to rate on a 5-point scale how familiar the item denoted by the word was to them in daily life (we used the same procedure as the one used by Snodgrass & Vanderwart, 1980). The mean rated familiarity for fruit and vegetables appeared to be slightly higher than the mean rated familiarity for objects (3.08 and 2.63, respectively).

Results. RS's score was significantly below the control subject's score for fruit and vegetables (RS: 13/20, control: 19/20, Fisher exact probability = .02) but the difference didn't reach significance for objects (RS: 16/20, control: 19/20, Fisher exact probability = 0.17).[5]

[5] Unfortunately, the testing had been aborted at this stage and there was no opportunity to ask RS to name the items used in that task.

Discussion

RS's performance was not perfect when asked to retrieve object-colour knowledge and he appeared to be impaired (as compared to the control subject) when asked to retrieve object-colour knowledge about fruit and vegetables. Interestingly, RS's impairment at retrieving object-colour knowledge about fruit and vegetables disappeared when the fruit and vegetables were presented as picture stimuli, indicating that at least in some conditions (i.e., from a picture) RS could accurately access object-colour knowledge about fruit and vegetables. We will discuss this point in the General Discussion.

GENERAL DISCUSSION

In this paper, we reported an additional case of a patient, RS, who shows more difficulties in processing fruit and vegetables than other categories of objects. In contrast to previously reported cases of category-specific deficits for fruit and vegetables (Farah & Wallace, 1992; Hart et al., 1985), RS's disproportionate impairment was not confined to the tasks requiring the production of the name of objects, such as picture naming and naming from description tasks. RS also showed a disproportionate impairment for fruit and vegetables in a word-to-picture verification task, when asked to describe them, both from a picture and a spoken name, and in an attribute verification task. Given that RS's deficit for fruit and vegetables was observed in tasks requiring access to semantic knowledge whatever the modality of input (a picture or a word) and even when no name production was needed, the most likely locus of his disproportionate impairment is the semantic processing level. RS's good performance for fruit and vegetables in a picture and word categorisation task further suggests that his semantic impairment only affects the retrieval of specific semantic attributes about fruit and vegetables but not category membership information.

RS's category-specific deficit for fruit and vegetables did not seem to be an artefact of potentially confounding factors, at least as far as word frequency, concept familiarity, or visual complexity are concerned. In a number of tasks, RS was presented with the items of the living/nonliving battery where all categories were equated in word frequency, and where fruit and vegetables had the highest mean familiarity value and the lowest mean visual complexity value. The category effect remained significant when these factors were controlled for in a logistic regression analysis. In the other tasks, fruit and vegetables were matched in familiarity to the other categories of items.

It has recently been claimed that familiarity is modulated by gender and, more particularly, that males are less familiar with fruit and vegetables than females (Albanese et al., 2000). This point appears to be particularly relevant in the face of the striking gender effect observed when examining the patients who have been reported to date with a dissociation along the animal/fruit and vegetable distinction. The patients presenting with a selective sparing of the fruit and vegetable category as compared to the animal category (namely, EW: Caramazza & Shelton, 1998; and KR: Hart & Gordon, 1992) were both females, whereas the three previously reported patients presenting with the reverse pattern (TU: Farah & Wallace, 1992; MD: Hart et al., 1985; and JJ: Hillis & Caramazza, 1991) were males. The present case of RS, a male patient, is consistent with this gender effect. Still, when taking into account the familiarity ratings of the male subjects who participated in the familiarity rating of the items of the living/nonliving battery, fruit and vegetables remained the most familiar category of items in the battery. Furthermore, controlling for gender-specific familiarity (instead of general familiarity) did not modulate the results of our logistic regression analyses (except for one contrast in the attribute verification task, where the difference between RS's score for fruit and vegetables, on the one hand, and animals, on the other hand, failed to reach significance after controlling for gender-specific familiarity).

In order to further investigate the issue of a potential confounding familiarity effect, RS's naming of fruit and vegetables was contrasted with his naming of domestic implements, that is, items belonging to the nonliving category and which we

believed would match fruit and vegetables in terms of idiosyncratic familiarity. Indeed, RS stated not only that he was poorly acquainted with cooking activities but also, more generally, that he knew little about household activities. On naming these items, RS was found to be impaired for fruit and vegetables but not for domestic implements as compared to a matched control subject.

