



When one can write SALTO as noun but not as verb: A grammatical category-specific, modality-specific deficit

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ABSTRACT

We report the naming performance of a Spanish patient (AQF) suffering from Primary Progressive Aphasia (PPA). AQF's performance revealed a grammatical category-specific deficit, with poorer performance in verb than in noun naming. Furthermore, this dissociation was only present in written naming. Importantly, the patient's dissociation between nouns and verbs was present also when we studied her performance with homonymous words. We argue that this dissociation is not due to a range of semantic factors but is a true grammatical category-specific deficit located at the lexical level of orthographic processing. Thus, we bring in new evidence in favour of grammatical category representation at a post-semantic level where output modalities are represented separately.

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1. Introduction

1.1. Background

The disproportionate impairment of certain aspects of language in brain damage is a valuable source of knowledge for understanding the mental organisation of linguistic representations. To this aim, particularly relevant are the so-called grammatical category-specific deficits. These deficits consist in a greater impairment of words belonging to one grammatical category in comparison to words belonging to other grammatical categories. Such deficits can involve a dissociation between function words and content words (Assal, Buttet, & Jolivet, 1981; Bub & Kertesz, 1982; Coslett, Gonzales-Rothi, & Heilman, 1984; Goodglass, 1993; Lecours & Rouillon, 1976; Lehrmitte & Derouesne, 1974; Patterson & Shewell, 1987; Rapp & Caramazza, 1997; for a summary see Pulvermüller, 1999), or between nouns and verbs (Berndt, Haendiges, Burton, & Mitchum, 2002; Berndt, Haendiges, Mitchum, & Sandson, 1997; Bird, Howard, & Franklin, 2000; Breedin, Saffran, & Schwartz, 1998; Caramazza & Hillis, 1991; Crepaldi et al., 2006; Hernández et al., 2008; Hernández, Costa, Sebastián-Gallés, Juncadella, & Reñé, 2007; Hillis, Tuffiash, & Caramazza, 2002; De Renzi & di Pellegrino, 1995; McCarthy & Warrington, 1985; Miceli, Silveri,

Villa, & Caramazza, 1984; Shapiro & Caramazza, 2003; Rapp & Caramazza, 1997; Robinson, Rossor, & Cipolotti, 1999; Silveri & di Betta, 1997; Sörös, Cornelissen, Laine, & Salmelin, 2003; Zingeser & Berndt, 1988, 1990).

Interestingly, noun–verb dissociations can be present in both comprehension and production (e.g., Daniele, Silveri, Giustolisi, & Gianotti, 1993; Miceli, Silveri, Nocentini, & Caramazza, 1988; Silveri & Di Betta, 1997) but also in production alone (Damasio & Tranel, 1993; Kim & Thompson, 2000; Miozzo, Soardi, & Cappa, 1994; Zingeser & Berndt, 1988), or in a single modality (oral or written) of input or output (Assal et al., 1981; Baxter & Warrington, 1985; Bub & Kertesz, 1982; Caramazza & Hillis, 1991; Coslett et al., 1984; Hillis & Caramazza, 1995; Hillis et al., 2002; Lecours & Rouillon, 1976; Lehrmitte & Derouesne, 1974; Patterson & Shewell, 1987; Rapp & Caramazza, 1997, 1998; Rapp & Caramazza, 2002). In the present article, we add to these cases by reporting the performance of an individual who shows a disproportionate impairment for verbs in comparison to nouns in only the written modality of output.

From a theoretical point of view, the existence of grammatical category-specific deficits has been used to argue that the organisation of lexical items in the brain is governed by grammatical class (e.g., Shapiro & Caramazza, 2003; Shapiro, Shelton, & Caramazza, 2000; Tsapkini, Jarema, & Kehayia, 2002). In the case of the noun–verb dissociation, the argument is that noun and verb processing might involve overlapping but also distinct neural structures that may be affected differently after brain damage. However, this interpretation has been repeatedly challenged. The

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core of the criticism is that nouns and verbs do not only differ in grammatical category (word class), but also in other important aspects. For example, verbs determine argument structure, while nouns do not. Indeed, it has been shown that the argument structure of verbs influences their retrieval in aphasic patients, with greater argument structure complexity leading to poorer verb retrieval (Kim & Thompson, 2000; Lee & Thompson, 2004; Thompson, 2003). However, Jonkers and Bastiaanse (1998) showed that transitive verbs were easier to retrieve than intransitive verbs for a patient with a noun–verb dissociation with disadvantage for verbs, implying that argument structure complexity is not always necessarily behind this type of dissociation.

Furthermore, verbs are morphologically more complex than nouns in most languages (e.g., Vigliocco et al., 2006). Importantly, nouns and verbs also differ along the semantic dimension. As a consequence, some authors have argued that the dissociation between nouns and verbs is not a grammatical category-specific deficit but a deficit for specific semantic features which correlate with the grammatical category distinction (e.g., Bird et al., 2000; Breedin et al., 1998; Marshall, Pring, Chiat, & Robson, 1996a; Marshall, Chiat, Robson, & Pring, 1996b, but see Shapiro and Caramazza (2001a, 2001b), for discussion). For example, nouns tend to represent objects and verbs tend to represent actions, nouns tend to be more concrete than verbs, and nouns also tend to have more perceptual properties in comparison to verbs. Thus, brain damage that results in a more marked impairment of, say, abstract representations would be naturally reflected in a grammatical category-specific deficit with poorer performance for verbs than for nouns. According to this view, one could not use the observed dissociation to make claims about how grammatical information is represented in the brain.

