Reply

In a recent article, we described a model of semantic memory based on neuropsychological observations from patients with semantic dementia (PRh) that can account for some of the puzzling effects of PRh lesions in monkeys. We also suggested that the term ‘recognition’ is often used inappropriately in the context of semantic memory and that it is the inferolateral temporal lobe that is associated with the processing of semantic knowledge.

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Further, based on anatomical considerations, damage to caudal cortical fields might be expected to have two effects: (1) Removing parts of representations stored in that cortical field, and (2) ‘disconnecting’ downstream fields from their normal pattern of sensory input. If this analysis is correct, then damage to more lateral or caudal portions of IT might be expected to have a somewhat greater effect on semantic memory than would damage to rostral regions alone.

It is the hierarchical organization of this distributed object representation, however, that allows the model to explain the pattern of lesion effects in monkeys. Specifically, the pattern of errors made by SD patients suggests a hierarchical model of semantic knowledge. Specifically, SD patients make errors that are generally category coordinate or superordinate, suggesting that pathology in SD ‘prunes back the semantic tree’, thus damaging ‘branch-reducing (subordinate) aspects of these patients’ knowledge’ but leaving higher-order ‘categorical information intact’. Similarly, in our model, a lesion disrupts complex representations of the conjunctions of object features stored in downstream regions of IT, but leaves intact the simpler features stored in upstream regions. This property of the model may go some way to explaining the dissociation between stimulus recognition and semantic memory reported by Simons et al. One can imagine that when a subject is asked if a particular item was in the study list, she could respond accurately by recognizing a feature or subset of features of the stimulus (e.g. she could recognize ‘red’ in a red object).

References


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References


High-frequency brain activity: perception or active memory?

Tallon-Baudry and Bertrand make a striking case for the significance of non-stimulus-locked high-frequency brain activity. When coherent figures are processed, large-scale neuro-physiological recordings demonstrate stronger spectral power in the 20–60 Hz range compared with control conditions when no coherent objects are being recognized. Furthermore, their most recent study even indicates a role of high-frequency brain activity in short-term storage of coherent engrams, a view which can well be linked to data and theory about the role of memory networks in cortical active memory.

With their investigations, Tallon-Baudry and Bertrand venture substantially beyond animal studies that focussed on cortical responses to simple stimuli like the arrangements of bars slowly moving across the visual field. These ‘moving-bar’ studies, and other research on high-frequency activity related to physically simple stimuli such as gratings, light flashes and tone pips, have provided important insights in cortical binding mechanisms. However, these studies are at the level of elementary perceptual processes. To test a theory about object representations and other meaningful cognitive entities, it is mandatory to explore the brain’s responses to the corresponding stimuli: illusory-figure responses versus comparable incoherent arrays, physically very similar pictures which do not elicit the perception of an object, and words whose shape and meaning have been learned versus meaningless but physically almost identical letter combinations for whom no previously learned representation exists. In demonstrating distinct modulation of high-frequency EEG and MEG responses to coherent and gestalt-like stimuli, Tallon-Baudry and Bertrand and their colleagues have made a major contribution to cognitive science.

We should, however, mention four issues raised in their article where, as to our view, data currently available call for modification and specification of their proposals.

Feature binding versus associative representations

Tallon-Baudry and Bertrand define their distinction between the binding hypothesis and a representational hypothesis in terms of bottom-up and top-down processes. Accordingly, top-down activation should apply to representations only. But one may well argue that top-down processes can also affect binding processes. It might be best to define the distinction in the following way: at the psychological level, ‘feature binding’ can be characterized as the linking of stimulus features according to cognitive principles. The most important examples here are those proposed by Gestalt psychologists, e.g. (e.g. the property that two bars are aligned) and common fate (e.g. stimuli that move together). Evidence that high-frequency responses reflect such gestalt principles comes from numerous EEG studies, for example those showing that bars moving in the same direction elicit stronger high-frequency responses than bars moving in opposite directions. Tallon-Baudry et al.’s finding of stronger high-frequency responses to Kanizsa’s triangle compared with those to a non-triangle can also be accounted for. Only their Kanizsa triangle included aligned lines and thus satisfied the criterion of continuity.

According to the feature-binding view, one may posit that it is the individual’s experience, not a general gestalt principle, which is crucial for high-frequency dynamics. Thus, high-frequency dynamics would be expected when learned associative representations are being activated. Tallon-Baudry and Bertrand’s term ‘object representation’ is both too narrow and too wide: too narrow because stimuli other than objects, for example written and spoken words, are not in the same type of phenomenon. And too wide, because objects presented in an unusual way, for example faces presented not upright but horizontally, can also affect binding responses. Learned associative representations can be postulated for all entities that have been subject to learning. These include many objects, Tallon-Baudry and Bertrand’s dalmatian dog pictures, written and spoken words, and, more generally, perceptions and actions linked by associative learning.

Notice that there are no Gestalt principles or other a priori cognitive principles that would predict feature binding for coherent items such as ‘USA’, but not for ‘SAU’. Choice of the letter combination that are meaningful in a particular language is arbitrary. However, the frequent occurrence of certain-stimulus forms during language acquisition suggests that such representations are being built up for them. Thus, a learned representation would not necessarily predict a impairment on their recognition task even if the pathology in SD did involve a human homologue of monkey PRh.

Which brings us finally to the issue of the putative functional homologies of cortical fields in human and non-human primates. Our statements pertaining to the monkey lesion results were accompanied by a great deal of qualification - both in the text and in our list of Outstanding questions – related to the question of homology and the location of pathology in SD. We therefore agree that the functional homology of human and monkey PRh is not well-established, and that conclusions based on monkey must, for the moment, remain tentative.

To summarize, when all evidence is reviewed, there is probably more agreement than disagreement between the monkey lesion results and our own. The hierarchical model we proposed can account for many of the effects of PRh lesions in the monkey and is also consistent with the pattern of deficits seen in SD patients. We and Simons et al. clearly agree that the question of functional homology of monkey and human PRh is unresolved, and is an important target for future study.

References


Update

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