Our study, in contrast to the studies of Farah and Wallace (1992) and Hart et al. (1985), also provides direct evidence on the extent to which the performance for fruit and vegetables deviates from the performance for animals. In all the semantic tasks in which access to specific semantic properties were required and in which the items had not to be named (word/picture verification, word and picture description, attribute verification tasks), RS's performance was the lowest for fruit and vegetables while his performance for animals was as good as for nonliving things. The pattern of performance observed in the naming tasks appeared to be slightly different. In the picture naming task, RS was worse at naming both animals and fruit and vegetables as compared to nonliving things. This pattern of impaired naming performance for animals in face of relatively spared performance in the semantic tasks could suggest that RS's naming deficit for animals arises as a consequence of damage to word retrieval processes from spared semantics. However, we found that RS's performance for animals improved in the naming to description task in comparison with the picture naming task. His performance for animals was then not significantly different from his performance for nonliving items, while his performance for fruit and vegetables remained significantly worse than for nonliving items. We suggested earlier that the kind of information provided in the verbal descriptions, by pointing directly to the *relevant* visual and nonvisual semantic properties of the item to be named, could have facilitated access to those semantic properties and, hence, to the item's semantic representation as a whole. That RS's performance in naming animals could have been facilitated when he was provided with *semantic* cues suggests that he had to suffer from a slight impairment in accessing the semantic representations for animals, in addition to his word retrieval impairment. Thus, RS could have suffered from a more subtle semantic deficit for animals than fruit and vegetables; the semantic tasks used in this study may not have been sensitive enough to detect this. Still, even if RS suffered from a semantic deficit for the animal category, his conceptual knowledge about fruit and vegetables appeared to be disproportionately impaired as compared to his conceptual knowledge about animals. So, taken all together, RS's pattern of performance is consistent with previous reports suggesting that a semantic impairment does not necessarily affect all the items from the living things category uniformly, but rather can conform to a finer-grained distinction between animals and fruit and vegetables.

RS's pattern of performance seriously challenges Devlin et al.'s (1998) correlational structure account for category-specific deficits, at least if Devlin et al.'s estimates of feature relations are taken into consideration. On the basis of these estimates, this account predicts that concepts of fruit and vegetables should be the most robust to mild damage. Consequently, in case of mild damage, the concepts of fruit and vegetables should be relatively spared in comparison with the concepts of animals and artefacts. RS has just presented with the reverse pattern—fruit and vegetables were disproportionately impaired in comparison with all other categories—while he did indeed suffer from very mild semantic damage, as shown by his performance at the semantic matching and the synonym matching tasks, for example, which was within the normal range (cf. Case Report). In contrast, RS's pattern fits well with the Tyler and colleagues' claims (Moss et al., 2002; Tyler & Moss, 2001) that the concepts of fruit and vegetables should be more vulnerable to mild damage than the concepts of animals. However, the reverse pattern of dissociation along the animal/fruit and vegetable distinction has also been reported in the patient EW (Caramazza & Shelton, 1998), who presented with a semantic deficit that could also be considered as a mild one, as EW scored 204/250 (82%) when asked to name the Snodgrass and Vanderwart (1980) set of items. EW was, however, impaired in naming animals and in

verifying semantic properties of animals while, for fruit and vegetables, her performance was close to perfect.[6] Thus, together with the case of EW, the present case report of a patient being disproportionately impaired in processing fruit and vegetables, and whose pattern of performance strongly suggests a semantic, rather than a purely word-retrieval locus for this category-specific deficit, provides additional neuropsychological data (cf. Garrard, Lambon Ralph, Watson, Powis, Patterson, & Hodges, 2001; Garrard, Patterson, Watson, & Hodges, 1998) that undermines the contribution of the correlational approaches in understanding the occurrence of category-specific deficits.

