Anomia: A doubly typical signature of semantic dementia

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ABSTRACT

This study was designed to explore the nature of the anomia that is a defining feature of semantic dementia. Using a pool of 225 sets of picture naming data from 78 patients, we assessed the effects on naming accuracy of several characteristics of the target objects or their names: familiarity, frequency, age of acquisition and semantic domain (living/non-living). We also analysed the distribution of different error types according to the severity of the naming deficit. A particular focus of the study was the impact on naming of a previously unconsidered variable: the typicality of an object within its semantic category. This factor had a major influence both on naming success and on the proportions of different error types. Moreover, and increasingly so with declining naming accuracy, the patients' single-word incorrect responses were more typical than the target names. The observed effects of typicality sit well within models of semantic memory that represent concepts in terms of patterns of co-occurrence of constituent features. The results add to a growing body of evidence that, throughout the progressive deterioration of conceptual knowledge that characterises semantic dementia, both accuracy of performance and the nature of error responses are increasingly determined by the domain-specific aspects of typicality relevant to the task in question.

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1. Introduction

Almost without exception, adult aphasic patients have anomia in one form or another (Schwartz, Dell, Martin, Gahl, & Sobel, 2006). This is perhaps because successful naming – which requires the speaker to use a fairly precise semantic representation of a concept in order to access and produce its appropriate verbal label – taps so many components of conceptual and language processing. Anomia is a defining feature of semantic dementia (SD), a neurodegenerative disorder resulting in fluent progressive aphasia (Hodges, Patterson, Oxbury, & Funnell, 1992; Snowden, Goulding, & Neary, 1989). Although SD patients often turn up in the clinic complaining of 'memory loss' (Hodges & Patterson, 2007), what they mean – and what they or their partners sometimes say if they are better observers – is that they are gradually losing memory for words. Even this is not an accurate description: these patients are gradually losing central conceptual knowledge as a result of progressive focal atrophy of the anterior temporal lobes (Davies et al., 2005; Noppeney et al., 2007).

The central semantic deficit that characterises SD is apparent whether patients are tested in receptive or expressive format and whether they are probed with words or pictures or real objects or sounds, etc. (Adlam et al., 2006; Bozeat, Lambon Ralph, Patterson, Garrard, & Hodges, 2000; Bozeat, Lambon Ralph, Patterson, & Hodges, 2002; Rogers, Lambon Ralph, Garrard, et al., 2004). The differing nature of the relationship between conceptual knowledge and various modalities of input/output, however – with arbitrary mappings between concepts and their names – means that tasks involving words tend to be more vulnerable than those restricted to objects or pictures of them (Adlam et al., 2006; Benedet, Patterson, Gomez-Pastor, & Garcia de la Rocha, 2006). Further, limitations on the methods available for testing conceptual knowledge mean that expressive tasks tend to be harder than receptive ones (Funnell, 1995; Graham, Hodges, & Patterson, 1994). As a result of these two facts, expressive tasks involving words as responses are usually most sensitive to the conceptual deterioration that is at the core of SD. This is why, despite the fact that SD patients are impaired at any task requiring semantic memory, naming assessments typically reveal the most severe deficits (Rogers, Ivanoiu, Patterson, & Hodges, 2006; Snowden, Thompson, & Neary, 2004).

What is the nature of this naming deficit that is the signature of SD? What types of stimulus items are most likely to yield success or failure? What are the most common error types, and does the answer to this question depend upon the characteristics of the object to be named? Given that SD is a degenerative condition, do these features of the anomia change with the severity of the semantic deficit?

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A fair amount might be thought to be known already about these issues, because no one studying semantic dementia can fail to comment on the striking anomia; and indeed there have been several papers addressing various aspects of this phenomenon. In terms of determinants of naming success, Lambon Ralph, Graham, Ellis, and Hodges (1998) asked which characteristics of the objects or their names affect the likelihood of a correct response. They analysed performance by each of nine SD patients on the 132 pictures (selected from the large Snodgrass and Vanderwart (1980) set) that had available values on the variables being evaluated, including – to list the three with a significant impact on naming success – familiarity of the objects depicted, frequency of the spoken names and age of acquisition of the names.

The nature of SD naming errors was investigated by Rogers et al. (2004a) with reference to the impact of the degree of semantic deficit. This study considered a larger set of naming data (a total of 57 separate assessments, from 15 SD patients tested longitudinally between 1 and 10 times each, with an average of 3.8 assessments/patient) but on a smaller set of items (the 48-item naming battery from Hodges et al. (1992)), and related the patients' performance to that of a lesioned connectionist model of semantic memory. In both patients and model, as semantic deterioration progressed, (a) the occurrence of semantically related naming errors first increased but then decreased and (b) the failure to make any naming response at all (omission errors) increased monotonically.

