Neural correlates of verb imageability

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Neuroimaging investigations in the concrete-abstract domain have repeatedly reported higher activity for abstract words in language-related regions of the left hemisphere (Grossman et al., 2002; Kiehl et al., 1999). A recent account (Rodríguez-Ferreiro et al., 2009) suggests that concrete and abstract words differ in their retrieval demands: the latter require more effortful integration due to being less imageable. Although imageability is claimed to be critical parameter affecting word retrieval, it is typically studied using a binary contrast of high- and low-imageable words. In the present study, we aimed at finding the support for linearly increasing engagement of language-related regions as a function of gradually decreasing imageability.

In a blocked fMRI experiment, three groups of German verbs were contrasted: tool verbs (denoting actions performed by hand with a tool, e.g. *to cut*), hand verbs (denoting actions performed solely by hand, e.g. to milk), and abstract verbs (e.g. *to hate*). A questionnaire completed by 50 German speakers confirmed the imageability hierarchy tool>hand>abstract, tool verbs being the most and abstract verbs the least imageable. Deep semantic processing was insured by the task. A verb (e.g. *to cut*) and two nouns (e.g. *bread* and *blood*) were presented in a triangular array; participants were required to choose the appropriate object for the verb. Stimuli were matched on frequency and length; the measures of association between a verb and the correct noun did not differ for tool and hand verbs, but were significantly higher than for abstract verbs. The baseline task aimed at the subtraction of visual processing and motor response from the experimental task was to identify which of two bottom strings of Wingdings characters was identical to the one on top. 17 healthy native German speakers (mean age 33) participated in the study.

Participants were significantly slower when choosing the appropriate object for abstract verbs than for hand verbs, and for hand verbs it took longer than for tool verbs. Concerning neuroimaging results, abstract verbs in contrast to hand verbs elicited stronger activation in the left inferior frontal gyrus (triangular part), middle temporal gyrus and temporal pole. Similarly, being contrasted to tool verbs, hand verbs elicited stronger activation in the same gyri, but it was bilateral and extended to orbitofrontal, parietal and occipital regions. The left inferior frontal and middle temporal gyri were the only regions where all three groups of verbs showed stronger activation relative to the baseline.

Region-of-interest analysis revealed that the amount of activation fits a linear model: abstract verbs elicited stronger activation than hand verbs, and hand verbs – stronger than tool verbs.

The converging behavioral and neuroimaging results indicate that imageability of a verb might influence both the time of its processing and the amount of cerebral activation it is related to. We argue that, in our experiment, it was imageability that modulated retrieval demands in a linear manner – specifically, through the engagement of inferior frontal and middle temporal regions.

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