CORTEX XXX (2013) 1–13

Available online at www.sciencedirect.com

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Journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

Broadly speaking: Vocabulary in semantic dementia shifts towards general, semantically diverse words

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ARTICLE INFO

Article history:
Received 12 June 2012
Reviewed 10 October 2012
Revised 17 August 2012
Accepted 7 November 2012
Action editors Peter Garrard and Brita Elvevag
Published online xxx

Keywords:
Conceptual knowledge
Spontaneous speech
Semantic memory
Semantic diversity
Latent semantic analysis

ABSTRACT

One of the cardinal features of semantic dementia (SD) is a steady reduction in expressive vocabulary. We investigated the nature of this breakdown by assessing the psycholinguistic characteristics of words produced spontaneously by SD patients during an autobiographical memory interview. Speech was analysed with respect to frequency and imageability, and a recently-developed measure called semantic diversity. This measure quantifies the degree to which a word can be used in a broad range of different linguistic contexts. We used this measure in a formal exploration of the tendency for SD patients to replace specific terms with more vague and general words, on the assumption that more specific words are used in a more constrained set of contexts. Relative to healthy controls, patients were less likely to produce low-frequency, high-imageability words, and more likely to produce highly frequent, abstract words. These changes in the lexical-semantic landscape were related to semantic diversity: the highly frequent and abstract words most prevalent in the patients' speech were also the most semantically diverse. In fact, when the speech samples of healthy controls were artificially engineered such that low semantic diversity words (e.g., garage, spanner) were replaced with broader terms (e.g., place, thing), the characteristics of their speech production came to closely resemble that of SD patients. A similar simulation in which low-frequency words were replaced was less successful in replicating the patient data. These findings indicate systematic biases in the deterioration of lexical-semantic space in SD. As conceptual knowledge degrades, speech increasingly consists of general terms that can be applied in a broad range of linguistic contexts and convey less specific information.

1. Introduction

Conceptual knowledge is central to the production of coherent, meaningful speech. This tight coupling between knowledge and speech is perhaps demonstrated most clearly in the syndrome of semantic dementia (SD), a progressive condition in which temporal lobe atrophy is associated with deterioration in verbal and non-verbal concepts (Hodges and

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http://dx.doi.org/10.1016/j.cortex.2012.11.004

Patterson, 2007; Bozeat et al., 2000). Although this loss of knowledge affects all semantically-driven behaviours, verbal and non-verbal, the impact on language is particularly pronounced. Word-finding difficulty is the primary presenting symptom in most patients and remains a key feature throughout the progression of the disorder (Lambon Ralph et al., 2001; Gorno-Tempini et al., 2011). Consistent with a general deterioration of conceptual knowledge, however, anomia in SD is not really a word-*finding* difficulty so much as a word-*knowing* difficulty. Unlike many patients with aphasia, SD cases show little benefit of phonological cues, suggesting that the problem is not at the lexical or phonological stages of word retrieval (Jefferies et al., 2008). Instead, naming problems in SD are influenced by precisely the same factors that affect the patients' performance in other semantic tasks. The names of objects are more likely to be retrieved if they are high in frequency and if the objects they refer to are highly familiar (Lambon Ralph et al., 1998) and if they are typical of their taxonomic category (Woollams et al., 2008). These factors also influence success in verbal and non-verbal comprehension (Jefferies et al., 2009; Adlam et al., 2006; Rogers et al., 2004b; Funnell, 1995) as well as in non-verbal expressive tasks like drawing and picture copying (Bozeat et al., 2003). Other studies have found a direct correspondence between naming ability for particular objects and knowledge for the same items in other tasks. Patients' ability to retrieve a word is predicted by their ability to give a definition of it (Lambon Ralph et al., 1999) and to respond appropriately to its referent in non-verbal tests (Garrard and Carroll, 2006). All of these findings support that view that anomia in SD is a direct consequence of deterioration in the underlying pan-modal concepts that are necessary for meaningful speech. This conceptual degradation has been linked to progressive atrophy in anterior temporal regions (Mion et al., 2010; Nestor et al., 2006). This region makes a critical contribution to the representation of verbal and non-verbal concepts (Pobric et al., 2010; Visser and Lambon Ralph, 2011; Marinkovic et al., 2003).