The issues addressed in the two papers just summarised form part of the current article. What, then, justifies this new study? The first motivation is simply one of magnitude. Our research group has been studying semantic dementia for over 15 years, and the patients are always tested on object naming. We can therefore offer, to the research community interested in this topic, one of the most extensive sets of SD naming data available anywhere in the world. Furthermore, the large data set should provide greater power to assess the impact of certain variables. For example, Lambon Ralph et al. (1998) found no significant difference between levels of naming success in the two broad semantic domains of natural kinds (living things) versus manmade artefacts. Given the considerable interest in this category distinction, and the fact that some theoretical accounts of patients showing a significant advantage for artefacts over natural kinds would lead one to expect a similar phenomenon in SD (Lambon Ralph, Patterson, Garrard, & Hodges, 2003), it seems worth re-evaluation in this larger analysis.

The second motivation is a subtle but significant shift in thinking about the nature of the semantic deterioration in SD. This has often been characterised as following a specific-to-general progression, in which specific components of conceptual knowledge degrade early, whereas more general features have greater staying power (Warrington, 1975). Such a progression is apparent in SD patients' increased propensity to give superordinate responses (e.g. "animal") in picture naming (Hodges, Graham, & Patterson, 1995; Rogers, Lambon Ralph, Garrard, et al., 2004), and in their more accurate classification of items at the superordinate as opposed to basic level in category verification (Rogers & Patterson, 2007). Although there is no doubt that general semantic information is most robust to the progressive deterioration in SD, the dimension of specificity is perhaps not the most precise way to capture the heart of the matter. The fact that a camel has four legs could, in some sense, be considered as specific a feature of its anatomy as the fact that it has a hump or two. What differs between legs and humps, of course, is their *typicality*. The great majority of land animals have four legs; only the camel was 'punished' by being saddled with a hump (see Rudyard Kipling's story on "How the Camel Got its Hump" and also Hauk et al., 2007).

Of course, the dimensions of specificity and typicality are closely related, in that general information concerning any given item is that which is typical of the item's category. Hence, casting the nature of the semantic degradation in SD in terms of typicality is not intended to supplant the characterisation in terms of specificity. It is more a shift of emphasis that might be described as follows. To think about the hump as a specific feature of the camel puts the emphasis on what is known about camels; to think about it as an atypical feature moves that emphasis towards what is known about animals in general. This seems appropriate because, as conceptual knowledge deteriorates, the broad outlines of a semantic domain are, increasingly, all that remain. It is sometimes said that patients with SD still know that a camel has four legs but no longer know that it has a hump. A better description is that the patients know neither of these things about a *camel*: what they know is that *things like this* typically have four legs and typically have no hump. This residual knowledge is apparent in production tasks such as delayed copy drawing, in which SD patients often produce 'typicalised' images that either omit unusual features, such as the hump on a camel, or insert common features, such as an extra pair of legs on a duck (Bozeat et al., 2003; Patterson & Erzinclioglu, in press).

Typicality means somewhat different things in different cognitive domains or tasks. In some expressive tasks, it refers to the mapping between a stimulus and the correct response to it; this is true, for example, in the task of reading words aloud (Glushko, 1979; Shallice, Warrington, & McCarthy, 1983), in which the relationship between spelling and pronunciation is typical for English words like *new*, *few* and *grew* but atypical for *sew*. In other cases, with respect to a receptive ability such as word recognition, typicality may refer to a surface characteristic of the stimulus: if one assesses the typicality of spelling patterns in written English words by measuring their bigram frequencies, then *new*, *few*, *grew* and *sew* are all fairly typical but *view* is less so (Hauk et al., 2006). The important point here is that, whenever SD patients have been assessed on tasks where typicality in the relevant domain has been manipulated, the results have revealed a striking advantage for the more typical items (see Patterson (2007) for a description of this pattern in eight different tasks varying typicality, some verbal and some non-verbal, some expressive and some receptive). The prevalence of typicality effects in SD performance suggests that semantic knowledge contributes to accurate processing of atypical items in any domain, even if the task is not explicitly semantic (Patterson et al., 2006). Moreover, SD patients' errors to atypical items in expressive tasks generally take the form of a more typical response than the target, such as *sew*→ "sue" in reading aloud (Woollams, Lambon Ralph, Plaut, & Patterson, 2007), or the humpless camels and four-legged ducks produced in delayed copy drawing (Patterson & Erzinclioglu, in press). These 'typicalisation' errors suggest that, in the absence of sufficient semantic activation, the more robust knowledge of typical patterns comes to dominate processing.

Perhaps surprisingly, given that anomia is such a prominent feature of SD, the impact of object typicality on picture naming has never been formally assessed, and to do so was a central goal of the analyses of SD naming presented here. An effect of typicality on SD picture naming accuracy and error response types would seem to be predicted by computational semantic memory models that represent concepts in terms of the conjunction of their constituent features (Devlin, Gonnerman, Anderson, & Seidenberg, 1998; Harm & Seidenberg, 2004; McRae, De Sa, & Seidenberg, 1997; Randall, Moss, Rodd, Greer, & Tyler, 2004; Rogers, Lambon Ralph, Garrard, et al., 2004). Within these models, the features of lower typicality items are both less frequent and less often shared with other items in that category relative to higher typicality items, and hence it is the lower typicality items that should be more vulnerable to semantic degradation. Moreover, when an error of commission is produced, this should tend to be of higher typicality than the target.