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Electro-cortical manifestations of common vs. proper name processing during reading

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ABSTRACT

The main purpose of the present study was to investigate how proper and common nouns are represented in the brain independent of memory retrieval processes. Participants were instructed to perform a lexical decision task while dense-array EEG was continuously recorded. Both ERP components (namely N400 and P300) and swLORETA suggested that proper name processing engaged a more widespread neural network and required more cognitive resources than common noun processing. Overall, our results come down in favor of the hypothesis that specific effects of proper vs. common noun processing exist, and they suggest a possible neuro-functional segregation of proper vs. common noun processing. The difference in proper and common noun processing seems to emerge at the level of storage or representation of lexical knowledge, and it may crucially depend on their semantic characteristics.

1. Introduction

The process by which semantic information is stored and retrieved during word processing is a central theme in cognitive psychology research. The neuroscience literature has provided evidence of dissociations in the way by which words belonging to different semantic classes are represented in the brain. Among these, proper vs. common noun distinction has received special attention. Both neuropsychological and neuroimaging studies suggest that proper and common nouns are differently implemented in the brain. Nevertheless, the functional and anatomical bases for the difference between proper and common noun processing is far from well understood (for a review see Semenza, 2011). Important evidence arises from the description of patients suffering from anomia. Anomia is a neurological condition that impairs one's ability to name persons and objects with no impairment of comprehension or repetition of the same words. Cases of selective anomia for proper names with normal retrieval of common nouns have been extensively described (Semenza, 2006). Patients suffering from proper name anomia are typically unable to name persons or geographical sites on the basis of their picture or upon definition, without showing any deficit in the ability to pronounce the corresponding words or comprehend their conceptual meaning. The reverse pattern, common noun impairment and efficient processing of proper names, has also been reported in patients suffering from focal brain damage (Martins & Farrajota, 2007). Important evidence about the dissociation between proper name vs. common noun impairment has also emerged in the literature about semantic dementia (for a detailed review see Patterson, Nestor, & Rogers, 2007).

Generally speaking, it seems that memory retrieval of proper names is more demanding than that of common nouns. For example, it has been shown that proper name anomia, as compared to common noun anomia, is rather frequent in the earliest stages of Alzheimer's disease and in mild cognitive impairment (Juncos-Rabadan, Facal, Lojo-Seoane, & Pereiro, 2013; Semenza, Mondini, Borgo, Pasini, & Sgaramella, 2003). These authors suggest that proper name anomia may be used to discriminate between such patients and normal controls. Greater difficulty to access the phonological forms of people's names than common nouns has also been observed as the tip-of-the-tongue (TOT) phenomenon. The TOT phenomenon consists of a failure to recall a word known, accompanied by the feeling that recall is imminent. TOT for proper names has emerged in the literature about mild cognitive impairment (Juncos-Rabadan et al., 2013), as well as in the literature about healthy people (Brown, 1991; Hanley, 2011) and healthy aging (Burke, MacKay, Worthley, & Wade, 1991; Evrard, 2002). Pelamatti, Pascotto, and Semenza (2003) also showed that proper names are more sensitive to hypoxia than common nouns. In their study, the authors investigated the effect of high altitude on the recall of supra-span lists of proper names and common nouns, and they found that high altitude had an important effect on the

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recall of proper names, while common nouns were more resistant to hypoxia. The greater difficulty to access or retrieve proper names probably relies on the kind of relation that each noun category has with its own reference. Proper names refer to individual entities. Common nouns refer to categories of items, and are often organized semantically in terms of common roots. In fact, a noun designating a category applies to a set of overlapping and interacting attributes (Semenza, 2006).