Two types of account of category-specific deficits could explain a double dissociation along the animal/fruit and vegetable distinction. The first type of account assumes a topographical category-like organisation of semantic knowledge within the brain (Caramazza et al., 1990; Caramazza & Shelton, 1998; Damasio, 1990; Tranel et al., 1997). According to this view, category-specific semantic deficits affecting selectively either the animal or the fruit and vegetable category reflect damage to a particular brain region that sustains the retrieval and processing of all the semantic knowledge associated with animals or with fruit and vegetables, respectively. Thus this account predicts that patients showing a selective deficit for animals or for fruit and vegetables should be impaired at retrieving any kind of semantic knowledge associated with the impaired category while all kinds of semantic knowledge associated with other categories should be spared. In contrast, the second type of account assumes that the topographical organisation of knowledge within the brain is based on the kind of semantic properties that are represented (Humphreys & Forde, 2001; Warrington & McCarthy, 1987; Warrington & Shallice, 1984). Within this framework, category-specific semantic deficits reflect damage to one or several semantic subsystems that store the particular kinds of knowledge that are particularly diagnostic for the impaired category, conceivably shape knowledge for animals and colour knowledge for fruit and vegetables (Humphreys & Forde, 2001; Warrington & McCarthy, 1987). Thus this account predicts that category-specific semantic deficits should be associated with disproportionate difficulty in retrieving specific kinds of object properties across all categories of objects.

RS's pattern of performance in tasks probing the retrieval of object-colour knowledge does not conform to the hypothesis of a loss of object-colour knowledge being at the origin of his deficit in processing fruit and vegetables. First, although RS was unable to name or describe fruit and vegetables from a picture, he could nevertheless accurately retrieve the colour associated with visually presented fruit and vegetables. Thus, at least for visually presented fruit and vegetables, RS's inability to retrieve semantic knowledge was not due to a loss of object-colour knowledge. Second, although RS had difficulty in retrieving object-colour knowledge from a spoken name, both for fruit and vegetables and for manufactured objects, his score was significantly lower than the score of the control subject only for fruit and vegetables. This pattern is inconsistent with the expectation of a general loss of object-colour knowledge in the condition of damage to the colour-knowledge store, which should equally impair colour-knowledge retrieval for fruit and vegetables *and* manufactured objects.

RS's pattern of performance in the object-colour knowledge retrieval tasks also speaks to the issue of the status of object-colour knowledge within a model of object knowledge representation. First, RS was able to retrieve colour-knowledge about visually presented fruit and vegetables despite his semantic impairment for this category of objects. Other patients have been reported with the opposite pattern of performance. For example, Della Sala et al. (2000) reported the case of three patients who could name colours perfectly (which suggests intact colour processing) and name visually

[6] Whatever the actual degree of semantic damage present in a given patient, if the category of fruit and vegetables were the most vulnerable category then, in case of impairment for the concepts of animals, the concepts for fruit and vegetables should be impaired as well (or even more impaired).

presented objects perfectly (which suggests intact structural and semantic knowledge about objects) but could not match visually-presented objects to their corresponding colour. Similarly, IOC, the patient studied by Miceli et al. (2001), was impaired at retrieving the colour of objects but performed close to normal range when asked to retrieve other visual as well as nonvisual semantic attributes about them. Thus, the case of RS, together with the cases reported by Della Sala et al. and Miceli et al., suggest that object-colour knowledge is represented in a segregated way from structural and semantic knowledge (see also Luzzatti & Davidoff, 1994; Price & Humphreys, 1989). Second, although RS was able to retrieve object-colour knowledge about visually-presented fruit and vegetables, he showed impaired performance when asked to retrieve the colour of fruit and vegetables from their spoken name. This pattern suggests that object-colour knowledge can be directly retrieved from the object's structural representation without requiring prior access to the object's semantic representation. In contrast, the retrieval of object-colour knowledge from a spoken name would require prior access to the object's semantic representation, on the basis of which the corresponding object's colour properties could be addressed (see Figure 3).

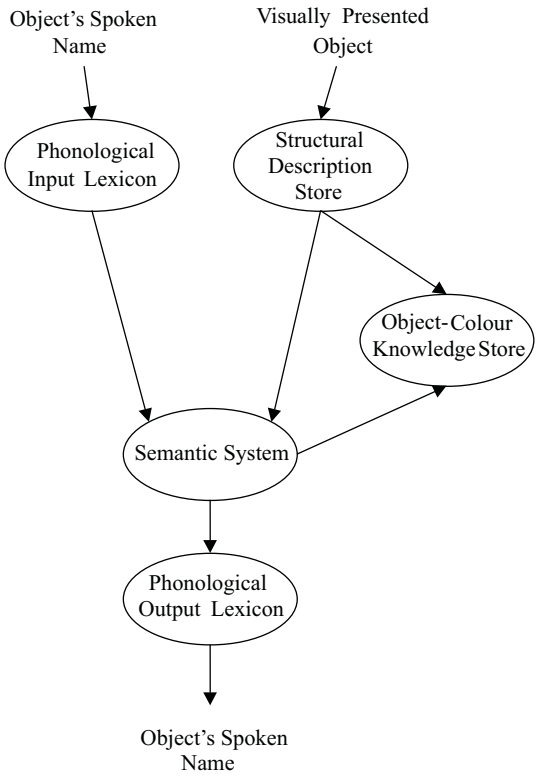

Figure 3. *A schematic representation of the stored knowledge systems involved in object-colour processing.*

Within such a model of object-knowledge representation, the various features of RS's performance in the object-colour knowledge retrieval tasks would be accounted for as follows. RS's more marked difficulty at retrieving colour knowledge for fruit and vegetables as compared to manufactured objects when provided with their spoken name results from the semantic representations of fruit and vegetables being disproportionately impaired in comparison with manufactured objects. In contrast, when provided with (black-and-white) drawings of fruit and vegetables, RS could retrieve their corresponding colour because of spared structural knowledge of fruit and vegetables from which (spared) object-colour knowledge could be accessed. Thus, within this model of how processing of an object's colour and its other properties are related, RS's pattern of performance is interpreted as resulting from selective (or disproportionate) damage to the semantic representations of fruit and vegetables in the face of *spared* representations of colour properties of fruit and vegetables, as well as spared representations of all the properties of objects belonging to the other categories.

A selective (or disproportionate) deficit in accessing objects' visual properties other than colour, namely objects' shape properties, either at the structural or semantic level of processing, also seems unlikely to explain RS's disproportionate impairment for fruit and vegetables. There was no evidence for an impairment at the structural processing level: RS performed within the normal range in two object decision tasks, he showed similar scores in accessing semantic knowledge from a picture and from a word (as evidenced in the word and picture description task), and he could accurately retrieve the colour associated with fruit and vegetables from a picture—a task presumably requiring accurate access to a structural description.

As regards the semantic level of processing, RS's performance in the attribute verification task indicated that he was impaired at retrieving visual—that is, colour and shape—knowledge for fruit and vegetables from a spoken input. There was no evidence, however, for an impairment at retrieving shape knowledge for animals nor for manufactured objects. Such a pattern is inconsistent with the hypothesis of a selective damage to a shape knowledge store, which should impair shape knowledge for all categories of items to a certain extent. One must add that, under the knowledge-specific account, a deficit in retrieving the shape attributes of objects should result in equal if not greater difficulty in identifying animals than fruit and vegetables, because shape knowledge is assumed to be *relatively* more diagnostic for animals than for fruit and vegetables. In fact, the reverse pattern was found in the present case.

The most parsimonious account for RS's pattern of performance across all tasks is that RS's semantic deficit impaired all kinds of semantic properties associated with fruit and vegetables (with the exception of colour properties) while relatively sparing all kinds of semantic properties associated with the other categories of objects. Hence, RS's pattern of performance can be taken as evidence in support of a topographical category-like organisation of semantic knowledge within the brain. Our data are, however, silent on the issue of knowing which organising principle would have led to such a topographical organisation of knowledge, i.e., the strength of association among semantic properties (cf. the OUCH model, Caramazza et al., 1990), the prevailing object properties that were pertinently associated in experience (cf. Damasio, 1990; Tranel et al., 1997), or evolutionary pressure (cf. the domain-specific knowledge hypothesis, Caramazza & Shelton, 1998). RS's apparent association of deficits for fruit and vegetables and manufactured food items seems to be compatible with the three proposals. Within the framework of the OUCH model, it can be argued that manufactured food items share some properties in common with fruit and vegetables (e.g., gustatory properties and functional and associative properties related to eating) and are hence represented through partly overlapping property clusters within the semantic space. Consistent with Damasio and his collaborators' proposal, it could be argued that the properties that are pertinently associated in experience for food items and fruit and vegetables are quite similar (e.g., similar modalities of transactions). Finally, within the framework of the domain-specific knowledge hypothesis, it might be that the specialised neural systems dedicated to processing plant life, which evolved at the time of our hunter-gatherer ancestors, now also process objects that appeared later in the development of the human environment—especially if these objects, as might be the case for food items, share with the original domain (i.e., plant life) similar perceptual cues for accurate identification and similar types of behavioural responses.

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