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Category-specific visual agnosia: Lesion to semantic memory versus extra-lesional variables in a case study and a connectionist model

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Abstract

There is a current debate on the causes of category-specific agnosia. The aim of this study was to examine the effects of lesional and extra-lesional variables on object recognition. Extra-lesional variables, such as visual complexity or familiarity, are factors that influence recognition. Using a connectionist model based on Farah and McClelland's (1991) study, we provide evidence that extra-lesional variables can yield dissociations in the recognition rate of different categories. Furthermore, it is shown that lesional and extra-lesional variables can interact ($p < .01$) when both are simultaneously modeled. Category-specific agnosia might thus result from complex interactions.

Keywords: Category-specific agnosia; Visual agnosia; Variables; Factors; Connectionist modeling

1. Introduction

Category-specific agnosia is defined as a recognition deficit for some object categories and not others in the absence of a primary sensory disorder. Many articles have been published as an attempt to explain the observed dissociations and several hypotheses have been proposed.

1. The deficit for one particular category can result from a lesion to a cortical area specialized in this category (Caramazza & Shelton, 1998; Goodglass, Klein, Carey, & Jones, 1966).
2. The deficit may result from a lesion to a cortical area specialized in the processing of one type of knowledge about the object, for example visual knowledge as opposed to functional knowledge (Warrington & Shallice, 1984), or figurative versus operative knowledge (Sirigu, Duhamel, & Poncet, 1991). Memory about objects knowledge would thus be divided into different functional modules, each specialized in the processing of one type of information rather than one object category (Allport, 1985).
3. Category-specific agnosia could result from a lesion of the access to a unique semantic memory system. According to this hypothesis, each object category would implicate different sensory channels at various levels, which, if lesioned, would impair recognition of certain categories more than others (Riddoch & Humphreys, 1987; Riddoch, Humphreys, Coltheart, & Funnel, 1988).
4. The observed dissociations could be related to or co-determined by different *variables* (Stewart, Parkin, & Hunkin, 1992; Takarae & Levin, 2001; Tranel, Logan, Randall, & Damasio, 1997). These variables include a number of factors which can explain the dissociation (familiarity, sensory ambiguity...), but exclude the neuropsychological factor per se, which is the anatomical localization of the lesion.

In 1984, Warrington and Shallice published a study of four cases with category-specific agnosia. For patient

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SBY in particular, variables such as name frequency and visual familiarity were controlled. Linguistic studies provided measures of name frequency. Normative values of the Snodgrass and Vanderwart (1980) picture battery were used as a measure of visual familiarity. SBY still recognized non-living objects better than living objects after controlling for these variables. Warrington and Shallice therefore suggested that semantic memory was fractionated.

On the other hand, Riddoch et al. (1988) proposed a model which explained dissociations as artifacts resulting from the impact of such variables on the access to semantic memory. This hypothesis received some support from authors like Stewart et al. (1992). They published a case with a category-specific dissociation on clinical examination, that disappeared when the variables "name frequency," "concept familiarity," and "visual complexity" were controlled for.

The debate thus opposes authors in favor of the anatomo-functional origin of category-specific deficits, according to whom dissociation depends upon the site of the lesion in a fractionated semantic memory system, to authors who postulate that dissociations result from artifacts related to uncontrolled extra-lesional variables. The latter support the notion of a unique semantic memory system.

Tranel et al. (1997) suggested an alternative view, in that both, variables and lesion site, could simultaneously co-determine category-specific dissociations. They analyzed nine variables for 215 pictures: homomorphy (shape similarity), familiarity, value for the subject, manipulability, characteristic movement, characteristic modality of perception (sight, touch, and audition) and age of acquisition. Using a principal component analysis, these authors demonstrated that three components could account for the variability in recognition rates among objects categories: the first component represents useful, practical, and common aspects of the object; the second concerns non-manipulable homomorphic objects; the third component groups objects with characteristic sounds. Physical and contextual characteristics of some categories (extra-lesional variables) could thus determine the regionalization of neural systems that are critical for the acquisition and recall of knowledge about these categories. In other words, there would be a link between these extra-lesional variables and neural systems specialized in their processing. Lesions of these specialized neural systems would impair recognition of the variables they are specialized in, which in turn would affect recognition of categories with a high ranking concerning these variables.

Taking all this into consideration, several questions remain unanswered:

1. What is the role of these extra-lesional variables? These variables are controlled for in many experiments, based upon the hypothesis that they could be responsible for the dissociations. However, this has never been formerly demonstrated to our knowledge.
2. As mentioned before, there are two main hypotheses concerning category-specific agnosia. According to one, lesion site is primordial, and according to the other, uncontrolled variables can explain the observed dissociations. Are these two hypotheses really conflicting as some authors suggest or can both, lesion site and variables, result in recognition deficit?

2. Case study

We studied a patient with category-specific agnosia and report on an analysis of the potential influence of two extra-lesional variables.

Patient DF, a warplane pilot, suffered from brain injury due to a car accident at the age of 27. We examined him four years after his accident. Attention was preserved (digit span forwards: 8 and digit span backwards: 7) and he performed well on tests evaluating executive functions that do not depend on the use of semantic knowledge (Modified Card Sorting Test: seven categories). A CT-scan made two years after his accident revealed bilateral anterior and inferior temporal lesions that predominated on the left, bilateral orbito-frontal lesions, as well as bilateral ventricle enlargement. DF had severe difficulties recognizing and naming objects. There was no deficit of elementary visual perception (Visual Object and Space Perception battery (VOSP) incomplete letters subtest: 19/20), shape perception or comparison (VOSP's shape detection subtest: 20/20, Thurstone's identical shape test: 60/60), or mental shape manipulation (VOSP's cube subtest: 10/10).

We studied DF's responses to the pictures of the Snodgrass and Vanderwart battery (1980). This battery contains 260 pictures in which two variables, familiarity and visual complexity, are controlled. Normative scores were obtained by asking 219 students to rate these two variables on a scale ranging from 1 to 5. We only used the 202 pictures of the 260 that can be sorted into 16 different categories, corresponding to those chosen by Battig and Montague (1969). The 58 remaining pictures cannot easily be attributed to any specific category (snowman, cigarette, thimble,...). The 16 categories can further be classified in two broad groups: manufactured (inanimate man-made) and natural. This classification respects the classic living versus non-living dichotomy, and it also enabled us to take into account other more specific categories such as body parts or natural elements (mountains, sun, clouds,...).

We presented all 202 pictures, one at a time, to DF. The size of each picture was 4×5 cm. We considered that DF recognized a picture if he found the correct name for it. If he could not, the experimenter