Brain Activation In Chronic Left Hemisphere Stroke During A Semantic Decision Task

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Introduction

- ***Aphasia:*** A neurological disorder resulting from damage to sections of the brain that are responsible for language and speech production (typically, left hemisphere)
- After a stroke, the brain undergoes tremendous recovery and complex reorganization, yet it remains unclear how persons with stroke reorganize their language
- Difficulty of task can be a confound for persons with aphasia (i.e. the same task may be overly easy or overly challenging depending on impairment)
    - We utilized an adaptive tasking program (Adaptive Language Mapping; Wilson et al., 2018) with 7 steps (levels of difficulty), which adapted to participants' abilities in order to accurately measure task-relevant activity rather than activity dependent on difficulty

Methods

Subjects:

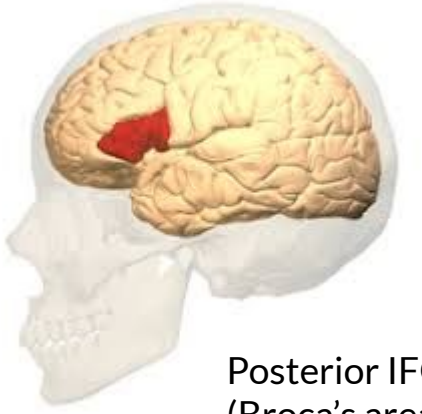
- N=10 chronic post-stroke (with clinical aphasia) [Age (M=62.6, SD=9.47 yrs)]
- N=16 typical controls (age-matched, p>.05) [Age (M=59.3, SD=10 yrs)]

Neuroimaging:

- Functional MRI acquired during a block design semantic decision task (Wilson et al., 2018); a total of 475 brain volumes acquired
- Used *fmriprep* to preprocess images (prepared for analysis) and move images to a standard template (MNI space), to allow for group comparison
- Activation during semantic decision task was contrasted with activation during a shape discrimination task using SPM12, to show brain activation significantly associated with semantic discrimination but *not* shape discrimination

Hypotheses

1. The control group will produce significant brain activation in left hemisphere language regions (specifically, posterior temporal cortex and posterior portion of the inferior frontal gyrus [Broca's Area]).
    a. If these areas are not affected by stroke, members of the stroke group will demonstrate significant activation in these areas.
2. The stroke group will produce significantly more bilateral brain activation (especially in homologue/parallel regions), reflecting language reorganization.



Posterior IFG
(Broca's area)

Behavioral Results

How well did everyone do on this task in the scanner? Was the stroke group worse overall at this task?

Stroke Group

- Semantic decision task: M=78.55%, SD=23.93
- Shape discrimination task: M=85.01%, SD=25.11

Control Group

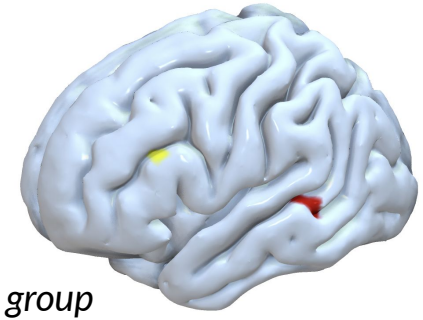
- Semantic decision task: M=85.31%, SD=7.31
- Shape discrimination task: M=85.50%,SD=3.33

Thanks to the adaptive nature of the task (i.e. shifting to accommodate ability), the Control Group was not significantly more accurate than the Stroke Group on the semantic decision task (t=1.07, p=0.30) or the shape discrimination task (t=.08, p=.94).

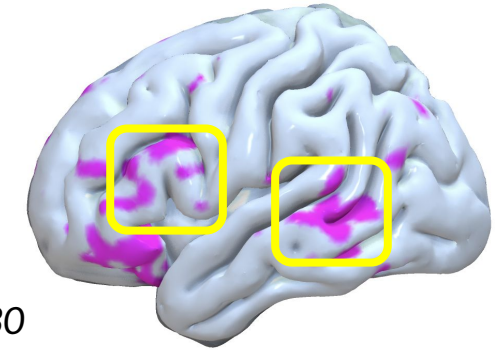
Note that the stroke group substantially more variable (much larger standard deviations), reflecting heterogeneous impairment severity in this group.

