



## Category-specific naming deficits for objects and actions: semantic attribute and grammatical role hypotheses

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### Abstract

Research on category-specific naming deficits and on noun and verb naming has raised questions about how organization of knowledge in the brain impacts word retrieval. The semantic attribute hypothesis posits that lexical access is mediated by brain systems that process the most definitive attributes of specific concepts. For example, it has been suggested that the most definitive attribute of living things is their visual form, whereas the most definitive attribute of non-living things is their function. The competing grammatical role hypothesis posits that access to a word depends on the grammatical role it plays in a sentence. Since nouns and verbs have different roles, it is assumed that the brain uses different systems to process them. These two hypotheses were tested in experimental subjects who had undergone left anterior temporal lobectomy (LATL) or right anterior temporal lobectomy (RATL) by assessing confrontation naming of living things, tools/implements, non-human actions, and human actions. The names of living things and implements are nouns and the names of actions are verbs. Within each grammatical class, items were characterized either predominantly by visual attributes (living things and non-human actions) or by attributes related to human activity (implements and human actions). Our results support the semantic attribute hypothesis. Patients with LATL were worse at naming tools/implements and human actions than RATL patients. Dysfunction in or removal of the left anterior temporal lobe disrupts fronto-temporal connections from the uncinate fasciculus. These connections may mediate activation of action-related information (i.e. movement plan and/or motor use) that facilitates the retrieval of names for tools/implements and human actions. © 2002 Elsevier Science Ltd. All rights reserved.

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### 1. Introduction

Studies have found a dissociation in naming nouns and verbs in some patients with brain injury or disease [2,14,37,59]. Evidence also has indicated that the distinction between nouns and verbs is relevant to patients who have undergone left anterior temporal lobectomy (LATL) for treatment of epilepsy refractory to pharmacologic treatment [21]. The current study tested two competing explana-

tions for the dissociation of noun (object) and verb (action) naming in LATL.

The first, and perhaps most obvious, explanation for differential effects of brain dysfunction on noun and verb naming is that different brain processing mechanisms are used for words in different grammatical classes. Miceli et al. [37] found that agrammatic patients were more impaired in naming actions (verbs) than objects (nouns), whereas anomic patients exhibited the opposite pattern. Zingeser and Berndt [59] reported similar results with picture naming, naming to definition, and narrative language tasks. Berndt et al. [2] investigated the possibility that differences in noun and verb naming might be due to reasons other than grammatical

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class. For example, they explored whether the selective deficits in verb naming observed in prior studies was related to the lower frequency of verbs relative to nouns. However, of their five patients with impaired verb naming, four retrieved the lowest frequency nouns as well or better than the highest frequency verbs. In two patients with selectively impaired naming of objects, lowest frequency verbs were named as well or better than the highest frequency nouns. These findings suggest that word frequency cannot account for differential individual capacity for retrieving nouns and verbs. Berndt et al. [2] also considered the possibility that impaired naming of verbs was an artifact of the static nature of drawings commonly used to portray verbs. However, they were able to replicate their findings when videotaped stimuli were substituted for the drawings. Finally, Berndt et al. [2] posited that the selective impairment in naming of nouns or verbs exhibited by their patients might reflect differential underlying deficits in knowledge of the meaning of nouns and verbs. However, they found that their patients could accurately differentiate between nouns and verbs in sorting tasks, and could identify the associated object or action on matching tasks. These findings suggested that, at least in their patients, deficits predominantly affected naming and spared meaning.

The second, competing explanation for dissociations in noun and verb naming is that nouns and verbs typically represent different kinds of semantic information. One area where the effects of semantic information on naming has been explored is the literature on category-specific deficits. For example, some brain injured patients demonstrate selective impairment in naming living things and foods [15,36,45], fruits and vegetables [17,22], animals [1,3,7,23,25], body parts [43,58], inanimate objects [54], tools and artifacts [3,6,43], and medical items [11]. Some studies have demonstrated double dissociations, wherein two patients exhibited complementary patterns of naming impairment across two categories [25]. Frequently, category-specific naming deficits are part of a larger semantic deficit, as evidenced by concomitant visual processing deficits of items from the category in question [7,44]. However, sometimes deficits have been limited to verbal processing, i.e. both naming and comprehension [36] or even to just naming [6,17,23]. Some investigators have suggested that category-specific deficits result from between category differences in word frequency, concept familiarity, and/or visual complexity [20,48]. However, more recent studies do not support these suggestions [5,45].

The existence of category-specific naming deficits has raised questions about how the neural representation of items from different categories impacts word retrieval, and about how the essential attributes of items that can be named distinguish them from items that cannot be named. The identification of such attributes may reveal important dimensions along which the human brain organizes information. The most commonly observed category dissociation has been between living things (such as animals,

fruits and vegetables, and flowers), and non-living things (such as tools, kitchen utensils, furniture, and transportation items) [15,43,47,54,55]. Warrington and Shallice [55] suggested that the essential difference between living and non-living things may be the relative degree to which their defining attributes are sensory or functional, respectively. Using computational modeling, Farah and McClelland [16] demonstrated that damage to sensory versus functional characteristics could account for category-specific impairments in knowledge of living versus non-living things, respectively.

Damasio and Tranel [14] extrapolated the sensory-functional dichotomy of Warrington and Shallice [55] in an effort to account for differential impairment in the naming of nouns and verbs. They posited that the neural representations of nouns (objects) reside predominantly in ventral temporal association cortices that comprise the “what” visual system [38], whereas the neural representations of verbs (actions), by virtue of the spatial and temporal attributes of actions, are subserved to a substantial extent by parietal and premotor cortices supporting spatial and praxis representations and the connections between these cortices [24]. In support of their hypothesis, they reported three patients, two with lesions of the left temporal lobe, who were more impaired in naming of objects, and one with a left premotor lesion, who was more impaired in naming actions.

Although the Damasio and Tranel hypothesis has powerful explanatory value in accounting for differential impairment in naming of nouns and verbs, it confounds the sensory/action and grammatical dimensions along which the defining attributes of word representations may be organized in the brain. There are nouns whose meaning involves action attributes as much or more than it involves visual attributes, e.g. “hammer”. Would the meaning of words such as “hammer” be represented predominantly in the cortices subserving the “what” visual system because it is noun, as Damasio and Tranel [14] posited, or would their meaning be represented predominantly in the cortices subserving the spatial and praxis systems because of the importance of its action attributes? Similar questions can be posed for verbs. The meaning of many verbs, e.g. “blooming”, involve primarily sensory attributes rather than spatial and human action features. Would the neural representations of actions, such as “blooming” reside predominantly in cortices subserving human action and praxis systems because they are verbs, or would they reside predominantly in the “what” visual system association cortices because of the importance of their visual attributes? The present investigation specifically examined the sensory/action and grammatical dimensions of noun and verb naming.

The sensory/action account, hereafter to be referred to as the semantic attribute hypothesis, predicts that the grammatical class of a word is irrelevant. Naming will be selectively impaired following a brain lesion if cortex or connections involved in processing a critical attribute of the concepts represented by the names has been damaged. For purposes

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