



Fishing is not wrestling: Neural underpinnings of the verb instrumentality effect



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ABSTRACT

Previous clinical research has shown a positive effect of instrumentality on verb retrieval in individuals with aphasia. Performance on instrumental verbs incorporating an obligatory tool into their conceptual representation (e.g., *to cut*) is more accurate compared to non-instrumental verbs (e.g., *to tear*), possibly due to more specific conceptual representations of instrumental verbs. Seeking the neural correlates of the differences between instrumental and non-instrumental verbs, we conducted an fMRI study with 16 German speakers who performed a verb-object matching task with instrumental and non-instrumental verbs. We found that an extensive neural network including but not limited to frontal and temporal language-related areas was more involved in the semantic processing of non-instrumental compared to instrumental verbs. We argue that this reflects a greater load associated with the processing of less semantically structured/restricted representations of non-instrumental verbs. The unavailability of additional neural resources needed for the processing of non-instrumental verbs in individuals with aphasia may lead to better behavioral performance on instrumental than non-instrumental verbs.

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1. Introduction

Verb retrieval is commonly impaired in aphasia (Berndt, Mitchum, Haendiges, & Sandson, 1997; Marshall, Pring, & Chiat, 1998). However, not all verbs are impaired to the same extent: numerous studies have convincingly shown effects of verb type on verb retrieval and comprehension in aphasia. Performance of individuals with aphasia on various verb tests is affected not

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only by grammatical characteristics of verbs such as argument structure or morphology (Bastiaanse & van Zonneveld, 2004, 2005; De Bleser & Kauschke, 2003; Dragoy & Bastiaanse, 2010; Jonkers, 2000; Kim & Thompson, 2000; Kiss, 2000; Luzzatti et al., 2002; Thompson, 2003; Thompson, Lange, Schneider, & Shapiro, 1997; Thompson, Shapiro, Li, & Schendel, 1994) but also by conceptual factors such as semantic complexity and imageability (Breedin, Saffran, & Schwartz, 1998; Luzzatti et al., 2002). Particular attention has been drawn to the conceptual factor of instrumentality and its role in verb production and comprehension in individuals with aphasia (Bastiaanse, 1991; Jonkers & Bastiaanse, 2007; Kambanaros & van Steenbrugge, 2006; Kambanaros, 2009; Kemmerer & Tranel, 2000; Malyutina, Iskra, Sevan, & Dragoy, 2014).

1.1. Facilitatory behavioral effect of verb instrumentality in aphasia

Instrumental verbs (*to cut, to mow*) are those referring to actions for which an instrument¹ (not being a body part) is used (Jonkers & Bastiaanse, 2007). They differ from non-instrumental verbs that refer to actions normally performed without an instrument (*to tear, to tie*). A positive effect of instrumentality (i.e., better performance on instrumental than non-instrumental verbs) has been found in individuals with aphasia across languages, tasks and aphasia types. For Dutch, Jonkers and Bastiaanse (2006) reported a positive effect of instrumentality for a group of non-fluent individuals with aphasia in a verb comprehension (verb-to-picture matching) task, but only when there was no name relation between the verb and the instrument (e.g., the effect would be present in *cutting – scissors*, but not *skiing – ski*). Jonkers and Bastiaanse (2007) found a positive effect of instrumentality in anomic speakers in an action naming task, both for name-related and non-name-related instrumental verbs. Kambanaros and van Steenbrugge (2006) tested action naming in bilingual Greek-English anomic speakers and reported a facilitatory effect of instrumentality in both languages. Finally, a recent study by Malyutina et al. (2014) showed that both non-fluent and fluent Russian aphasic speakers benefited from instrumentality in an action naming test. Although no positive effect of instrumentality was found for some groups of individuals with aphasia and some tasks (e.g., verb production in Broca's aphasia in Jonkers and Bastiaanse (2007); verb-picture matching in fluent and anomic speakers in Jonkers & Bastiaanse (2006) and Kambanaros and van Steenbrugge (2006); see also Bastiaanse, 1991; Kemmerer & Tranel, 2000; Kambanaros, 2009), lack of effects was largely restricted to processing conditions that place a greater processing load. As suggested earlier (Kambanaros, 2009; Malyutina et al., 2014), such conditions may not leave sufficient cognitive resources in order to effectively process additional semantic components. Thus, such conditions interfere with the effect of instrumentality that is typically facilitatory in tasks that place a smaller processing load and leave more resources for processing the semantic component of instrumentality. Importantly, instrumental verbs have never been shown to present a greater challenge than non-instrumental verbs.

The advantage of instrumental over non-instrumental verbs finds support in theoretical linguistics. Firstly, the two verb groups differ in the number of meaning constituents (Jackendoff, 1990; Pinker, 1989). For instrumental verbs, an instrument is an inherent part of the verb's conceptual representation (Jonkers, 1998):

to clean: [CAUSE([]_i[INCH[NOT BE([SPOTS], [ON_d[]_j)]])]]
to polish: [CAUSE([]_i[INCH[NOT BE([SPOTS], [ON_d[]_j)]])](BY[_{instrument}RAG])]

In the examples above, the instrumental verb *to polish*, in contrast to its non-instrumental counterpart *to clean*, incorporates an instrument (*rag*) into an otherwise identical conceptual representation: 'the agent []_i causes not to have spots on the theme []_j'.² Moreover, according to the hierarchy of semantic roles that constrains grammaticalization patterns crosslinguistically (Fillmore, 1968), the instrument is ranked higher than the theme/patient (although lower than the agent). This results in, for example, the instrument role having an advantage over the theme/patient role in the competition to become a subject (Givon, 1984; Kiparsky, 1987). This theoretical perspective on the instrument as a constituent of conceptual representations and a highly ranked semantic role suggests that the instrument is a prominent component of the verb's conceptual/semantic representation.

According to the Semantic Complexity Hypothesis (Breedin, Boronat, Saffran, & Shipley, 1999; Breedin et al., 1998), an enriched representation facilitates the activation of the verb lemma/lexeme in tasks that are not too cognitively demanding (e.g., single word production as opposed to sentence production). Breedin et al. (1998, 1999) demonstrated that the production of semantically under-specified verbs (i.e., semantically simpler, "light" verbs, such as *to go*) was more compromised than of verbs with more enriched semantics (i.e., "heavy" verbs, such as *to run*, containing a primitive *to go* and specifying it) in individuals with aphasia. Along these lines, we argue that the easier retrieval of instrumental verbs may be explained by their more structured and thus more specific representations than those of non-instrumental verbs, since the meanings of instrumental verbs are restricted by the semantic component of the instrument. In other words, the additional semantic component (the instrument) in representations of instrumental verbs restricts their meanings and thus allows fewer semantic connections with nodes related to different ways of performing the action. Thus, instrumental verbs refer to fewer

¹ Throughout the manuscript, the terms 'tool' and 'instrument' are used interchangeably and refer to an external aid (not being part of the body) used to perform an action.

² INCH (inchoative) refers to the verb form expressing the change of state; d is an optional determiner.

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