Examining Functional Connectivity in the Language Processing Center through fMRI in Relation to the Onset of Psychosis in Schizophrenia

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Introduction

- **Schizophrenia** disorders the brain's ability to perceive through repeatable periods of psychosis (McCutcheon et al., 2020), (Rahman & Lauriello, 2016).
- Currently no reliable methods for early intervention or prediction
- **Functional connectivity** is a newer field in neuroscience that quantifies the interactions between regions of the brain
- **Wernicke's Area (WA)** and **Broca's Area (BA)** in the left hemisphere involved in speech processing and production (Ćurčić-Blake et al., 2013).
    - Disconnect between WA and BA → **auditory-visual hallucinations (AVH)**
- **Data: *N*-back tests** are done to test working memory and incur inner speech. Individuals indicate if a displayed letter is the same as a prespecified letter (0-back) or as a letter shown *N* trials back (*N* = 1 or 2).

Goal

Analyze the functional connectivity between WA and BA in control and schizophrenic individuals to determine the likelihood of the onset of schizophrenia.

Methods

Analysis with SPM12

1 Raw fMRI Data → Preprocessed Images

a. Realignment
b. Slice-timing adjustment
c. Coregistration of anatomical/functional data
d. Normalization + Smoothing

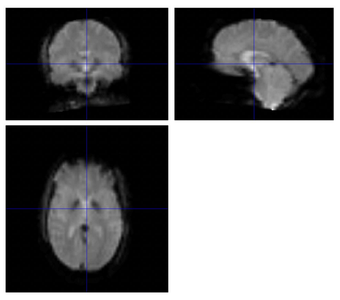


Figure 1, Raw fMRI image

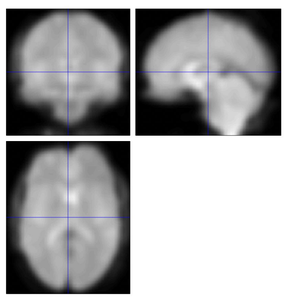


Figure 2, preprocessed fMRI image

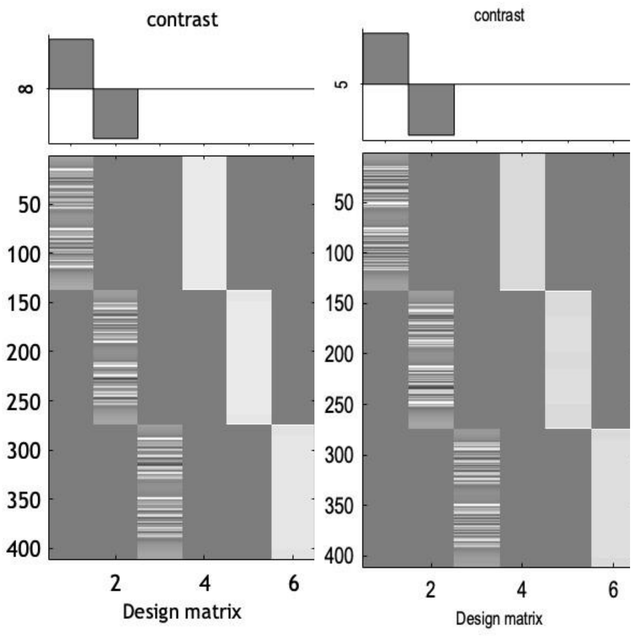


Figure 3, Design model of control vs. SZ brain activity

2 Beta-Weighting + Statistical Analysis

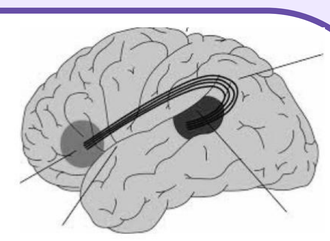
a. Compare conditions (back0, back1, back2) in each scan to determine relative activity of regions → **design matrix**
b. Multiply by contrast vector [0.33 -0.33]
c. Visualize BOLD signals

3 Dynamic Causal Modeling (DCM)

a. Random effects analysis to determine time series of regions of interest
b. Use contrast files to create models
c. Bayesian comparison of different connectivity networks in the brain

Discussion

- The BA-WA connection was modeled in CTRL vs. SZ
- Functional connectivity was successfully determined
- While BOLD differences are discernable, the degree to which the BA-WA connection is significant is yet to be calculated



Levelt, W. J. M. (2013). A history of psycholinguistics: The pre-Chomskyan era. Oxford: Oxford University Press.

