In their recent review, Murray and Bussey discuss in detail the findings from studies of perirhinal cortex function in non-human primates, and propose a model suggesting involvement of the perirhinal cortex in recognition memory and in visual perception. It is interesting to consider how this evidence accords with studies of perirhinal cortex function in humans, and the authors proceed to discuss the emergent literature on this issue. They note that amnesic patients with damage including the perirhinal cortex tend to show recognition memory deficits but that those with damage confined to the hippocampus or fornix perform relatively normally on tests of recognition memory.

One outstanding question that was raised by Murray and Bussey's article relates to whether findings in patients with the disorder of semantic dementia concur with their model of perirhinal function. Semantic dementia results in a progressive, yet selective deterioration of semantic memory affecting both verbal and non-verbal aspects of conceptual knowledge. Other cognitive domains, such as the phonological and syntactic aspects of language, non-verbal problem solving, working memory and visuospatial and perceptual abilities, are relatively unaffected. Of note is the fact that, pathologically, such individuals invariably show non-Alzheimer forms of neurofibrillary tangle pathology that is found in other forms of focal lobar atrophy. Murray and Bussey suggest that it is damage to "the ventromedial temporal cortex, including the perirhinal cortex, [that] results in semantic dementia" (p. 148), and that the perirhinal cortex might, therefore, be associated with the processing of semantic memory. The aim of this letter is to document recent data from semantic dementia which seem potentially problematic for Murray and Bussey's theoretical position.

Recent neuropsychological investigations of semantic dementia have revealed that the disorder is associated with focal atrophy of the entorhinal cortex (especially the pole and inferior and middle temporal gyri (Brodmann areas 38/20), with sparing of at least at early stages of the disease) of the hippocampal complex (hippocampal, parahippocampal gyr and subiculum). The status of the perirhinal cortex is clearly of vital importance but presents difficult methodological problems: the exact location and extent is controversial. It is currently considered to occupy the banks of the collateral sulcus and extend rostrally onto the medial surface of the temporal pole. This complex morphology without well-defined boundaries (unlike the hippocampus, for example) presents considerable difficulty for current volumetric MRI techniques based upon planimetry or stereology. To overcome these problems we used an automated voxel-by-voxel morphometric technique to identify changes in grey matter volume in six patients with semantic dementia. Although the caudal portion of the perirhinal cortex appeared normal, the status of the rostral section was less certain. Of more importance was the very strong correlation between the degree of anterolateral temporal lobe atrophy and semantic memory impairment, suggesting that this region, rather than the perirhinal cortex, may be the critical area for the processing of semantic knowledge.

Further evidence which seems contradictory to Murray and Bussey's view comes from recent neuropsychological studies that have investigated the integrity of episodic memory in semantic dementia. In contrast to the profound loss of semantic memory that is the hallmark of the disorder, episodic memory is often relatively preserved (see Ref. 8 for a review). Most patients show better recall of recent autobiographical memories compared to those from the more distant past, and it has been demonstrated that patients can temporarily relearn "forgotten" vocabulary through frequent practice, although the benefit of thisrote learning is quickly lost once practice ceases. The evidence most pertinent to the debate about the perirhinal cortex in semantic dementia is the robust finding of preserved non-verbal recognition memory in the disorder, using tests akin to the delayed-matching-to-sample tasks employed in animal studies. We have consistently found normal forced-choice recognition memory for both monochromatic and colour 11 pictures of objects and animals, despite the patients showing profound impairment on tests of semantic knowledge comprising the same stimuli. A recently conducted series of single-case studies compared yes/no recognition memory for familiar items categorized as still "known" or now "unknown" on the basis of prior assessments of comprehension and naming. These experiments demonstrated that patients with semantic dementia typically show normal recognition memory for familiar objects11 and famous faces,12 irrespective of whether their semantic knowledge about the test items is intact or severely degraded.

