Left hemisphere frontotemporal effective connectivity during semantic feature judgments: Differences between patients with aphasia and healthy controls

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Introduction

- Feature knowledge plays a critical role in the organization of the semantic system.
- Evidence from both healthy individuals and persons with stroke-induced aphasia (PWA) suggests correctly assigning or rejecting attributes to conceptual targets requires the integrated functioning of anatomically-remote areas spanning left frontotemporalparietal cortex.
- Inferior frontal gyrus, pars triangularis (IFGtri), and middle frontal gyrus (MFG) are implicated in domain-general cognitive control.
- Middle temporal gyrus (MTG) for multimodal lexical-semantic processing.
- However, little is known about the impact of stroke on the dynamic connectivity of such regions during semantic tasks.

Study Aims

1. To examine frontotemporal effective connectivity for semantic judgments in PWA relative to controls using dynamic causal modelling (DCM).
2. To examine the relationship between connectivity parameters, behavioral performance, and cortical integrity in PWA.

Participants

- 18 controls (10M, mean age = 60.3 ± 10.9 years).
- 25 PWA (17M, mean age = 63.0 ± 11.0 years, mean months post onset = 15 ± 5 months).

Behavioral testing:

- Western Aphasia Battery-Revised (WAB-R) to obtain an Aphasia Quotient (AQ), an overall index of aphasia severity for each patient.
- Pyramids and Palm Trees Test (PPT) to assess nonverbal semantics.
- Psycholinguistic Assessment of Language Processing in Aphasia (PALPA), subtest 51: Word Semantic Association - Assessing lexical semantics for high and low imageable items.

MRI Methods

- MRI images acquired on a Siemens Trio TIM with a 20-channel head + neck coil.
- TI parameters: TR/TE = 2300/2.91ms, 176 sagittal slices, 1mm voxels.
- Functional parameters: TR/TE = 2570/30ms, 40 axial slices, interleaved with 2x2x3mm voxels.
- fMRI task included 108 imageable and 36 scrambled control stimuli.

MRI Analysis

- Talairach space conversion.
- Statistical Analysis: 1st level GLM: Modulated the WFU-PickAtlas 2nd level analysis: One-sample t-test in each group.

Effective Connectivity Methods: DCM

- Volume of Interest (VOI) Selection: Peak maxima identified in each region from controls' 2nd level analysis for pictures – scrambled, uncorrected, p < 0.01 (see below).
- Anatomically-constrained bounding regions created to (1) ensure each subject's peak 30mm from control group (2) account for PWA lesions.
- VOIs located and extracted for each subject per flowchart.

Inference

- Family-wise Bayesian Model Selection (BMS) to determine which family of models best fit the data.

Model Space

- Motor, sensory, visual, and non-sensory connections.

Results: VOI Integrity, Location, & Activation

Regional integrity in PWA

- LMTG and LMGF most damaged and spared regions, respectively.
- Noisy VOIs (i.e., threshold (p = 0.1 due to ≥50% damage in bounding region) in LIFGtri and LMTG for three and five PWA, respectively.

VOI location in PWA vs. controls

- Differences in task choice between PWA and controls.
- No significant differences between groups in beta weights from anatomically-constrained bounding regions.
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- Provides some certainty that potential between-group differences in connectivity are not due to between-group differences in regional activity.

Conclusions

- When accounting for lesion in the patient group, all participants exhibited activation for semantic judgments in close proximity in each VOI.
- Both groups demonstrated a preference for Family 2: Input to LIFG.
- PWA demonstrated high reliability on interactions between LIFG and LMFG and modulation of frontal areas by LMTG.
- Network differences possibly due to interactions with other areas, including right hemisphere homologues of VOIs.

Selected References


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