Neuroanatomical correlates of language deficits after surgical treatment of gliomas: Evidence from VLSM

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Introduction

- Left-hemisphere gliomas induce a large-scale reorganization of the language network before surgery (Anderson, Damasio, & Tranel, 1990). Therefore, surgery acts upon a reorganized language network
- If surgical damage to area A causes a language deficit, area A remained critical for language processing despite the pre-surgical reorganization

⇒ **We aimed to identify neuroanatomical correlates of language deficits early after glioma surgery using voxel-based lesion-symptom mapping** (VLSM; Bates et al., 2003)

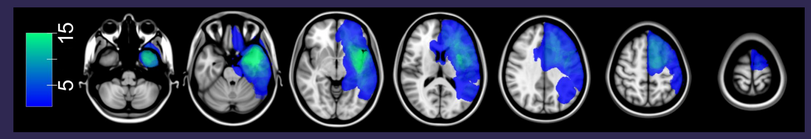
- VLSM identifies brain areas whose damage affects a behavioral measure of interest on a voxel-by-voxel basis

Method

- **Participants:** 60 Russian-speaking monolingual patients with left-hemisphere gliomas. 22 females; mean age 40 years (range 18 – 60 years); 31 patients with low-grade gliomas; all were right-handed or ambidextrous
- **Language assessment:** Russian Aphasia Test (Ivanova et al., 2016)
  - **Production:** Naming, picture-based sentence and discourse production; non-word, word, and sentence repetition
  - **Comprehension:** Non-word discrimination, lexical decision, auditory word- and sentence-to-picture matching, discourse comprehension
  - **Outcome measures:** The differences between post- vs. pre-surgical scores in individual RAT subtests, and averaged across comprehension and production subtests
- **MRI:** Whole-brain T1-, T2- and T2-FLAIR-weighted imaging using a 3T scanner (Siemens Magnetom Skyra or GE Signa HDxt) during the first week after surgery
- Using SPM12, individual T1 scans were re-aligned to AC-PC and re-sliced to the MNI152 template; other modalities were co-registered to the resulting individual T1 scans
- Resection cavities were manually delineated in ITK-SNAP, followed by non-enantiomorphic normalization in SPM12
- **VLSM analysis** (package version 2.55). All results shown are significant at $p = .05$ after a permutation-based correction for multiple comparisons

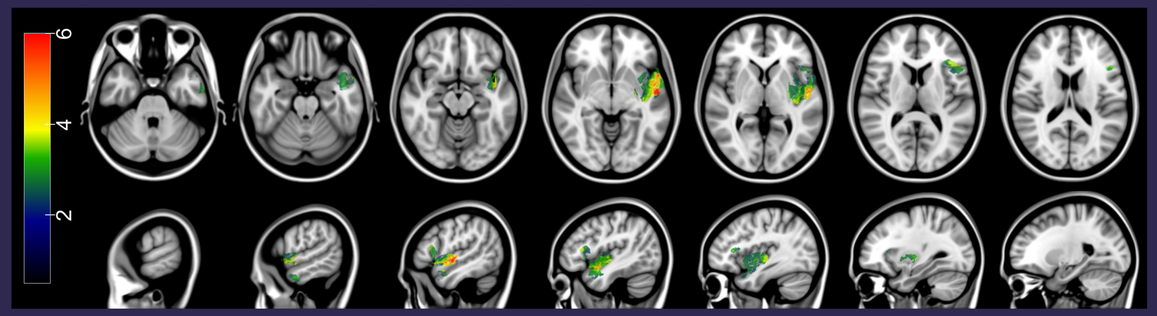
Results

Lesion overlay (The color of each area denotes the number of patients with a lesion in this area)



Comprehension (individual scores averaged across all comprehension subtests; colors denote *t*)

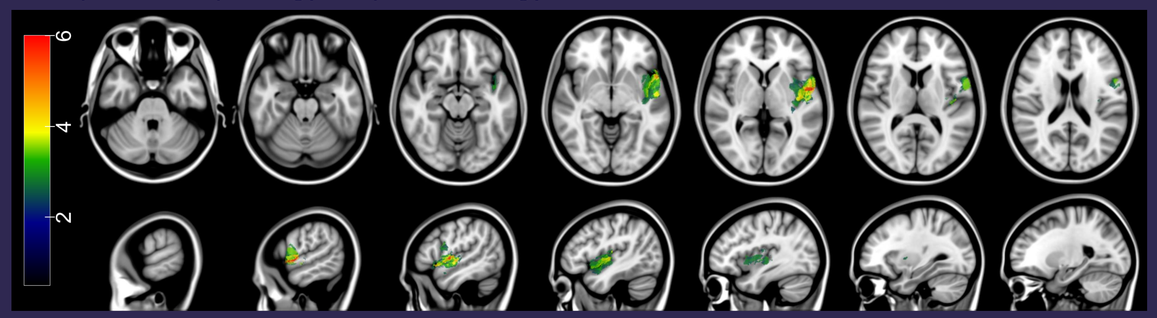
- Superior and middle temporal gyri, pars opercularis, insula



- Discourse, sentence, and word comprehension subtests show similar neuroanatomical distributions; no sig. clusters for non-word discrimination subtest

Production (individual scores averaged across all production subtests; colors denote *t*)

- Superior temporal gyrus, precentral gyrus, insula



- Word production, and non-word and sentence repetition subtests show similar neuroanatomical distributions; no sig. clusters for other production subtests

Discussion

- **Few clusters in the 'classical' language areas.** This is explained by their infrequent surgical damage as a result of intraoperative language mapping
- **The involvement of insula** may be driven by damage to the arcuate fasciculus, which runs underneath the insular cortex and is critical for language processing
- **Areas outside the 'classical' language areas are implicated in post-surgical language deficits.** This finding is in line with the recent neuroanatomical models of language processing (Hickok & Poeppel, 2007). Given the large-scale pre-surgical reorganization of the language network in this patient population, these areas demonstrate a lower potential for functional reorganization