The interpretation of some of these results must be treated with a certain degree of caution because of the pervasive problem in recognition memory research of control participants performing close to ceiling. This makes it difficult to establish definitively that recognition memory—although far better than would be expected given the patients' profound loss of semantic knowledge—is truly normal. To address this issue, we recently carried out a study using a demanding recognition memory test designed in order that control participants would not perform at ceiling (Simons et al., unpublished data). We found that the controls did indeed score below ceiling, averaging 55.8 out of 62 (SD = 3.2), and that a group of five patients with semantic dementia were not significantly impaired according to comparisons of d' sensitivity measures (controls d' = 3.47, var d' = 0.19, semantic dementia: d' = 2.65, var (d') = 0.1, difference not significant). The evidence suggests, therefore, that patients with semantic dementia do possess intact non-verbal recognition memory even when their semantic knowledge about the test stimuli is severely degraded. This recognition memory capability is supported, we have proposed, by perisylvian anatomical information about the studied target items.

Based on the neuropsychological and behavioural evidence, therefore, we believe that Murray and Bussey's assumption that the perirhinal cortex is responsible for semantic memory is not proven. We also suggest that the data from semantic dementia may be problematic for the position that the perirhinal cortex is responsible for semantic recognition memory and the processing of semantic knowledge. We have demonstrated that, therefore, associations with semantic knowledge are used, most patients with the disorder do perform within normal limits on forced-choice recognition memory based, presumably, on preserved non-verbal recognition memory. In our studies it is only patients who have reached advanced stages of the disease who show profound impairments. It is clear that, unlike patients with Alzheimer's disease, patients with semantic dementia, it is difficult to see how their profound impairment of semantic memory can be explained by a model that assumes the perirhinal cortex is responsible for semantic memory processing as well as recognition memory.

To summarize, it is currently unclear whether it is valid to base a putative association between the perirhinal cortex and semantic memory upon the evidence from semantic dementia.
of the puzzling effects of PRh lesions in model of the function of the perirhinal lobe that is associated with the processing of semantic knowledge. It seems plausible, therefore, that the integrity of the perirhinal cortex underlies the normal recognition memory demonstrated in semantic dementia, and that it is the inferolateral temporal lobe that is associated with the processing of semantic knowledge.

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References

Reply

In a recent article, we described a model of the perirhinal cortex (PRh) that can account for some of the puzzling effects of PRh lesions in monkeys. We also suggested that the object information thought to be stored and processed in networks including PRh was akin to semantic memory in human material. The core of a system specialized for storing knowledge about objects, analogous to a semantic system in memory (in humans), p. 146). Simons, Graham and Hodges have raised several salient points concerning our model and its relationship to semantic memory and semantic de- ments (SD) in humans. Specifically, their main points are as follows: first, they provide preliminary evidence suggest- ing that similar regions of PRh may be spared in SD, and that the extent of anterolateral temporal cortex damage is correlated with semantic memory impairments. Second, Simons et al. report that in patients with SD there is rela- tively preserved episodic memory, in- cluding recognition memory.

We believe that the finding re- ported by Simons et al., that the sever- ity of damage is related to the extent of damage to the anterolateral temporal cortex, is entirely consistent with our model, regardless of whether the dam- age includes PRh. This is because our model assumes that the neural circuitry coding a visual representation of an object is distributed across the anterolateral inferior temporal (IT) cortex. Thus the greater the tissue damage in this region, the more this distributed representation will be compromised.

Furthermore, based on anatomical considerations, damage to caudal IT fields might be expected to have two effects: (1) removing parts of rep- resentations stored in that cortical field, and (2) ‘disconnecting’ down- stream fields from their normal pattern of sensory input. If this analysis is cor- rect, then damage to more lateral or caudal portions of IT might be ex- pected to have a somewhat greater ef- fect on semantic memory than would damage to rostral regions alone.

It is the hierarchical organization of this distributed object represen- tation, however, that allows the model to explain the pattern of lesion effects in monkeys. Similarly, the pattern of errors made by SD patients suggests a hierarchical model of semantic knowl- edge. Specifically, SD patients make er- rors that are generally category coordi- nate or superordinate, suggesting that pathology in SD ‘prunes back the se- mantic tree’, thus damaging ‘finer-

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