

Object decision under semantic impairment: the effects of conceptual regularities on perceptual decisions

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ABSTRACT

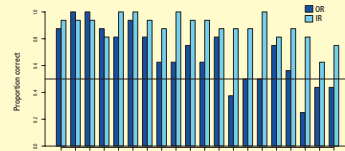
Although patients with semantic deficits can sometimes show fairly good performance on tests of object decision, we present evidence that this pattern applies when nonsense-object stimuli do not respect the regularities of the domain. Twenty patients with semantic dementia viewed pairs of line drawings, with a real and a chimeric animal side-by-side, and were asked to decide which was real. The chimeric was either more prototypical (over-regular condition) or less prototypical (irregular condition) than the real animal. Performance in both conditions was modulated by the extent of the patients' semantic impairment; but regardless of severity, patients were less successful in the over-regular than the irregular condition. The most severe patients were no better than chance on over-regular stimuli, but above 80% correct on irregular stimuli. The results are consistent with a recurrent distributed model of conceptual knowledge, in which structured semantic representations emerge from the interaction of high-level perceptual representations.

EXPERIMENT 1: OVER-REGULAR ANIMAL TEST (OAT)

- Task: Which one is real?
- For over-regular (OR) stimuli, chimeric is more prototypical than target (like gorillas on right).
- For irregular stimuli (IR), chimeric is less typical than target (like lions on right).
- OR and IR item pairs matched for difference between target and chimeric. In examples shown, both items include an animal with a tail and an animal without a tail.
- 16 items in each condition
- 20 SD patients tested

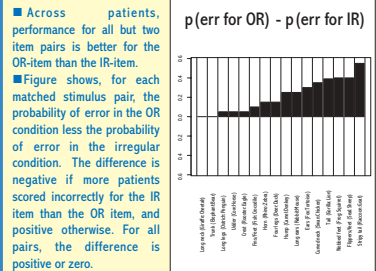


Proportion correct by condition and patient



- Performance in both conditions deteriorates with magnitude of semantic impairment...
- BUT performance is much worse when targets are unusual and distractors are regular (OR condition).

Analysis by item pairs

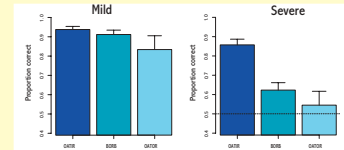


- Across patients, performance for all but two item pairs is better for the OR-item than the IR-item.
- Figure shows, for each matched stimulus pair, the probability of error in the OR condition less the probability of error in the irregular condition. The difference is negative if more patients scored incorrectly for the IR item than the OR item, and positive otherwise. For all pairs, the difference is positive or zero.

EXPERIMENT 2: COMPARISON TO BORB

13 of the 20 patients also performed the short version of the Birmingham Object Recognition Battery (BORB). Here participants are shown a series of individual pictures of objects, and for each must decide if it is real or not. Scores were compared to the two conditions of the OAT. Results are plotted separately for milder and more severe cases.

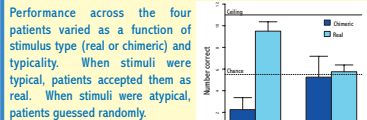
Proportion correct by severity and test condition



- Milder patients performed well in both conditions of the OAT and on the BORB. 95% confidence intervals for mean proportion correct overlap for all three conditions.
- More severe patients performed well on the IR condition of the BORB and poorly in the BORB and in the OR condition of the OAT. Performance was reliably better than chance in the BORB, but not in the OR condition of the OAT.

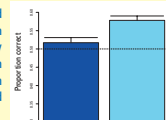
Over-regularisation effects in the BORB

- Four patients completed the entire BORB (128 items total). From this large battery we culled:
- 11 typical-looking chimeras
- 11 typical-looking real animals
- 11 atypical-looking chimeras
- 11 atypical-looking real animals



Performance across the four patients varied as a function of stimulus type (real or chimeric) and typicality. When stimuli were typical, patients accepted them as real. When stimuli were atypical, patients guessed randomly.

Performance on the matched subset was not reliably better than chance. Performance on the battery as a whole was reliably better than chance, and reliably better than performance on the matched subset.

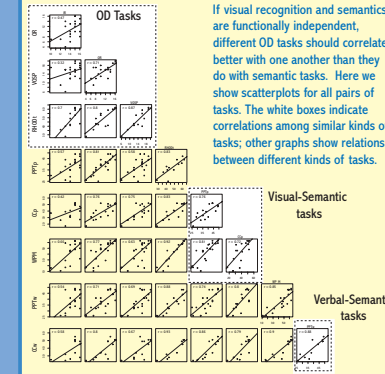


EXPERIMENT 3: COMPARING OD AND SEMANTIC TASKS

In addition to the OAT and the BORB, data were collected from most of the 20 SD patients on the following tasks, which vary in the extent to which each depends upon visual, verbal, and semantic processing:

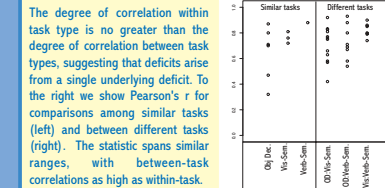
- VOSP object decision: a 2AFC object decision task using silhouettes.
- Pyramids and Palm Trees: a semantic matching task that can be administered with solely pictures or solely words.
- Came and Cactus: same as above with more difficult stimuli.
- Category comprehension: a 9AFC word-picture matching task.

Scatterplots



If visual recognition and semantics are functionally independent, different OD tasks should correlate better with one another than they do with semantic tasks. Here we show scatterplots for all pairs of tasks. The white boxes indicate correlations among similar kinds of tasks; other graphs show relations between different kinds of tasks.

Within- and between-task comparisons

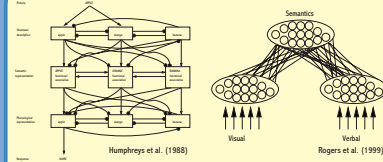


The degree of correlation within task type is no greater than the degree of correlation between task types, suggesting that deficits arise from a single underlying deficit. To the right we show Pearson's r for comparisons among similar tasks (left) and between different tasks (right). The statistic spans similar ranges, with between-task correlations as high as within-task.

CONCLUSIONS

- Patients with semantic dementia increasingly tend to accept typical-looking stimuli and reject atypical-looking stimuli in a 2AFC object decision task.
- Severely impaired patients can perform well on the task when real-animal targets respect the regularities of the domain, and chimeric distractors do not. The same patients perform poorly when the reverse is true (Experiments 1&2).
- In the standard OD task (the BORB), targets and distractors are not matched for typicality. Performance on this task falls between performance in the OR and IR conditions of the OAT (Experiment 2).
- Severely impaired SD patients perform at chance for a subset of BORB items matched for typicality, but reliably better than chance on the complete battery (Experiment 2).
- The degree of correlation among different varieties of object decision, visual-semantic, and verbal-semantic tasks is no greater than the degree of correlation between these task types, suggesting that patient deficits on all of these tasks arise from a single underlying impairment (Experiment 3).

Implications for theories of object recognition



- Many models of visual recognition posit that visual stimuli first activate independent pre-semantic visual representations that mediate recognition, which feed forward to activate semantic representations. Visual recognition is spared under semantic impairment because semantic processing does not influence the activation of visual representations.
- The current results are more consistent with an interactive account of visual-semantic processing, in which semantics automatically constrains visual processing. As semantic knowledge degrades, idiosyncratic object properties are lost but typical properties are retained. Hence, the system can discriminate typical from unusual-looking items under damage.

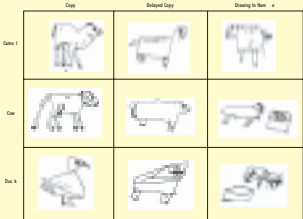
References

Riddoch, M. J. and Humphreys, G. W. (1987). Visual object processing in optic aphasia: A case study of semantic access apraxia. *Cognitive Neuropsychology*, 4 (2), 131-185.
 Humphreys, G. W., Riddoch, M. J. and Quinlan, P. T. (1988). Cascade processes in picture identification. *Cognitive Neuropsychology*, 5 (1), 67-103.
 Rogers, T. T., Lambon Ralph, M. A., Patterson, K., McClelland, J. L., and Hodges, J. R. (1999). A recurrent connectionist model of semantic dementia. Poster presented at the 1999 meeting of the Cognitive Neuroscience Society.
 *NOTE: M. A. Lambon Ralph contributed to this work while at the University of Bristol, and is now at the University of Manchester, Manchester, UK.

Are object recognition and semantics independent...

Case studies have reported patients with impaired access to semantics from vision, with relatively good visual object recognition as assessed by tasks requiring the participants to discriminate real from chimeric objects (object decision; see Riddoch & Humphreys, 1987). Such cases have been interpreted as providing evidence that visual object recognition and semantic memory are functionally independent.

...or interdependent?



However studies of patients with semantic dementia show that semantic impairment can greatly disrupt performance on visual tasks that do not require access to semantic information. Such patients perform within the normal range in delayed copying tasks when the stimulus items depict non-meaningful abstract shapes, but are greatly impaired when they depict meaningful objects. The above figure shows drawings produced by one such patient, I.F., in a direct copy condition, after a ten-second delay, and when given the object's name. I.F.'s delayed-copy was stereotyped and impoverished relative to his immediate copy, despite otherwise intact episodic memory. These and other findings suggest that visual and semantic knowledge systems interact more-or-less automatically in visual object processing.