How verbs and non-verbal categories navigate the syntax/semantics interface: Insights from cognitive neuropsychology

Michele Miozzo [a,b,*], Kyle Rawlins [a], Brenda Rapp [a]

[a] Johns Hopkins University, United States
[b] Columbia University, United States

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ABSTRACT

We report on two individuals with acquired language impairment who made thematic role confusion errors in both comprehension and production. Their confusions were remarkably specific, affecting the roles associated with spatial prepositions ("The box is in the bag" confused with *The bag is in the box*) and adjectival comparatives ("The glove is darker than the hat" confused with *The hat is darker than the glove*) but not the roles associated with verbs (e.g., in *The woman helps the man*). Additional results showed that the confusions did not arise from spatial deficits, deficits affecting the semantics of spatial terms and adjectives, or difficulties with spatial and comparative relationships. Interestingly, the selective deficits are well-explained by linguistic theories that propose that non-verbal lexical categories, when used as predicates, depend on special mechanisms and structures for linking their thematic roles to syntactic argument structures. These are the first neuropsychological results to show that thematic role assignment is supported by distinct brain mechanisms for verbal and non-verbal lexical categories. These findings have important implications for our understanding of the linguistic knowledge associated with verbal vs. non-verbal word classes and of the conditions under which these forms of knowledge support sentence processing.

1. Introduction

Sentence processing involves the transformation of concepts into acoustic forms in speech production, and follows the opposite trajectory – from acoustic forms to concepts – in speech comprehension. Psycholinguistic and linguistic research in the last twenty years has highlighted the key functions that verbs play in sentence processing and linguistic representations. The lexical entries of verbs contribute to specifying the concepts that fit a sentence, the morphological forms of words, and the order in which words should appear. We can say that verbs characterize events (or 'eventualities'; Bach, 1986) and provide a framework for mapping event representations into sentences. However, verbs/events are not the only category that can provide the main 'predicate' of a sentence – other words classes can as well. Indeed, sentences are not only structured around verbal predicates (*The traffic light turned red*) but also predicative nouns (*This is a traffic light*), adjectives (*The traffic light is red*) and prepositional phrases (*The traffic light is on the street*). When these other lexical categories appear in this central role of a sentence, they do not themselves have the structural properties of verbs.

* Corresponding author at: Department of Cognitive Science, Johns Hopkins University, 237 Krieger Hall, 3400 North Charles Street, Baltimore, MD 21218, United States. Tel.: +1 410 516 5250; fax: +1 410 516 8020.

E-mail address: mm1150@columbia.edu (M. Miozzo).

A range of linguistic accounts of predication (e.g., Baker, 2003; Croft, 1991) have proposed that non-verbal predicates that surface as the nuclei of sentences must rely on specialized semantic and syntactic mechanisms, unlike verbs. In the present investigation we explore how these differences between verbs and other word classes may affect sentence processing. We provide the first neurolinguistic evidence that specialized mechanisms are recruited to enable the construction of sentences around lexical categories other than verbs. Specifically, we report on individuals with acquired language impairment whose production and comprehension is remarkably intact with sentences involving verbal predicates, but impaired with sentences involving predicates based on other lexical categories. The striking selectivity of the sentence deficits provides a unique opportunity to examine the mechanisms underlying sentence processing and characterize how these mechanisms differ depending on lexical categories.

