

things. In the same sense Shakespeare is just as little about the brain as Vivaldi's *Four Seasons* is about the weather, as Malevich reveals about the spiritual depths of the Russian soul, or as Darwin contains scripts for docu-soaps.

In the end, what strikes us is that, in this book, Shakespeare's message is read for its factual meaning, that the metaphors are decoded as containing early sketches of knowledge awaiting long overdue confirmation from brain researchers. Surely it is hard to ignore that Shakespeare the playwright did not write these plays just to be read. Plays are conceived to be performed by actors and to be seen, heard and felt by an audience. Plays are not treatises on the soul, but scenarios for enacting emotions

and for communicating with an audience in a theatre. The scenarios only come to life when embodied by actors and watched by agents. The book misses out on this aspect. But this is not to say that these aren't matters that can and will be taken up by scientists soon! In fact, one can easily imagine a brain imaging study in which the participants hear and see fragments of plays reprinted here. In that case, the next edition of this book would be accompanied with an interactive DVD that allows us to watch the play while seeing brain scans of participants' brain activity.

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Letter

## Weighing up the facts of category-specific semantic deficits

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Caramazza and Mahon [1] discuss competing theoretical accounts of the organization of conceptual knowledge, in the light of evidence from patients with category-specific semantic deficits. They conclude that their 'Domain-Specific' hypothesis, in which evolutionary factors have resulted in specialized neural systems for concepts in a limited set of domains, namely animals, fruit and vegetables, conspecifics, and tools, is the only one that is consistent with the 'facts' of category-specific deficits. Although we agree that there are many problems for alternative theories and that none provides a complete account of the data, we wish to highlight a fact that is not mentioned by Caramazza and Mahon, but which presents a challenge to the Domain-Specific hypothesis [2,3].

The fact in question is that most patients with category-specific semantic deficits show a *graded* impairment rather than an all-or-none dissociation. That is, few patients are within the normal range for their 'preserved' category across all semantic tasks on which they are tested. In support of this point, we cite just a few illustrative cases – patients 'JBR' [4], 'Michelangelo' [5] and 'RC' [6] – but there are many more. The few cases for whom performance is consistently within the normal range for the preserved category – for example, 'EW' [7] – are the exception rather than the rule. How would graded impairments arise from a lesion to a distinct, dedicated neural system for a specific category or domain? One possibility is that the neural circuits are close together in the brain, so that large and/or diffuse lesions affect more than one system, but to differing degrees. However, this argument remains untestable unless precise claims are

made about the neuro-anatomical correlates of the proposed domain specific systems. Although the lesion data show some broad correlations between bilateral antero-medial and inferior temporal lobe damage and living things deficits, there is much variation in the extent and location of lesions and the degree of impairment in 'preserved categories'. For example, patient 'EW' [7] has a highly selective deficit for animals – which we might expect to be associated with a small focal inferior temporal lobe lesion – yet she has a large area of encephalomalacia within the left posterior frontal and parietal lobes. Extensive fronto-parietal lesions are more commonly associated with artifact deficits.

A related point concerns the nature of dissociations in neural activity produced by concepts in different domains as revealed in functional imaging studies. Caramazza and Mahon cite evidence for category- or domain-specific activations in a number of imaging studies as further support for the Domain-Specific account. However, the regions of interest are rarely *selectively* recruited by a specific domain or category; rather, different categories produce activation across many of the same regions, but to different degrees [8]. Rather than separate systems dedicated to individual domains, this suggests that concepts within different domains place more or fewer processing demands on different elements within a single system [9]. A possible reply to this point is that the domain-specific neural system should be interpreted as arising from a network of connections within pools of neurons that are common to the processing of many domains, but then it is difficult to see how this differs from a unitary system in which category structure emerges as a function of overlap and correlation within concepts.

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Although these considerations might not disprove the Domain-Specific hypothesis, they seem at least as problematic for this theory as do many of the facts raised by Caramazza and Mahon for alternative accounts. However, the model is so underspecified that it is possible to develop explanations for most patterns of data. This flexibility significantly undermines the explanatory power of the account and essentially renders it unfalsifiable. The challenge for Caramazza and Mahon, therefore, is to specify what would count as evidence inconsistent with their hypothesis. More generally, we suggest that it is unlikely that any one of the existing theories (including our own) can accommodate all the 'facts', and that a more promising approach would be to develop integrative theories that combine insights from several different accounts (e.g. [10]).

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#### Letter Response

## There are facts...and then there are facts

Reply to Moss and Tyler

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The facts of category-specific semantic deficits are as follows (for review see [1]): (i) the domains living animate, living inanimate and non-living can each be disproportionately impaired; (ii) category-specific semantic deficits are not associated with deficits to a type or modality of knowledge; and (iii) cross sectional studies of patients with degenerative diseases have not documented an interaction between severity of conceptual impairment and direction of category-specific impairment. In their letter, Moss and Tyler [2] reinforce the emerging consensus that the above three facts demonstrate that the Sensory/Functional [3] and Conceptual-Structure theories [4] are inadequate to explain category-specific semantic deficits. We proposed a Domain-Specific framework that is consistent with these uncontested facts [5]. As was noted in that article, there are many ways in which the proposed framework might be elaborated in the context of a broader range of facts. For instance, data from functional neuroimaging and neuropsychology might converge on the assumption that information is organized by modality or type of knowledge *within* object domains.

A strength of the Domain-Specific framework is that it uniquely predicts that the neural organization of conceptual knowledge should be relatively resistant to variation in sensory experience. For instance, the framework

predicts that congenitally blind individuals should present with the same category-specific organization of higher-level visual areas (e.g. fusiform gyri) as is observed in sighted individuals. Another prediction is that category-specific semantic impairments can arise from brain damage that occurs prior to any significant perceptual experience [6].

Despite the explanatory and predictive power of the Domain-Specific framework, Moss and Tyler argue that it cannot account for the fact that the majority of cases of category-specific deficit do not present with normal performance in the 'spared' categories. However, as Moss and Tyler also admit, there *do* exist well-studied cases in which category-specific semantic deficits are accompanied by normal performance in the spared categories (for example, [7]). Given that clear evidence of selective impairments *does* exist, the weaker findings of disproportionate (but not selective) category-specific impairments have an explanation in the source of neuropsychological data: experiments of nature can be messy. Regardless, the proposed Domain-Specific framework is not committed to a simplistic phrenological position in which a specific domain is represented in a single neural region.

Similarly, Moss and Tyler argue that functional neuroimaging results indicating category-*differential* as opposed to category-*selective* patterns of activation cannot be interpreted within a Domain-Specific framework. This

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