

FISHING IS NOT WRESTLING: NEURAL CORRELATES OF THE VERB INSTRUMENTALITY EFFECT

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Rationale

- the positive effect of instrumentality on verb retrieval and access has been found in individuals with aphasia, both fluent and non-fluent (Malyutina et al., 2014)
- performance on instrumental verbs incorporating an obligatory tool into their conceptual representation (*to fish*) is more accurate as compared to non-instrumental verbs for which a tool is not required to perform the action (*to wrestle*)
- this effect was attributed to richer conceptual representations of instrumental verbs facilitating concept-lemma mapping (Breedin et al., 1999)



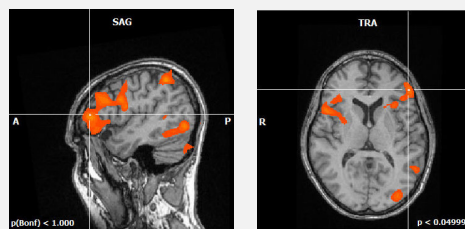
to fish



to wrestle

Seeking for the neural correlates of the difference between instrumental and non-instrumental verbs, we investigated the effect of verb instrumentality on BOLD signal in neurologically intact individuals without language impairment

Results



- a direct contrast between non-instrumental and instrumental verbs resulted in stronger effects for non-instrumental verbs in:

left-lateralized temporal areas, frontal and parietal regions bilaterally, extending also to bilateral sensorimotor and left occipital regions

- the opposite contrast 'instrumental verbs – non-instrumental verbs' yielded no additional activation



- regions of interest (ROIs) were functionally defined based on a conjunction of the three verb conditions versus the baseline symbol condition:

abstract verbs > symbols, instrumental verbs > symbols, non-instrumental verbs > symbols

- verbs elicited stronger activation than symbols in the left-lateralized frontal and temporal regions with the largest clusters located in:

inferior frontal gyrus (triangular part), middle temporal gyrus, supplementary motor area

- individual mean β values (average of all voxels activated within each of the three ROIs; coefficients of the GLM) were analyzed using repeated measures ANOVA in the ROIs:

non-instrumental verbs > instrumental verbs

IFG: $F(1,15) = 9.05, p < .01$
MTG: $F(1,15) = 4.80, p < .05$
SMA: n.s.

- processing time:

Condition	Mean accuracy, % correct (SD)	Mean RTs, ms (SD)
Instrumental	99.7 (0.7)	1453 (180)
Non-instrumental	99.4 (1.0)	1520 (236)

non-instrumental verbs > instrumental verbs
 $t(15) = -2.70, p < .05$

Method

Participants

- 16 native speakers of German (8 female; mean age 32.4 y.o., range 26-39 y.o.), all right handed, with normal or corrected to normal vision, and with no history of neurological or psychiatric disorders

Materials

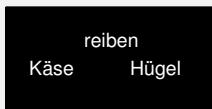
- 144 German verbs: 48 instrumental (*to knit*), 48 non-instrumental (*to tear*), and 48 filler abstract (*to wait*), matched on frequency (based on the German DWDS corpus, <http://www.dwdscorepus.de>) and length in syllables; instrumental and non-instrumental verbs did not differ in imageability, as shown in a preliminary questionnaire study
- for each verb, two nouns were chosen, one matching to the verb meaning, and another not matching (e.g., *Käse reiben* 'to grate cheese' or *Hügel reiben* 'to grate a hill'); the scores for plausible and implausible noun matches differed significantly, as shown in another questionnaire; word association measures (extracted from the DWDS corpus) showed the same degree of associations between a verb and a matching noun in the instrumental and non-instrumental groups

Procedure

- 12 blocks of each type (instrumental, non-instrumental, abstract verbs, and symbols)
- 9 s fixation cross > an instruction (*Wörter* 'words' or *Zeichen* 'symbols') of 2 s duration > four trials per block, each lasting for 4 s plus a 0.5 s blank screen
- 2 sessions; the total scanning time was 26 min 18 s

Data acquisition and analysis

- 1.5-T Magnetom AVANTO, Siemens, at the University Hospital Grosshadern, Munich
- MPRAGE anatomical images: TR = 1900 ms, TE = 3 ms, FA = 15°, 176 of sagittal slices, FOV = 250 mm, slice thickness = 1 mm, in-plane resolution = 0.98 x 0.98 mm
- BOLD images: TR = 3000 s, TE = 50, FA = 90°, 35 axial slices, slice thickness = 3 mm, gap = 0.75 mm, interleaved acquisition, in-plane resolution = 3 x 3 mm, FOV = 250 x 250 mm, matrix = 64 x 64
- imaging data were analyzed in Brain Voyager QX 2.0.7; behavioral – in SPSS 17.0



Conclusions

NON-INSTRUMENTAL VERBS > INSTRUMENTAL VERBS

- both reaction times and the amount of brain activation indicate greater processing load for non-instrumental verbs than for instrumental in healthy individuals, which is consistent with previous aphasia studies (Malyutina et al., 2014)
- non-instrumental verbs elicit additional activation in the inferior frontal and middle temporal gyri, which have been previously found responsive to various linguistic tasks and specifically involved in verb meaning retrieval (see, e.g., Damasio & Tranel, 1993; Gennari et al., 2007; Tranel et al., 2003)
- these same regions are often damaged in individuals with aphasia, which makes their recruitment impossible and causes the verb instrumentality effect: a specific disadvantage of non-instrumental verbs