

NEURAL SUBSTRATES OF ACTION NAMING AS REVEALED BY VOXEL-BASED LESION-SYMPTOM MAPPING

Akinina, Yu.^{1,2} y.akinina@rug.nl, Dronkers, N.^{2,3,4}, Dragoy, O.²



1 - University of Groningen, Groningen, the Netherlands
2 - National Research University Higher School of Economics, Moscow, Russia
3 - VA Northern California Health Care System, Martinez, USA
4 - University of California, Davis, USA



INTRODUCTION

Data on neural substrates of action naming are fragmentary:

- Studies that have mapped picture naming to the brain and informed contemporary neurolinguistic naming models have implied object naming and nouns
- Neural substrates of verb processing have rarely been investigated with statistically robust lesion methods, such as voxel-based lesion-symptom mapping (VLSM)
- White matter substrates of verb processing are still largely understudied

The aim of our study was to reveal grey and white matter structures associated with action naming in left hemisphere stroke patients using VLSM. To narrow down the focus of the research, we only investigated the lexical-semantic naming stages.

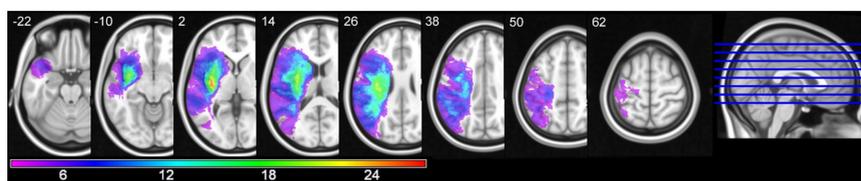


Figure 1. Lesion overlay map with a minimum of four patients per voxel (voxels eligible for analysis)

METHODS

Participants: 40 pre-morbidly right-handed Russian speakers after left hemisphere stroke (21 females; mean age = 51.7 ± 10.97 (33 – 78 years old), mean post onset time = 24.88 ± 28.15 (3 – 146 months))

Materials & Procedure: 80 black-and-white drawings of actions (Akinina et al., 2015) used in an action naming task: "Please name in one word what the character is doing in the picture"; inflected form required

Scoring: Any identifiable lexical verb named during the normative procedure = *correct*. Any other lexical verb or noun = *incorrect*. Phonological errors and morphological form errors were disregarded. *Naming accuracy* = proportion of correct responses to all complete verbal responses (i.e., disregarding no responses)

MRI acquisition: 1.5 T Siemens Magnetom Avanto

Lesions analysis: After preprocessing, lesion masks were manually delineated in ITK-snap (Yushkevich et al., 2006) based on T1, T2 and FLAIR images, then normalized to MNI152 1 mm³ template. Misalignments between normalized and original lesion masks were manually corrected.

GREY MATTER ANALYSIS

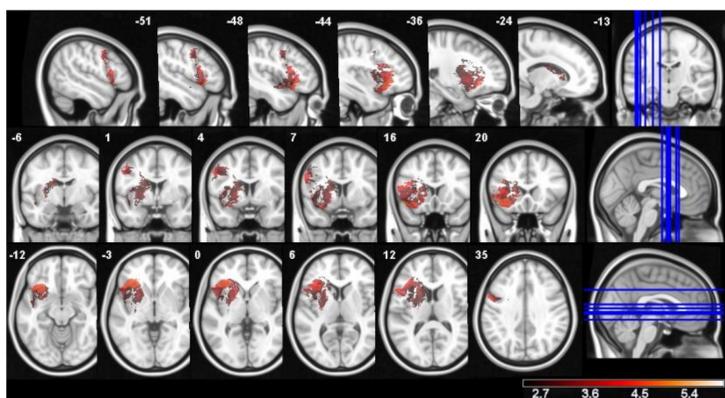


Figure 2. VLSM-map ($p < .01$; thresholded based on cluster size and permutations $N = 1000$) for action naming. Higher T -values appear in lighter hue.

VLSM analysis (Bates et al., 2003, <http://neuroling.arizona.edu/resources.html>) : naming accuracy as the main outcome variable.

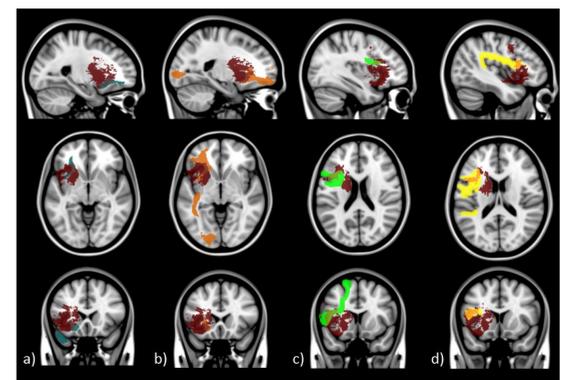
Patient age and lesion size : covariates.

Overlay with Automated Anatomical Labeling atlas revealed damage to the left hemisphere structures: inferior frontal gyrus; anterior part of the insula; precentral gyrus at the level of middle frontal and inferior frontal gyri; parts of the basal ganglia – putamen, caudate nucleus and globus pallidus.

WHITE MATTER ANALYSIS

Figure 3. White matter association tracts disrupted by the VLSM map.

- Uncinate fasciculus;
 - Inferior fronto-occipital fasciculus;
 - Frontal aslant tract;
 - Superior longitudinal fasciculus, III.
- VLSM map is in red.



To formally assess white matter involvement, we uploaded the binarized VLSM map as the input for the Tractotron software (as a part of BC toolkit v2.0; <http://www.brainconnectivitybehaviour.eu>) to map it to the tractography reconstructions obtained from the group of healthy controls (Rojkova et al., 2015).

Association tracts with 100% probability of disconnection: left frontal aslant, inferior fronto-occipital, uncinate fasciculi, and superior longitudinal fasciculus III.

DISCUSSION

Expected findings

- **Left inferior frontal gyrus** : frequently associated with lexical retrieval, cognitive control over semantics and general conflict resolution
- **Left precentral gyrus** : a part of motor network; can be interpreted as evidence in favor of embodied cognition hypothesis

'Novel' findings

- **Left anterior insula:**
 - Is associated with fluency (Bates et al., 2003), but can also subserve verb processing (Kemmerer, 2012)
- **Left basal ganglia:**
 - Have a role in general cognitive control : suppressing and enhancing relevant activities (Crosson, 2007)
 - Might be involved in action word processing (Cardona et al., 2013)

Expected findings

- **Left uncinate** and **inferior fronto-occipital fasciculi** : frequently associated with semantic processing
- Picture naming model of Duffau and colleagues (2014) : part of ventral stream of visual information processing during picture naming

'Novel' findings

- Damaged connections of **left aslant tract** to the inferior frontal gyrus might impede lexical retrieval and semantic knowledge control (Sierpowska et al., 2015)
- **Left superior longitudinal fasciculus III** might contribute to a broad range of non-spatial/motor functions including motor neuron system, semantic processing and response inhibition (Parlatini et al., 2017)