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Ever decreasing circles: Speech production in semantic dementia

Lotte Meteyard [a,*], *Emma Quain* [a] *and Karalyn Patterson* [b]

[a] *School of Psychology and Clinical Language Sciences, University of Reading, Reading, UK*
[b] *Department of Clinical Neurosciences, University of Cambridge, Addenbrooke's Hospital, Cambridge, UK*

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ABSTRACT

We explored the impact of a degraded semantic system on lexical, morphological and syntactic complexity in language production. We analysed transcripts from connected speech samples from eight patients with semantic dementia (SD) and eight age-matched healthy speakers. The frequency distributions of nouns and verbs were compared for hand-scored data and data extracted using text-analysis software. Lexical measures showed the predicted pattern for nouns and verbs in hand-scored data, and for nouns in software-extracted data, with fewer low frequency items in the speech of the patients relative to controls. The distribution of complex morpho-syntactic forms for the SD group showed a reduced range, with fewer constructions that required multiple auxiliaries and inflections. Finally, the distribution of syntactic constructions also differed between groups, with a pattern that reflects the patients' characteristic anomia and constraints on morpho-syntactic complexity. The data are in line with previous findings of an absence of gross syntactic errors or violations in SD speech. Alterations in the distributions of morphology and syntax, however, support constraint satisfaction models of speech production in which there is no hard boundary between lexical retrieval and grammatical encoding.

1. Introduction

The relationship between lexico-semantic and grammatical information, particularly during speech production, is an enduring topic of argument and research (Bock, 1987; Bock and Warren, 1985; Chang et al., 2006; Dell et al., 1999; Ferreira and Dell, 2000; Garrett, 1980; Goldrick, 2006; Levelt et al., 1999; Schiller and Costa, 2006; Schriefers et al., 2005; Vigliocco and Hartsuiker, 2002). Grammatical encoding and lexical retrieval are intimately related: during the early stages of production, a pre-verbal message is translated into lexico-semantic representations (words) that are assigned to particular roles (syntactic structures) to express the message (who did what and to whom) (Bock, 1999; Bock and Levelt, 1994; Garrett, 1980). At the lexical level, some grammatical and semantic distinctions correlate highly: e.g., nouns and verbs largely correspond to objects and actions (Vigliocco et al., 2006); the meanings of verbs correlate closely with the argument structures in which they can appear (Levin, 1993) and nouns are held to carry or define the syntactic

* *Corresponding author*. School of Psychology and Clinical Language Sciences, Psychology Building, Whiteknights Campus, University of Reading, Reading RG6 6AL, UK.
E-mail address: l.meteyard@reading.ac.uk (L. Meteyard).
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information that controls their determiners (Schiller and Caramazza, 2006; Schiller and Costa, 2006; Schriefers et al., 2005). Some theorists propose that syntactic features are linked to or part of lexico-semantic (lemma) representations (Levelt et al., 1999) and constraint satisfaction models of language also propose a multi-dimensional role for the lexicon (Seidenberg and MacDonald, 1999). These models are most developed for language comprehension, but the frameworks can be applied to production. The 'lexicon' includes information about semantic, phonological and morphological features of words, as well as the argument structure for verbs, and the relative frequency or probability of a given element of information (Seidenberg and MacDonald, 2001). The constraint satisfaction approach does not place a hard boundary between the lexicon (single word meaning and single word forms) and syntax. Syntactic and morphological structures are emergent properties rather than stable, rule based representations that can be stored and retrieved holistically. Constraint satisfaction fits well with incremental speech production models (Timmermans et al., 2012). In both cases, multiple sources of linguistic and non-linguistic information are integrated in real time during production. There is limited pre-planning of utterances and the availability of information plays an important role in determining the structure of output. For example, concepts that are more salient (e.g., because they are animate, more imageable or presented earlier) are assigned more prominent grammatical roles (e.g., sentence subject) (Bock and Warren, 1985; McDonald et al., 1993; Timmermans et al., 2012). This means that lexical selection plays an important part in determining the final structure of a sentence as well as its component words. In sum, there is evidence for a close interplay between lexical, morphological and local syntactic information (Bock, 1987; Dell et al., 1999; Ferreira and Dell, 2000; Patterson et al., 2001; Vigliocco and Hartsuiker, 2002).