Brain Results: Control Group

- There was a statistically significant activation in Broca's area (yellow) and the posterior temporal cortex (red) in the left hemisphere, when compared with shape discrimination ($p<.0001$).
  - For comparison, there was no statistically significant effect found in a non-hypothesized left hemisphere brain region, the supramarginal gyrus ($p>0.2$).



Whole group



RC30
control exemplar

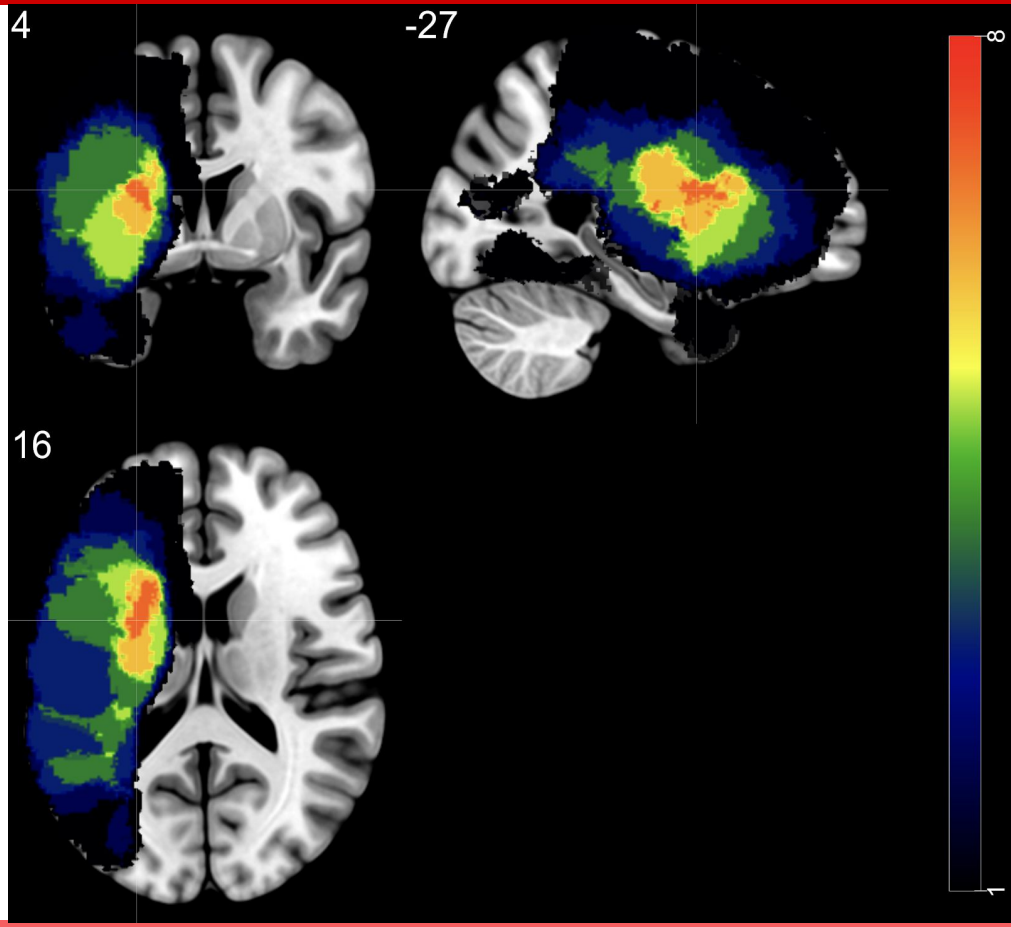
Broca's area and posterior temporal cortex in yellow boxes

Brain Results

Lesion heat map

Area in red is showing lesion overlap of 8 subjects, area in black is showing lesion of a single subject

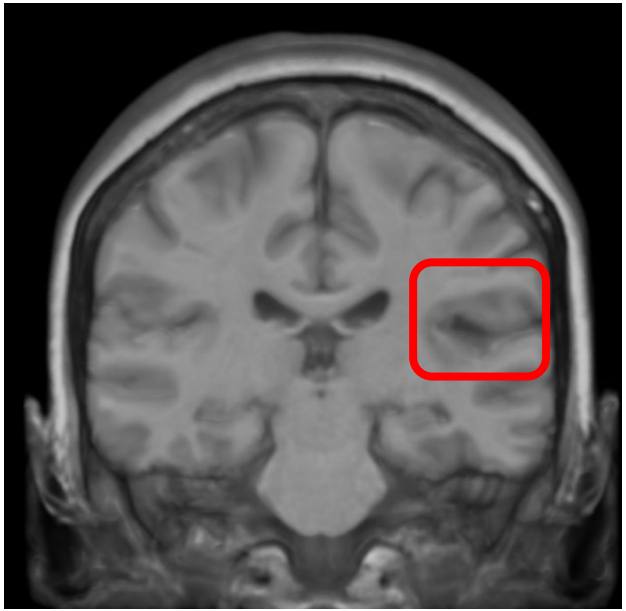
All left hemisphere middle cerebral artery territory strokes