There is no doubt that some of the cases with a grammatical category-specific deficit reported in the literature may actually not be due to damage to the lexical system *per se* (but to the semantic system: see Bird et al., 2000). However, there are other reported cases in which the lexical level seems the most plausible locus for the deficit (Berndt et al., 2002; Luzzatti et al., 2002). For example, in a large-scale naming study involving 58 aphasic patients, Luzzatti et al. (2002) showed that the respective noun or verb deficits of about 1/5 of these patients remained even after the possible influence of other confounding variables was eliminated (see also Luzzatti & Chierchia, 2002, for a discussion of these data).

Perhaps the most convincing cases of a deficit located at the lexical level are those in which the noun–verb dissociation is present in only one modality of output (Baxter & Warrington, 1985; Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Hillis et al., 2002; Rapp & Caramazza, 1998). For example, patient SJD (Caramazza & Hillis, 1991) performed almost perfectly on the oral production of nouns and verbs and on the written production of nouns, but her production of written verbs was severely impaired. This dissociation was very similar in the production of the noun and verb forms of homonyms (e.g., “to watch” and “the watch”). Interestingly, the reverse pattern was presented by patients HW (Caramazza & Hillis, 1991) and MML (Hillis et al., 2002). For example, MML showed progressive deterioration of oral verb production, while her oral naming of nouns and written naming of nouns and verbs remained preserved. Even more conclusively, patient KSR (Rapp & Caramazza, 2002) presented with a *double* dissociation of grammatical category by modality: in a homonym generation task, he produced spoken nouns less accurately than spoken verbs and written verbs less accurately than written nouns.

Such dissociations are hard to attribute to a semantic deficit given that such a deficit should, in principle, affect the two modalities of output similarly. Furthermore, the presence of patients with disproportionately impaired noun production as compared to verb production (e.g., Hillis, Oh, & Ken, 2004; Rapp & Caramazza, 2002; Shapiro et al., 2000) rules out the possibility that noun–verb dissoci-

ations are due to verbs being intrinsically more difficult than nouns. Thus, the most plausible conclusion is that such modality-specific deficits originate during retrieval of modality-specific (orthographic or phonological) lexical forms (see Chialant, Costa, & Caramazza, 2002, and Caramazza, 1997, for a discussion of this issue).

1.2. Neural correlates of noun–verb representation

To understand the organisation of linguistic representations, we also need to ask how they are instantiated in the brain. Evidence about the neural representation of nouns and verbs suggests that some neural regions are more critical for accessing one or the other word class. For example, Event Related Potential (ERP) studies indicate distinct spatial and/or temporal activation patterns for nouns and verbs (e.g., Dehaene, 1995; Federmeier, Segal, Lombrozo, & Kutas, 2000; Kellenbach, Wijers, Hovius, Mulder, & Mulder, 2002). Also, some studies employing Positron Emission Tomography (PET) have revealed distinct regions of neural activation during noun and verb retrieval (Longe, Randall, Stamatakis, & Tyler, 2007; Perani et al., 1999; Shapiro, Moo, & Caramazza, 2006; Shapiro et al., 2005; Tranel, Damasio, & Damasio, 1997; Tyler, Bright, Fletcher, & Stamatakis, 2004). Other PET studies, however, have not found such distinctions (Tyler, Russell, Fadili, & Moss, 2001; Warburton et al., 1996).

Studies of focal brain damage or degenerative disease suggest that verb impairment is broadly associated with damage to the left frontal cortex, while noun impairment is associated with damage to the left temporal lobe (e.g., Damasio & Tranel, 1993; Hillis, Wityk, Barker, & Caramazza, 2003; Pulvermueller, Lutzenberger, & Preissl, 1999; Tranel, Adolphs, Damasio, & Damasio, 2001; for a review, see Mätzig, Druks, Masterson, & Vigliocco, 2009; but see Aggujaro, Crepaldi, Pistarini, Taricco, & Luzzatti (2006) for findings indicating a crucial role of left posterior temporal lobe and inferior parietal regions in verb retrieval). Converging information comes from functional imaging studies, which have shown more frontal activation for naming verbs and tools (Damasio et al., 2001; Grabowski, Damasio, & Damasio, 1998; Grafton, Fadiga, Arbib, & Rizzolatti, 1997) and more temporal activation in naming nouns other than tools (Tranel et al., 1997). Accordingly, repetitive transcranial magnetic stimulation (TMS) of left frontal regions affects verb more than noun production (Capelletti et al., 2008; Cappa, Sandrini, Rossini, Sosta, & Miniussi, 2002; Shapiro, Pascual-Leone, Mottaghy, Gangitano, & Caramazza, 2001). Importantly, the TMS study conducted by Capelletti et al. localized the frontal region crucial for the processing of verbs as the left anterior midfrontal cortex.

Few studies have specifically treated the neural correlates of formal and modality-specific representations of nouns and verbs. One such study was conducted by Hillis et al. (2004), in which the authors tested the oral and written naming performance of individuals with non-fluent Primary Progressive Aphasia (non-fluent PPA), fluent Primary Progressive Aphasia (fluent PPA) and amyotrophic lateral sclerosis with frontotemporal dementia (ALS-FTD). Hillis et al. (2004) showed that patients with non-fluent PPA and ALS-FTD, who are thought to have a prevalent frontal lobe disfunction, were more impaired on verb than on noun naming and more impaired on oral than on written naming. Conversely, patients with fluent PPA, who are thought to have a prevalent temporal lobe disfunction, showed the opposite pattern, both for grammatical category and modality. Thus, the authors concluded that separate brain regions are crucial for accessing the oral and written word forms of nouns and verbs.

One of the most convincing pieces of evidence for the neural dissociation between nouns and verbs by modality was presented by Hillis et al. (2003). These authors studied two patients with focal brain ischemia who were disproportionately impaired in written naming of verbs while written naming of nouns and oral

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