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The conceptual structure of cabbages and things

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Introduction

In 1994 Eleanor Saffran co-authored with Myrna Schwartz a seminal review of semantic memory impairments and their implications for the representational format and organisation of conceptual knowledge. In that paper, they argued that conceptual knowledge is distributed across a network of different sub-systems or "attribute domains," including at least a perceptual and functional or propositional system. Saffran's theoretical and empirical development of this approach has contributed to its becoming an influential framework for the investigation of semantic memory, throughout both the neuropsychological and neuroimaging literature.

The work that we will discuss addresses the question of how conceptual knowledge is organised and represented in the brain. It asks whether domains (such as living things or man-made artefacts) and categories (such as tools or fruit) are represented explicitly or whether domain and category structure emerges out of a unitary distributed system. Evidence from patients with 'category-specific deficits' and neuroimaging studies seem to suggest that conceptual knowledge is explicitly structured in independent content-based stores. Many studies point to these as being organised by property type into the distinct "attribute domains" posited by Saffran and many others, rather than by category/domain of concept per se (e.g., living vs. non-living things). However, we have recently developed a different theoretical account, based on analyses of the fine-grained details of semantic impairments, connectionist modelling and neuroimaging studies, in which concepts are represented as patterns of activation over multiple semantic properties within a unitary distributed system, which is not necessarily differentiated, functionally or neurally, into separate sub-stores for different kinds of semantic property. Within this context, category-specific deficits emerge as a result of differences in the structure and content of concepts rather than from damage to one or more property-specific sub-systems. The critical variables in explaining patterns of deficit within this system are correlation and distinctiveness rather than property type. We claim that living things have many shared, correlated properties with only weakly correlated distinctive properties, while artefacts have fewer, more weakly correlated properties which tend to be more distinctive. Since correlated properties are more robust in the face of damage, this predicts that the shared properties of living things will tend to be preserved while distinctive properties are lost. For artefacts the shared-distinctive dissociation should be less marked, since distinctive properties are protected by form–function correlations and shared properties are fewer and less inter-correlated.

Patient studies

We have tested these predictions in a variety of studies on patients with category-specific semantic deficits as a result of Herpes Simplex Encephalitis (HSE) or semantic dementia. For example, in one study we probed the patients' knowledge for the distinctive and shared properties of living and non-living things by means of a property verification task, asking question such as: *Do cats have whiskers* [*distinctive*]; *Do cats have legs* [*shared*]? Within the shared and distinctive conditions, half of the questions concerned perceptual properties, and the other half, functional properties (e.g., *Do cats chase mice*?). Fig. 1 shows the results for a group of four patients with living things deficits following HSE for the categories of animals and tools (which are the most representative categories within the living and artefact domains, respectively). All patients were significantly impaired on distinctive relative to shared properties of animals, but equally accurate for shared and distinctive properties of tools. There was no support for the claim that living things deficits arise from selective damage to a sub-system storing perceptual attributes; patients were no less accurate in their judgements concerning perceptual than functional properties of animals. We have found a similar pattern of disproportionate impairment for distinctive properties of living things across a range of tasks, including sorting and word–picture matching (Tyler & Moss, 2001).

Neuroimaging studies

Recent neuroimaging data from our lab is also consistent with the conceptual structure account, in showing that the same regions of temporal cortex are activated when subjects process concepts from different semantic categories (animals, tools, fruits/vegetables, etc; Devlin et al., 2002; Tyler et al., 2003). In further studies we have shown that differences in neural activation arise, not as a consequence of the way in which concepts in different categories are represented, but rather as a consequence of the kinds of processing that they require. In one recent fMRI study, we asked subjects to silently name pictures of objects from different categories (e.g., *animals*, *tools*) at either a basic level (e.g., *dog*, *hammer*) or a domain level (as a living or non-living thing). While there was no difference in domain level naming for objects from different categories, basic level naming produced greater activation in L anterior medial temporal regions for living things compared to artefacts. We argued that this was because basic level naming requires more fine-grained differentiation than domain level naming, and thus is more likely to engage anterior medial structures where processes of integration and differentiation occur (Bussey & Saksida, 2002). Moreover, since living things require more fine-grained differentiation than artefacts (because of their more numerous and correlated properties), this region of temporal cortex should be more highly engaged when processing living things at a basic level.

In sum, studies of the fine-grained details of the impairments of patients with semantic deficits and neuroimaging studies of semantics support our claim that conceptual knowledge is represented in a

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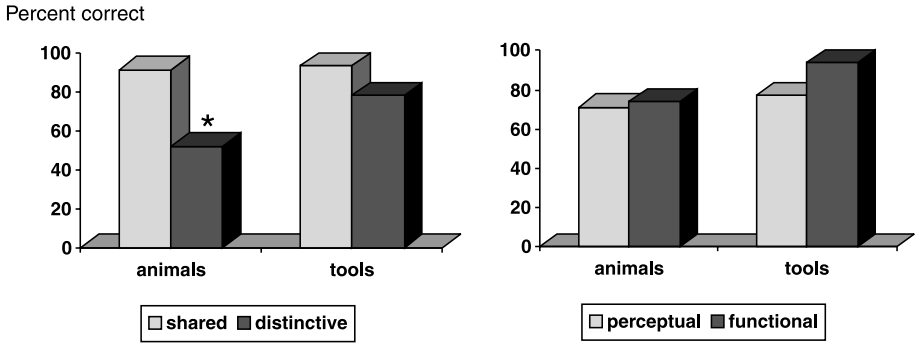

Fig. 1. Property knowledge task: mean percent correct responses for each category by property type for group of four HSE patients with category-specific deficits for living things. *, Significant difference for all patients ($p < .05$ at least).

distributed functional and neural system in which differences arise as a function of the content and structure of concepts.

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