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The relation between content and structure in language production: An analysis of speech errors in semantic dementia

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ABSTRACT

In order to explore the impact of a degraded semantic system on the structure of language production, we analysed transcripts from autobiographical memory interviews to identify naturally-occurring speech errors by eight patients with semantic dementia (SD) and eight age-matched normal speakers. Relative to controls, patients were significantly more likely to (a) substitute and omit open class words, (b) substitute (but not omit) closed class words, (c) substitute incorrect complex morphological forms and (d) produce semantically and/or syntactically anomalous sentences. Phonological errors were scarce in both groups. The study confirms previous evidence of SD patients' problems with open class content words which are replaced by higher frequency, less specific terms. It presents the first evidence that SD patients have problems with closed class items and make syntactic as well as semantic speech errors, although these grammatical abnormalities are mostly subtle rather than gross. The results can be explained by the semantic deficit which disrupts the representation of a pre-verbal message, lexical retrieval and the early stages of grammatical encoding.

1. Introduction

1.1. Errors in speech production

There is a long tradition of using naturally-occurring speech errors to inform models of language production, under the assumption that such errors are constrained by components of linguistic processing (Bock & Levelt, 1994; Cutler, 1981; Fromkin, 1971). One of the first models of speech production was based on an analysis of an extensive corpus of such errors in normal, healthy speakers (Garrett, 1984). Speech errors produced by different aphasic patient groups have formed the basis of debates about particular deficits and how they relate to the intact language system (Bates & Wulfeck, 1989; Nickels & Howard, 2000; Rapp & Goldrick, 2000, Goldrick, 2006). Here we present an analysis of naturally-occurring speech errors in a group of patients with a diagnosis of semantic dementia (SD), a progressive neurological condition. SD is a subtype of Fronto-Temporal Dementia (FTD, Hodges & Patterson, 2007; Snowden, Neary, & Mann, 1996) in which there is relatively focal atrophy of the anterior inferior temporal lobe bilaterally, though often more severe on the left (Rosen et al., 2002; Mummery et al., 2000; Galton et al., 2001; Seeley et al., 2005).

The striking feature of SD is a fairly selective deterioration of semantic information across all modalities of input and output, both verbal and non-verbal. Non-verbal manifestations of the deficit have been found in delayed copy drawing, where distinctive features are lost (e.g. the hump of the camel) and common features intrude, particularly for living things which share many attributes (e.g. a duck is drawn with four legs; Bozeat et al., 2003). Patients are poor at matching pictures of objects to their characteristic sounds as well as their names (Bozeat, Lambon Ralph, Garrard, Patterson, & Hodges, 2000) and they show impaired use of objects, especially less common ones (e.g. a corkscrew or stethoscope, Bozeat, Lambon Ralph, Patterson, & Hodges, 2002). At mild-moderate stages, when SD patients can still perform categorisation tasks, they are better are categorising pictures at the general level (i.e. animal or non-living thing), than at the basic level (e.g. dog or bird), and better at the basic level than at the specific level (e.g. labrador or collie) (Rogers & Patterson, 2007). Verbal manifestations of the semantic deficit are seen in impaired object naming and word-to-picture matching, such that these tests are routinely used in diagnosis (Hodges & Patterson, 2007). In free speech, the anomia typical of SD results in open class items being replaced by more general, indefinite terms (e.g. 'thing', 'stuff' and 'place') and an increased reliance on high frequency, high familiarity items and pronouns (Bird, Lambon Ralph, Patterson, & Hodges, 2000).

In sum, SD presents a remarkably focused deterioration in conceptual-semantic knowledge such that specific, distinctive information is lost and expressions of knowledge become increasingly

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general, with better preservation of typical, familiar and highly frequent information (Patterson et al., 2006; Warrington, 1975). Given these qualities, the syndrome provides a unique opportunity to explore how a degraded semantic system (and associated lexical deficits) affect speech production.[1] Most models of spoken language production share the assumption that there are three distinct levels of processing. First is a level at which the pre-verbal message is generated and concepts are retrieved to express it (message generation). Second, there is an intermediate level at which lexico-semantic representations (words) are selected to express the concepts (retrieval of open class items); it is also thought that syntactic information is retrieved at this point and sentence structure is generated (closed class items and morphology). Third, phonological representations are retrieved that map onto the selected words (e.g. Bock, 1999; Garrett, 1984; Goldrick, 2006; Levelt, Roelofs, & Meyer, 1999; Vigliocco & Kita, 2006). At present, all models assume cascading of information (i.e. partial information from one level can be accessed by the next) from conceptual to lexico-semantic representations, as this allows multiple candidates to be activated for a particular target (Goldrick, 2006; Levelt et al., 1999); interactivity between other levels is still a topic of much debate (Dell, 1986; Rapp & Goldrick, 2000; Roelofs, 2004; Vigliocco & Hartsuiker, 2002).