While the majority of studies have focused on single-word production in SD, some have investigated the impact of semantic deterioration on connected speech. Although patients exhibit subtle abnormalities in the syntactic structure of their speech (Meteyard and Patterson, 2009) they are for the most part able to produce fluent and grammatically well-formed sentences. Speech in SD is, however, characterised by dramatic reductions in content. Patients use words from a more restricted vocabulary, with a tendency towards over-reliance on highly familiar, 'light' words (Meteyard and Patterson, 2009; Ash et al., 2006; Wilson et al., 2010; Bird et al., 2000; Patterson and MacDonald, 2006). Bird et al. (2000) analysed the vocabulary used by SD patients when describing the Cookie Theft picture. Used commonly in aphasia assessment, this is a drawing of a domestic scene in which two children surreptitiously pilfer biscuits while their mother washes up. They found that, relative to the descriptions of healthy controls, patients were more likely to use words that were high in frequency and low in imageability. The shift towards higher frequency words is not surprising, since patients display better comprehension of high-frequency words across a range of tasks (Jefferies et al., 2009; Bozeat et al., 2000; Funnell, 1995). The preponderance of low-imageability words is more puzzling, since most SD patients show *poorer* comprehension of these words, relative to more concrete terms, in formal testing (Jefferies et al., 2009; Hoffman and Lambon Ralph, 2011). Bird et al. argued, however, that the apparent preference for more abstract words was a direct consequence of the loss of low-frequency words from the patients' vocabularies. Within the set of words typically used to describe the Cookie Theft picture, frequency and imageability are correlated such that higher frequency words tend to be less imageable. Therefore, as SD patients came to rely predominantly on higher frequency words, a concomitant reduction in imageability occurred. Bird et al. modelled this effect by creating an artificial Cookie Theft description based on those of healthy controls, and progressively degrading it by removing the low-frequency terms and replacing them with higher frequency words. The engineered descriptions exhibited the same shift in vocabulary towards the more abstract end of the imageability scale. As well as providing insights into the properties of connected speech in SD, this study illustrated the importance of considering the relationships between different lexical-semantic variables when assessing their effects in speech production.

Most studies of connected speech in SD have used picture description to elicit speech samples (Ash et al., 2006; Bird et al., 2000; Wilson et al., 2010; Patterson and MacDonald, 2006). There are a number of advantages to this approach. Because the topic is highly constrained, there is high degree of uniformity in the speech produced by healthy individuals. This provides a reliable baseline to which the patients' speech can be compared, allowing for the use of particular words to be investigated (e.g., "over-flowing" in the Cookie Theft description; Patterson and MacDonald, 2006). The constrained topic also tends to magnify word retrieval difficulties because patients are forced to attempt to describe objects and events that they may not recognise or fully understand (Sajjadi et al., 2012). In contrast, in free speech SD patients are often adept at masking their language impairments by avoiding topics for which they have little knowledge. A limitation of picture description, however, is that it mainly probes concrete objects and actions. It does not provide much opportunity for discourse about emotions or inter-personal relationships, which are an important element of real conversational speech, and it mainly solicits simple, present-tense constructions such as "The water is over-flowing" (or, in the patients' speech, more typically "The water is coming down"; Patterson and MacDonald, 2006). Finally, the size of the speech sample elicited from each participant is usually limited to a couple of hundred words. In the present study, we analysed a more naturalistic set of speech samples that avoided some of these limitations. We analysed the words used by seven SD patients during an autobiographical memory interview (Kopelman et al., 1990; Irish et al., 2011). The advantages of this method are as follows:

1. The content of the speech was more representative of natural conversations. In the autobiographical memory interview, patients were asked to describe significant events from their lives. In addition to the concrete, sensory aspects of these events, patients often described their

Please cite this article in press as: Hoffman P, et al., Broadly speaking: Vocabulary in semantic dementia shifts towards general, semantically diverse words, Cortex (2013), http://dx.doi.org/10.1016/j.cortex.2012.11.004