An important and debated issue concerns the neural underpinnings of proper vs. common noun processing. One influential view is that proper name processing takes essentially place in the left temporal pole (Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Tranel, 2009). The first study pointing out the role of the left temporal pole in proper naming is that of Damasio et al. (1996). The authors described a large sample of patients with focal brain lesions, and they tested their naming ability by means of a series of standardized tests. In that study, 13 patients out of 127 were found to have a selective impairment in face naming. The highest region of lesion overlap was the left temporal pole. In a parallel study using PET, the authors tested a group of healthy individuals while they performed a word-retrieval task. Participants had to name visually presented famous people, animals and tools. The results revealed differentiated activations of the left temporal regions in response to the three categories of stimuli, similarly to the results of the clinical investigation. In particular, proper name retrieval was associated to an activation of the left and the right temporal pole. The activation of the right temporal pole was interpreted as reflecting the visual face recognition processes. In a subsequent PET study, the same research group (Grabowski et al., 2001) asked a group of participants to name pictures belonging to two conceptual categories: famous landmarks and famous faces. Both famous landmark and famous face naming was associated with an increased activity of the left temporal pole. This finding was interpreted as evidence that this region is critical for retrieving the names of unique entities such as persons and landmarks. In other words the activation of the left temporal pole seemed to be linked to the level of specificity of word retrieval rather than the conceptual class to which the stimulus belongs. In a further study, Damasio, Tranel, Grabowski, Adolphs, and Damasio (2004) confirmed the association between a selective impairment in proper name retrieval and a lesion located within the left temporal pole, which was found in 39 out of 139 patients. Nevertheless, in the corresponding PET study, performed with a group of healthy participants, the authors found that naming faces, as compared to animals and tools, involved the activation of a widespread set of cerebral regions. In addition to evidencing the involvement of the anterior part of the left superior temporal sulcus (as in their previous studies), and of the right temporal pole (as in Damasio et al., 1996), the authors also found an involvement of the ventromedial prefrontal cortices and the anterior cingulate cortex. The last two regions are generally related to the processing of emotions (see for example Etkin, Egner, & Kalisch, 2011). According to the authors, they would be required because unique familiar faces are emotionally salient stimuli. In 2006, Tranel (2006) reported two clinical studies in which he compared patients affected by a left or a right temporal pole damage. Patients with a left temporal pole lesion had a lower performance on person naming and famous landmark naming tasks as compared to patients with a right temporal pole lesion and control participants.

As underlined in a recent review by Semenza (2011), the left temporal pole theory is not unambiguously supported by single case studies of selective proper name anomia. For example, in their study Martins and Farrajota (2007) contrasted the case of a patient with left temporal pole damage and spared proper name retrieval vs. a patient with undamaged left temporal pole and deficient proper name retrieval. Some studies suggest that other anatomical structures are crucially involved in proper name retrieval, and indeed Damasio et al. (2004) also found that proper name processing was associated to the activation of a complex and widespread neural network. Anticipating the conclusion of Damasio et al. (2004) showing the involvement of frontal structures in proper name retrieval, Proverbio, Lilli, Semenza, and Zani (2001), in an ERP study described in more detail below, found that proper name retrieval was associated to a strong activation of the left anterior temporal region (which is in agreement with the left temporal pole hypothesis), as well as left fronto-central cerebral regions. The contribution of left frontal regions in proper name retrieval was also emphasized in two recent neurosurgery studies. In fact, Giussani et al. (2009) evaluated patients who underwent surgery by using direct electrical stimulation mapping for brain tumors, and they compared an object naming task to a famous face naming task. Face naming was associated to an activation of the left superior, middle, and inferior frontal gyri, as well as of the anterior part of the superior and middle temporal gyri. In another study (Papagno et al., 2011), surgical removal of the frontal part of the left uncinate fasciculus, the structure connecting the left temporal pole to the orbito-frontal cortex, resulted in selective deficit in naming of famous faces and objects as compared with patients without removal. The authors concluded that the left uncinate fasciculus is part of a circuitry involved in the retrieval of word form for proper names.

Important evidence about the functional as well as the neural underpinnings of proper vs. common noun processing might emerge from electrophysiological studies. Nevertheless, to our knowledge, few ERP studies have investigated the difference between proper and common noun processing. A first study was conducted in the acoustic modality by Muller and Kutas (1996). The authors compared ERPs to spoken sentences starting either with a proper name or a common noun. The results showed that both N1 (about 125 ms post-stimulus) and P2 (about 225 ms post-stimulus) components were larger in response to proper names than to common nouns. The authors evidenced that the articulatory duration of the stimuli ranged from 169 to 535 ms for proper names, and from 212 to 658 ms for common nouns, so that the effects found in N1 and P2 components emerged when only one or two phonemes of any given word had been articulated. In the light of this, the authors underlined that the initial 120 ms of words provided sufficient information to reveal whether a sound is the beginning of a proper name or a common noun, and they interpreted the early N1/P2 effects as probably due to a physical difference in articulation, or to differences in the phonetic features of the stimuli. As for the visual modality, only three ERP studies have investigated the difference between proper and common noun processing. In a first study Dehaene (1995) used a word classification task with five categories of stimuli (animal names, verbs, numerals, proper names and meaningless consonant strings). No effect of the lexical category of the words was found in the early visual processing stages (namely, P1 and N1 components). A significant effect of the lexical category was found in the time window between 280 and 356 ms after stimulus onset. In particular, proper name processing was associated to a left temporal negativity, extended towards the left inferior temporal regions, with a similar tendency on the right. This negativity was interpreted as indexing the lexical access for proper names. In a second study Proverbio et al. (2001) asked their participants to silently retrieve proper and common nouns based on written definition in order to perform a phonological decision task. The authors found that silent proper name retrieval, as compared to common noun retrieval, required more cognitive resources and was associated to a stronger activation of left anterior temporal and left fronto-central cerebral regions starting at 150 ms after the probe (i.e., the definition of the target word). In a third paper Proverbio, Mariani, Zani, and