SD speech is usually characterised as fluent and relatively normal as regards syntax and phonology. Nevertheless, reduction of morphological and syntactic complexity, relative to normal speakers, has been documented (Benedet, Patterson, Gomez-Pastor, & Garcia de la Rocha, 2006; Patterson & MacDonald, 2006). If all levels of linguistic processing interact with the conceptual-semantic system, abnormalities beyond the semantic and lexical components of language should be observed in SD (Benedet et al., 2006). Alternatively, major abnormalities may only be observed for those components that directly rely on conceptual-semantic information, in particular message generation, lexical retrieval and some aspects of grammatical encoding (see below). A simple way to assay this hypothesis is through an analysis of errors produced by SD patients in conversational speech. We divide the areas of interest into four broad sections: (1) message generation; (2) the retrieval of open class items; (3) the retrieval of free and bound closed class items and (4) phonology.

1.2. Message generation

Before we open our mouths to speak, the message we want to convey must be at least partially generated. Message generation may include specifications of event semantics or thematic roles (i.e. an abstract marking of who did what to whom) which are then translated into syntactic constructions with phrasal categories (i.e. a subject noun verbing an object noun) during grammatical encoding (Chang, Bock, & Goldberg, 2003; Ferreira & Bock, 2006). The message "activates a set of possible structural realizations" (Bock & Warren, 1981, p.63; Bock, 1982) which influence syntactic assignment and interact with lexical retrieval during subsequent encoding.

For patients with SD, there is a deterioration of the conceptual-semantic information that underpins message generation. This may impact production in two ways. First, conceptual deterioration might cause problems during the generation and maintenance of structured message representations (e.g. MacKay, Burke, & Stewart, 1998) as specific information cannot be retrieved. So we might expect underspecified descriptions of events, simplified utterance structure and a reliance on light verbs and pronouns that do not have an established discourse referent. The latter prediction is motivated by two studies which used Cookie theft picture descriptions, in which the narrative speech of SD patients used light terms (e.g. 'thing' and 'place') in place of specific open class words and an increased used of high frequency, high familiarity items (Bird et al., 2000; Patterson & MacDonald, 2006). Second, conceptual deterioration may disrupt event semantics and be shown in gross syntactic errors, e.g. violations of word order or phrase structure. The issue of grammatical encoding has been largely neglected in research on SD (but see Patterson & MacDonald, 2006; Tyler, Moss, Patterson, & Hodges, 1997), probably because patient's speech is on first impressions fluent and well formed, in contrast to the salient semantic deficit and anomia.

1.3. The retrieval of open class items

Anomia is characteristic of SD and has received substantial research attention (see Woollams, Cooper-Pye, Hodges, & Patterson, 2008, for an analysis of a large corpus of SD naming errors). We expect to see substitution and omission errors on open class items as appropriate words will be too unstable or too degraded to be retrieved successfully (Nickels & Howard, 2000). As noted above, there is evidence that the free speech of patients with SD shows an increased use of light terms, so we will look specifically for substitution errors consisting of light verbs and what we will call light nouns (e.g. 'thing', 'stuff' and 'place').

Apart from substitution and omission, conflicts can also arise between conceptual and lexical access. The classic example is the tip-of-the-tongue state in which the concept is available but the word-form is not, much to the speaker's frustration (e.g. Brown & McNeill, 1966; Vigliocco, Antonini, & Garrett, 1997). When such conflicts arise during production, the original structure activated by the message may no longer be feasible, and an alternative structure may have to be generated to accommodate problems with lexical access (e.g. Levelt & Maassen, 1981). In SD we might expect to see the breakdown and restart of utterances (when lexical retrieval fails completely) and syntactically and semantically anomalous sentences that result from erroneous lexical items appearing in pre-activated structures (when lexical retrieval goes awry).

The selection of lexical items and the building of syntactic frames are intimately linked and, more importantly, the correct assignment of lexical items to phrasal roles (who did what to whom) involves both semantic and syntactic information. Lexico-semantic representations are assigned to particular roles (e.g. the agent of an action) according to a conceptual message; thus this assignment cannot be independent of conceptual-semantic content (Bock, 1982; Bock & Warren, 1985). During syntactic encoding, when phrases are being built, lexico-syntactic information marks the appropriate context for a given word (Bock, 1999; Bock & Levelt, 1994) and is likely to influence the encoding of an item's syntactic environment. Verbs are thought to dictate the argument structure of the sentences in which they appear (Levin 1993; Altmann, 2004), and Levelt et al. (1999) proposed that 'lemmas' (holistic lexical representations) are marked for syntactic information (e.g. lexical class) amongst other things. For example, a selected lemma that is marked as a noun should/will not be assigned to a verb position in a syntactic frame.

It is an interesting question how the degraded semantic information in SD will affect this assignment process. The fact that syntactic information is abstracted across numerous members of a given class (e.g. all nouns, all verbs) and is probably redundantly coded (e.g. Bates & Wulfeck, 1989) should make it at least relatively robust to lexico-semantic deficits. With this in mind, we might not expect gross phrasal violations (e.g. if the content of a specific noun is degraded, it may still be marked a noun). However, it is an open question whether other syntactic errors, with closed

[1] Analyses of speech in Alzheimer's disease cannot rule out that errors are a product of attentional or memory impairments, rather than impaired lexical access or semantic impairments per se (Bates, Harris, Marchman, & Wulfeck, 1995). SD represents a more selective deficit.