Lexical access in semantic variant PPA: Evidence for a post-semantic contribution to naming deficits

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**ABSTRACT**

The most salient clinical symptom of semantic variant primary progressive aphasia (PPA) is a profound and pervasive anomia. These patients’ naming impairments have been shown to reflect in large part a domain-general deterioration of conceptual knowledge that impacts both linguistic and non-linguistic processing. However, it is possible that post-semantic stages of lexical access may also contribute to naming deficits. To clarify the stages at which lexical access breaks down in semantic variant PPA, eleven French-speaking patients were asked to name objects, and were then queried for semantic, lexical-syntactic, and word form information pertaining to the items they could not name. Specifically, our goal was to determine whether patients can access intermediate representations known as lemmas, which mediate the arbitrary mapping between semantic representations and word forms (phonological and orthographic forms). The French language was chosen for this study because nouns in French are marked for grammatical gender, a prototypical type of lexical-syntactic information, represented at the level of the lemma. Access to word form information is also dependent on lemma access under some theoretical views. We found that six of the eleven patients showed partial access to either lexical-syntactic properties of unnamed items (grammatical gender), word form information (initial letter), or both. Access to these types of information suggests that a lemma has been retrieved, implying a breakdown at the post-semantic stage of word form retrieval. Our results suggest that although degraded conceptual knowledge is the main cause of naming deficits in semantic variant PPA, in some patients, a post-semantic component also contributes to the impairment.

1. Introduction

Lexical access refers to the process of retrieving a word from the mental lexicon and encoding it for speech production. Most researchers agree that lexical access involves a series of stages including at least: (1) conceptual preparation yielding a semantic representation of the word to be produced; (2) retrieval of an abstract entity known as a lemma that encodes word-level syntactic information (e.g., grammatical category, grammatical gender, argument structure); (3) retrieval of a word form (a phonological form in the case of speaking); and (4) transformation of this word form into a motor plan for the speech apparatus, involving processes such as syllabification and phonetic encoding (Dell, 1986; Dell et al., 1997, 2013; Levelt et al., 1999; Schwartz et al., 2006). The first three of these stages are depicted in Fig. 1A.

Theories of lexical access differ in many details, including the number of stages, the precise nature of representations at each stage (e.g., localist or distributed, componential or holistic), and how information flows between stages (e.g., strictly feed-forward, or interactive and bi-directional) (Caramazza, 1997; Dell, 1986; Levelt et al., 1999). However, one aspect of the model architecture is common to most approaches, and is critical to the present study. This is the assumption that there are intervening representations that mediate the arbitrary mapping between semantic representations and word forms (phonological and orthographic forms). These intermediate representations are referred to as lemmas (Kempen and Huijbers, 1983). The lemma concept has strong empirical support. Studies of spontaneous and experimentally induced speech errors have shown that word-level exchanges tend to respect grammatical category but are indifferent to word form, suggesting that these errors involve the manipulation of lemmas. In contrast, phoneme-level exchanges are...
sensitive to phonological but not syntactic factors, suggesting that they take place at a later stage of phonological encoding (Fromkin, 1971; Fay and Cutler, 1977; Garrett, 1975; Shattuck-Hufnagel, 1979). Reaction time studies have shown that semantic and phonological distractors impact picture naming with different time courses, again suggesting distinct stages (Schriefers et al., 1990; Levelt et al., 1999).

Patients have been described who can accurately report the grammatical gender of words even when they cannot retrieve the word form, suggesting access to lemma representations that encode lexical-syntactic information but are devoid of segmental content (Badecker et al., 1995; Caramazza, 1997; Henaff Gonon et al., 1989). The “tip-of-the-tongue” phenomenon in healthy speakers can be interpreted similarly: the feeling of knowing a word reflects successful retrieval of the lemma, even though the word form cannot be retrieved (Brown, 1991; Vigliocco et al., 1997). In languages that mark grammatical gender, this lexical-syntactic information can be reported with impressive accuracy in tip-of-the-tongue states (Miozzo and Caramazza, 1997; Vigliocco et al., 1997). Taken together, there is a rich body of evidence that retrieval of lemmas can be dissociated from retrieval of word forms.

Semantic variant primary progressive aphasia (PPA), which we consider to be essentially equivalent to semantic dementia (Adlam et al., 2006), is a clinical syndrome characterized by progressive loss of conceptual knowledge or semantic memory due to degeneration of anterior and inferior temporal brain regions (Warrington, 1975; Schwartz et al., 1979; Snowden et al., 1989; Hodges et al., 1992). Anomia is typically the earliest and most prominent symptom of semantic variant PPA. Word retrieval difficulty is modulated by factors including word frequency (Warrington, 1975; Hodges et al., 1992; Lambon Ralph et al., 1998), object familiarity (Lambon Ralph et al., 1998), item specificity (Hodges et al., 1995), and item typicality (Wooliams et al., 2008), and becomes increasingly severe over the course of the disease (Hodges et al., 1995).

At which stage(s) of the lexical access process does word retrieval go awry in semantic variant PPA? One stage that is clearly impacted in all individuals with semantic variant PPA is the first stage: conceptual preparation leading to a semantic representation. Several decades of research have shown that anomia in semantic variant PPA is just one manifestation of a domain-general deterioration of conceptual knowledge that affects all expressive and receptive modalities. Underlying impairments of conceptual knowledge have been demonstrated with non-linguistic semantic tasks such as semantic matching between pictures (Bozeat et al., 2000), object use (Hodges et al., 2000), sound to picture matching (Bozeat et al., 2000), picture categorization (Rogers and Patterson, 2007), knowledge of object features (Adlam et al., 2006; Rogers et al., 2004) and delayed picture copy (Patterson and Erzinçlioğlu, 2009); see Hodges and Patterson (2007) for review. Furthermore, the progression and severity of naming deficits are strongly associated with the progression and severity of the deterioration of conceptual knowledge (Adlam et al., 2006; Hodges et al., 1995; Jefferies and Lambon Ralph, 2006; Lambon Ralph et al., 2001; Rogers et al., 2004; Reilly et al., 2011).

A deficit at the stage of conceptual preparation leading to a semantic representation is depicted in Fig. 1B. In this hypothetical example, one feature for ‘dog’ does not exist (woof), some features are partially activated (guard, pet: light blue) and one feature that does not belong to ‘dog’ is partially activated (meow). A degraded semantic representation may or may not lead to successful lemma retrieval (depending on the degree of degradation, and the integrity of the links between the semantic and lemma levels). In this example, lemma retrieval is not successful. (C) Impairment at the level of lemma retrieval. In this example, the semantic representation is completely intact, but because of the degraded links between semantic representations and lemmas, no lemma is activated. (D) Impairment at the level of word form retrieval. The semantic representation is intact and a lemma has been selected, so lexical syntactic information (grammatical gender) is available. In this example, there is partial activation (light blue) of the word form (the first phoneme), which is not sufficient for the word to be produced.

Fig. 1. Model of lexical access. (A) The architecture of the model is based on Dell et al. (1997). Blue shading and lines represent successful cascading activation of a feature-based semantic representation, a lemma and a word form, which would then be syllabified, encoded and mapped to a motor plan. (B) Impairment at the level of semantic representations (indicated by a red line). Note that one feature for ‘dog’ is not activated (woof), some features are only partially activated (guard, pet: light blue) and one feature that does not belong to ‘dog’ is partially activated (meow). A degraded semantic representation may or may not lead to successful lemma retrieval (depending on the degree of degradation, and the integrity of the links between the semantic and lemma levels). In this example, lemma retrieval is not successful. (C) Impairment at the level of lemma retrieval. In this example, the semantic representation is completely intact, but because of the degraded links between semantic representations and lemmas, no lemma is activated. (D) Impairment at the level of word form retrieval. The semantic representation is intact and a lemma has been selected, so lexical syntactic information (grammatical gender) is available. In this example, there is partial activation (light blue) of the word form (the first phoneme), which is not sufficient for the word to be produced.
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