Figure 4, BA-WA connection

Alternative routes include

a. Seed-based correlation analysis in WA and BA, use of AdaBoost to determine the weighted significance of each brain region in schizophrenic diagnosis
b. Analyzing a dataset presented with an auditory stimulus + speech prompt
c. Using a Pearson cross-correlation to observe functional connectivity throughout the language processing center

Limitations of our research are

a. Lack of access to preprocessed databases
b. Only included few regions of interest; more than just BA and WA are involved in language processing

Future applications may be

a. Early diagnosis of schizophrenia for treatment
b. Development of drugs that target the language processing center
c. Researching other disorders caused by irregular functional connectivity

Results

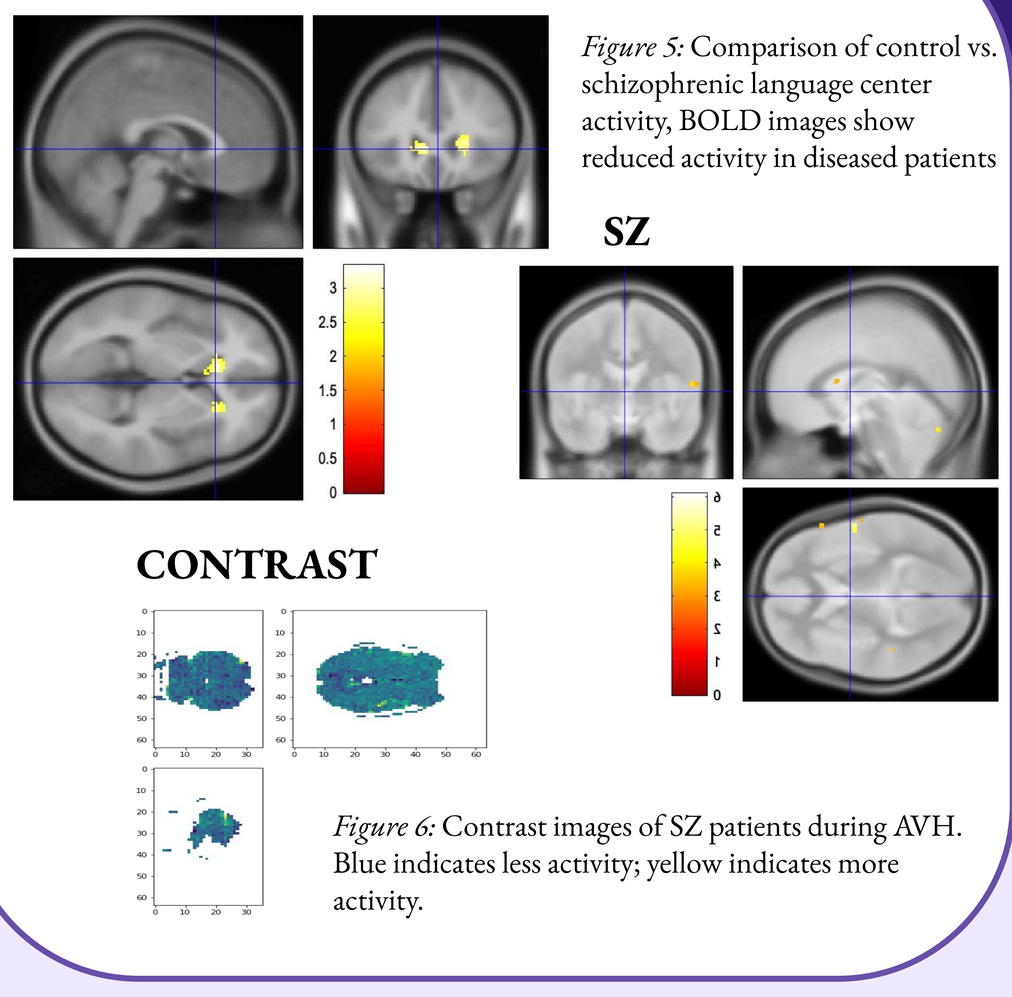


Figure 5: Comparison of control vs. schizophrenic language center activity, BOLD images show reduced activity in diseased patients

Figure 6: Contrast images of SZ patients during AVH. Blue indicates less activity; yellow indicates more activity.

References

1. McCutcheon, R. A., Reis Marques, T., & