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Relearning of verbal labels in semantic dementia

Julie S. Snowden*, David Neary

Cerebral Function Unit, Greater Manchester Neuroscience Centre, Hope Hospital, Salford, Manchester M6 8HD, UK

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Abstract

Semantic dementia is a degenerative disorder of temporal neocortex characterised by loss of word and object concepts. There is limited evidence that temporary relearning of lost vocabulary may be possible, attributed to sparing of hippocampal structures. However, learning is variable across patients and factors underlying learning success are poorly understood. The study investigated relearning of object names in two severely anomic semantic dementia patients. Following memory models that assume that hippocampal memories require some neocortical representation to underpin them it was predicted that relearning would be influenced by patients' residual semantic information about stimuli. Experiment 1 confirmed that residual knowledge influenced learning success. On the assumption that neocortical knowledge encompasses concepts of space and time, as well as words and objects, it was predicted that learning would be affected by the availability of contextual (temporo–spatial) information. Experiment 2 demonstrated effective learning of object names, attributed to the patient's use of temporal order and spatial position knowledge. Retention of object names over months was linked to the patient's capacity for autobiographical experiential (temporo–spatial contextual) association. The findings indicate that relearning of lost vocabulary is possible in semantic dementia, indicating a role of the medial temporal lobes in the acquisition of semantic information. Effective learning does not imply reinstatement of lost concepts, but, it is argued, does involve some reacquisition of meaning. The findings challenge the traditional semantic–episodic memory dichotomy and are consistent with a "levels of meaning" account of semantic memory.

Keywords: Semantic memory; Anomia; Learning; Concepts; Knowledge

1. Introduction

Semantic dementia is the descriptive term applied to the progressive loss of semantic knowledge that occurs in association with focal degeneration of the temporal neocortex [14,28]. A salient characteristic is an inability to name and to understand the meaning of words [14,28,41]. Impaired naming ability is frequently so profound that patients score at floor level on standard picture naming tasks. The semantic disorder is not, however, confined to a single sensory modality [3,33]. Patients have difficulty recognising faces and objects, may no longer understand the significance of non-verbal auditory sounds such as the ringing of a telephone or doorbell and may fail to identify smells, tastes or tactile stimuli. Non-semantic cognitive skills, by contrast, remain well preserved. Language is phonologically and syntactically correct and patients speak fluently and without effort. Patients carry out normally perceptual matching, spatial judgement and constructional tasks and show no difficulty in the detection and discrimination of tastes, smells and tactile stimuli that they do not recognise. A striking clinical feature is patients' well preserved current day-to-day memory. Patients have no difficulty recalling autobiographical events, remember appointments, carry out activities at the appropriate time of day unprompted and find their way around their locality without becoming lost, enabling a degree of functional independence that would be inconceivable in patients with classical amnesia.

There is evidence, both from neuroimaging [4,5,13,22] and post-mortem pathological examination [33,34] that inferior and middle temporal gyri are predominantly affected, highlighting the importance of these temporal neocortical structures for the representation of conceptual knowledge. Medial temporal structures are typically relatively intact and it is the preservation of hippocampal structures to which patients' capacity for current day-to-day memorising is attributed.

There is, nevertheless, growing awareness that the conceptual separation between memory systems, namely a temporal neocortical system for the representation of semantic facts and a medial temporal system for the formation of episodic memories, is an oversimplification. Despite

* Corresponding author. Tel.: +44-161-787-2561; fax: +44-161-787-2993.
E-mail address: julie.snowden@man.ac.uk (J.S. Snowden).

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impressive functioning in their daily lives patients with semantic dementia typically perform rather poorly on traditional episodic memory tests, indicating that impairments in semantic memory also influence episodic memory performance. Moreover, there is anecdotal evidence that patients with semantic dementia can learn new factual information and reacquire lost semantic information at least to some degree. In our experience, a patient in the process of selling her house had no difficulty learning the name of her solicitor and of prospective purchasers. Several patients have successfully learnt the names of new acquaintances including hospital personnel and of newly prescribed medications. The patient KE who failed to recognise a newly purchased electric toaster had no difficulty learning its function and was able to consistently use it appropriately [29]. The inference is that the hippocampal system may play an important role, not only in event memory, but also in the acquisition of semantic facts. Such a view is supported by complementary findings that patients with classical amnesia, in whom the hippocampal system is damaged, are impaired in their acquisition of new semantic information [8,40,45]. Nevertheless, in semantic dementia acquired information is unstable and depends on constant rehearsal. Our patient who could name her solicitor and house purchasers with ease during the period of her house sale no longer recognised those names a few weeks after her house sale was complete. The assumption is that although the hippocampal system supports new learning an intact neocortical system may be necessary for the stable, long-term representation of semantic knowledge.

If the hippocampal system supports semantic learning then it ought to be possible to demonstrate fact learning too in an experimental test setting, albeit reliant on frequent rehearsal. However, to date formal evidence for successful fact learning has been limited. Graham et al. [11] demonstrated effective learning in their patient DM. Over a 15 months period DM showed improved performance on tests of naming and verbal fluency, which were attributed to his home drill. In a controlled study of category fluency, DM produced significantly more exemplars for categories that he practised at home than for non-practised categories. This beneficial effect of practice rapidly declined once he ceased his daily drill. DM is, however, unusual. Graham et al. found no benefit from practice in other patients with semantic dementia. The authors contrast, in particular, DM's performance with that of the patient AM, who showed no evidence of improvement from self-initiated study, despite his apparently high level of motivation and the comparable time spent on his daily exercises.

The factors that underlie fact learning in semantic dementia are, thus, far from clear. Why should DM show relearning of category exemplars but not AM? Why, moreover, should learning of semantic information be demonstrated so rarely in patients with semantic dementia in a formal test setting whereas convincing, albeit anecdotal, examples of effective learning are regularly demonstrated in patients' daily life? Graham et al. posit several possible factors that might contribute to performance differences between DM and AM. Firstly, the two patients adopted different learning strategies. DM used descriptions, drawings and photographs of the concepts corresponding to the irretrievable names to assist vocabulary learning and words and pictures were organised predominantly by category. Thus, DM was continually activating both semantic and phonological representations of vocabulary that he was attempting to learn. By contrast, AM concentrated principally on word lists organised by initial letter, so that his practice was purely phonological. In view of the established memory advantage of semantic over phonological processing [16] DM's superior learning of vocabulary may be attributable to his more efficient learning strategy. Secondly, the two patients differed considerably in terms of the magnitude of their anomia. AM performed virtually at floor level on a simple test of picture naming, whereas DM showed a relatively mild anomia. Thirdly, the patients may have differed in terms of the degree to which their anomia reflected genuine underlying semantic impairment. AM showed clear semantic loss, as evidenced by his poor performance on the pyramids and palm trees test [15], whereas DM's scores on the same test were virtually normal.

Graham et al. regarded the factors relating to semantic severity as of lesser interest than the strategic factor: they argued that patients such as AM might simply be so severely affected that little can be done to remedy the situation. There are nevertheless theoretically important reasons why issues of severity might be relevant. DM's deficit is very mild. Although his naming skills are impaired it is likely that he has some remaining conceptual information pertaining to the objects whose names he is attempting to learn. It is probable that he recognised the pictures and photographs that he used as aide-memoires. In learning category exemplars he may have understood the meaning of category labels under which he grouped verbal terms. He may even have comprehended some of the words that he had difficulty retrieving. Thus, he had residual semantic information upon which to 'tag' the verbal labels that he was attempting to learn. By contrast, most patients with semantic dementia have a severe semantic loss, which cuts across input modalities: patients show no understanding of the words, of category labels and of pictures corresponding to words that they cannot retrieve. They have no meaningful tags on which to link the phonological form of the word. Thus, although a learning strategy that activates semantic representations might certainly be relevant in accounting for DM's superior naming performance, it might be precisely because of his relatively mild disorder and hence the availability of residual semantic information that he is in a position to derive such benefit. A requirement for successful learning may be a meaningful substrate upon which the information to be learnt can be tagged. If that is so, then it is plausible that DM is unrepresentative of the semantic dementia population. He might be capable of relearning words only because his semantic impairment is so