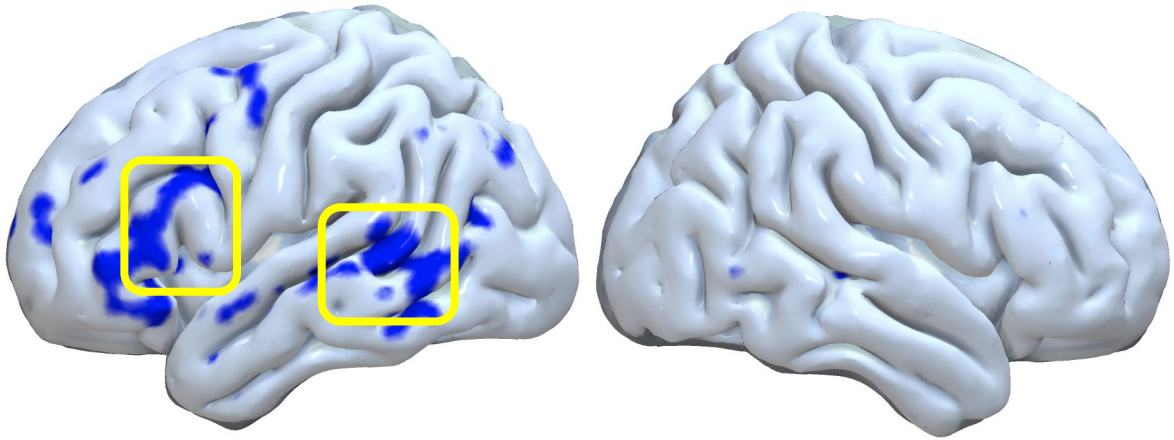


Brain Results: Stroke Group Examples

RC7 (very small temporoparietal junction lesion), task accuracy=85.42%

Most similar activation to control group (very mild aphasia; small lesion size): activation in both Broca's area and posterior temporal cortex



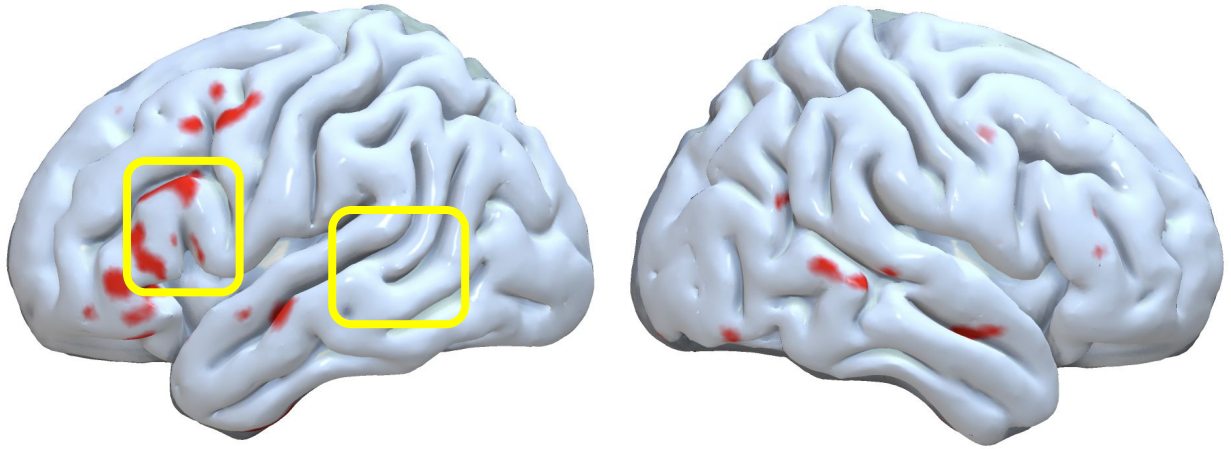


Broca's area and posterior temporal cortex in yellow boxes

Brain Results: Stroke Group Examples

RC2 (posterior temporoparietal lesion, mild anomic aphasia), task accuracy=83.45%