Neuropsychological evidence from patients with impaired semantic representations, on the other hand, is frequently reported as demonstrating independent impairment of semantic and grammatical processes (Kave et al., 2007), which in turn would suggest a separation between lexical retrieval and grammatical encoding. Semantic dementia (SD) is a progressive neurological condition, associated with degeneration of the anterior temporal lobes bilaterally, and manifesting as a fairly selective deterioration of conceptual and semantic information across all modalities of input and output, both verbal and non-verbal (Bozeat et al., 2000; Hodges and Patterson, 2007). The deterioration can be characterised as a gradual reduction in aspects of knowledge specific to individual concepts, paring semantic memory back to its barest and most general bones (Patterson et al., 2006; Warrington, 1975).

Lexical deficits in speech production are well documented in SD (Hodges and Patterson, 2007; Hodges et al., 1992; Patterson and MacDonald, 2006). Normal language processing, both receptive and expressive, depends on conceptual information that supports the semantic content of lexical items, and anomia is typically the first noticeable symptom of SD (Hodges and Patterson, 2007; Nickels and Howard, 2000). The narrative speech of SD patients displays a reliable pattern of light or vague terms (e.g., 'thing' and 'place', 'do' and 'go') in lieu of specific open class words (Kave et al., 2007; Meteyard and Patterson, 2009) and other lexical items tend to be from high frequency, high familiarity bands (Ash et al., 2006; Bird et al., 2000; Patterson and MacDonald, 2006). Apart from this characteristic anomia, free speech in SD is considered fluent and basically intact as regards phonology and grammar (Wilson et al., 2010). Patients with SD make scarcely if any more phonological errors than healthy speakers in spontaneous speech, where the patients are only using words whose meanings they still know (Meteyard and Patterson, 2009; Patterson, in press; Sajjadi et al., 2012; Wilson et al., 2010) They do not produce gross syntactic errors or differ from controls on measures such as the number of embeddings, proportion of words in sentences or verbs with inflections (Meteyard and Patterson, 2009; Wilson et al., 2010).

The evidence for preserved phonology in SD patients' spontaneous speech is fairly consistent (Meteyard and Patterson, 2009) but evidence for preserved morphological and syntactic processing is mixed. Kave et al. (2007) completed an analysis of the lexical, morphological and syntactic characteristics of a single SD patient, AK, at three different time points across 3 years and compared against a small control group. For part of the analysis, the authors used a set of measures developed to quantify aphasic speech production: Quantitative Production Analysis (QPA) (Saffran et al., 1989). The patient was asked to retell the Cinderella fairy-tale and in the latter-two time points needed story-relevant pictures to produce sufficient speech for analysis. Therefore, the data were in fact obtained from both familiar narrative and picture description tasks. The authors reported no difference between AK and the control group for the number of well-formed sentences, noun and verb phrases (NP and VP) elaboration (i.e., the number of words in a NP or VP), the number of arguments used per verb or the complexity of verb inflections and auxiliaries used. These results were contrasted against conceptual and lexical measures which showed a clear deterioration in conceptual knowledge. Breedin and Saffran (1999) analysed both the comprehension and production of SD patient DM, and also used the QPA to analyse speech production. His performance was within the normal range on all measures. Using a very different technique requiring production of specific structures, Benedet et al. (2006) reported that a Spanish SD patient ILJ had difficulty in producing complex morphological forms, both inflectional and derivational. Furthermore, although able to generate typical Subject–Verb–Object sentences on demand, ILJ had problems with less typical constructions, such as relatives and passives. When asked for passives, which are rare in everyday spoken Spanish (though normal speakers can and do produce them on demand), ILJ tended to omit or substitute the required auxiliary or just produce an active sentence.

There have been four case-series studies of English-speaking SD patients, one exploring verb morphology and three analysing sentence content and structure. With regard to morphology, 11 SD patients were impaired in producing and recognising the correct past-tense forms of irregular verbs, especially less frequent ones; the degree of this deficit was significantly correlated with the patients' comprehension impairment on a verb synonym task (Patterson et al., 2001). Of the case-series studies of SD speech content/structure, two used narrative descriptions from the Cookie theft picture. Bird

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