1.1. Verb lexical entries

It is generally agreed that at least two distinct representations of a sentence are computed – one semantic, another syntactic. The semantic representation specifies the thematic frame, that is, the grid of thematic roles performed by the various participants in an event (Fillmore, 1968; Gruber, 1976; Higginbotham, 1985; Jackendoff, 1972). To repeat the customary catchphrase, a verb and the major thematic roles describe *who did what to whom*, where *who* corresponds to the role of agent, *what* to the event described by the verb, and *to whom* to the role of the patient, theme, and possibly further roles such as goal. Concepts satisfying each of these roles have semantic characteristics that may vary from one event to the other. For example, concepts taking the role of agent in the event *running* are typically animate, not a requirement for the agents in the events of *standing* or *falling.* In contrast to the semantic representation, the syntactic representation specifies the types of phrases comprising a sentence and therefore encodes the positions and grammatical relationships (e.g., agreement) of the words in a sentence (Bresnan, 2001; Van Valin & LaPolla, 1997). A number of arguments have been proposed in support of the existence of distinct semantic and syntactic sentence representations. A primary argument is the lack of one-to-one correspondence between thematic frames and syntactic structures. In many instances a thematic frame can map onto more than one syntactic representation, as in the case of English transitive verbs. The same thematic roles appear in the sentence *Bob kicks the ball* and its passive counterpart *The ball is kicked by Bob* – in both cases, *Bob* is the agent and *ball* the theme. Disjunctions like these imply distinct representations encoding the semantic and syntactic features of sentences.

According to a number of theories, the lexical entries of verbs contain information that guides the computation of both semantic and syntactic representations of sentences (Bock & Levelt, 1994; Bornkessel & Schlesewsky, 2006; Collina, Marangolo & Tabossi, 2001; Kemmerer & Eggleston, 2010; Kim & Thompson, 2000; Pinker, 1989; Vigliocco, Vinson, Lewis, & Garrett, 2004). Part of the information stored at this level specifies the thematic roles

corresponding to the event described by the verb (Grimshaw, 1990; Levin & Rappaport Hovav, 1995). The retrieval of the thematic frame dictates what concepts can satisfy particular roles and provides a grid for constructing semantic representations in which concepts are assigned their proper thematic roles. In terms of syntactic representation, verb lexical entries also specify the argument structure, which defines the number and types of phrases that must appear as complements of the verb in addition to the subject. Some verbs have no complements, only the subject (e.g., *smile*; *Bob smiles*), while other verbs take one or more complements (e.g., *lost*; *Bob lost the key*). Argument structure provides key information for building syntactic representations. There is a tight and systematic correspondence between the thematic frame and the argument structure of a verb, and the two-way mapping between semantic and syntactic representations taking place in sentence production and comprehension depends crucially on this correspondence.

Mounting evidence from psycholinguistic research supports this view that the lexical entries of verbs provide information critical for the mapping between thematic frames and syntactic argument structures, underscoring the pivotal role that verbs play in sentence processing. For example, studies comparing the response latencies of unimpaired participants to verbs varying in the number of arguments (and thematic roles) have reported that response latencies increase as a function of the number of arguments a verb requires, even in tasks that do not demand access to argument structure (e.g., when written words are presented in isolation for lexical decision) (Boland, Tanenhaus, & Garnsey, 1990; MacDonald, Pearlmutter, & Seidenberg, 1994; Shapiro, Brookins, Gordon, & Nagel, 1991; Trueswell & Kim, 1988). Effects of argument number were also observed in ERP (Rubin, Newhoff, Peach, & Shapiro, 1996). Further converging evidence was obtained in fMRI studies that examined BOLD response in processing one-, two-, and three-argument verbs. A graded BOLD response that varied according to argument number was reported, most typically in bilateral angular gyri but also in left inferior frontal cortex (Palti, Ben-Shachar, Hendler, & Hadar, 2007; Shetreet, Palti, Friedemann, & Hadar, 2007; Thompson et al., 2007). Sensitivity to argument number, so pervasive in normal participants, was lacking in aphasic individuals whose lesions extended over left posterior perisylvian cortex (Shapiro, Gordon, Hack, & Killackery, 1993; Shapiro & Levine, 1990). In verb naming, aphasic individuals with lesions in Broca's area showed increasing difficulty with increasing argument number (e.g., Jonkers & Bastiaanse, 1996; Kemmerer & Tranel, 2000; Kim & Thompson, 2000, 2004). Overall, the neuroimaging and neuropsychological data suggest that a brain network extending over 'classical' language areas and the angular gyrus underpins the computation of verb features critical for sentence processing.

1.2. Non-verbal categories

Verbs are not the only words that assign specific thematic roles. A case in point is that of *locatives*, describing spatial relations. Locatives take various forms in different languages. For example, in English, they surface as prepositions