Note Broca's area activation but not posterior temporal activation (lesion in posterior temporal area)

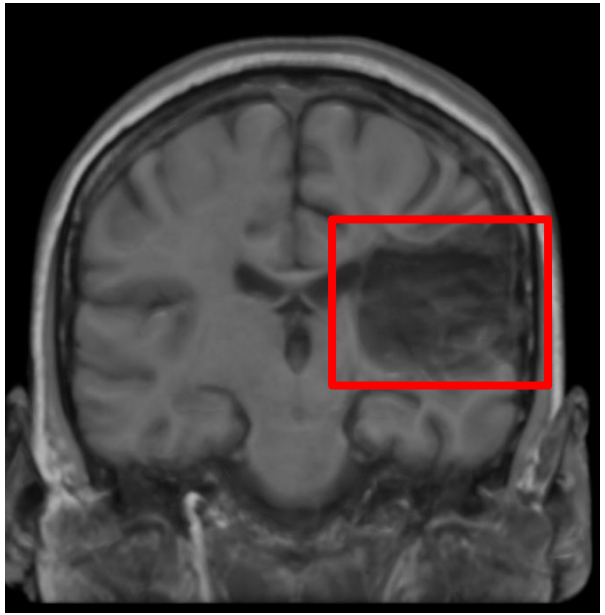


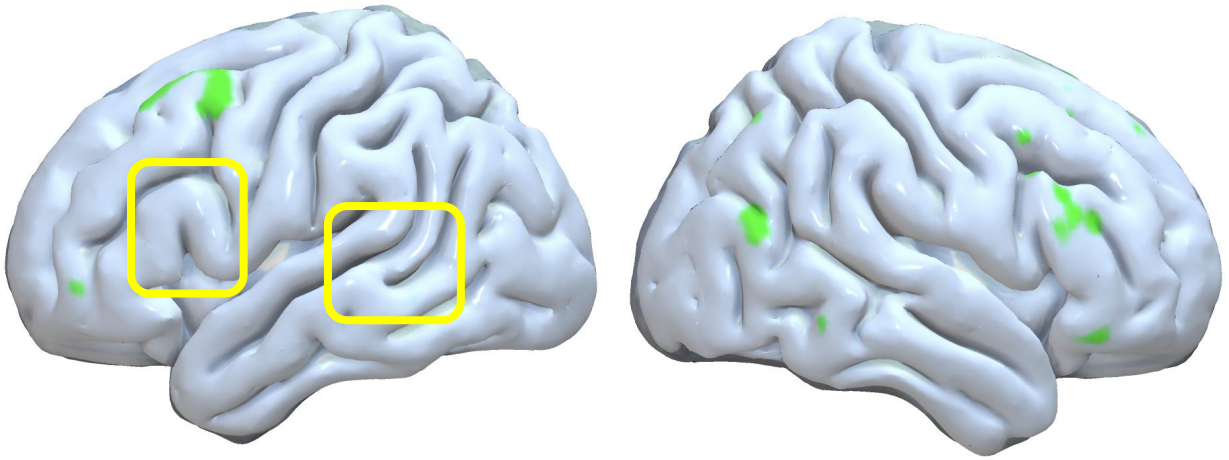
Broca's area and posterior temporal cortex in yellow boxes

Brain Results: Stroke Group Examples

RC56 (temporo-parieto-frontal lesion, severe Broca's aphasia), task accuracy=74.78%

Most dissimilar activation to control group (severe aphasia; large lesion), no significant activation in either Broca's area or posterior temporal cortex due to lesion location





Broca's area and posterior temporal cortex in yellow boxes

Summary

1. **Performance (accuracy) in the scanner was comparable between the stroke and control groups, with the stroke group showing more intra-group variability (i.e. different language impairment severity)**
    a. We did not report this here, but, on average, the stroke group reached lower levels of difficulty on the task compared with the control group
2. **The control group produced statistically significant brain activation in left hemisphere Broca's area and posterior temporal cortex**
    a. Members of the stroke group without damage to those areas demonstrated significant brain activation here as well
3. **The stroke group produced more bilateral brain activation (especially in homologue/parallel regions), reflecting the occurring of language reorganization**
    a. Especially in those with more severe aphasia/larger lesions.

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FMRIPREP Tools and references: https://github.com/poldracklab/fmriprep/blob/master/REFERENCES.md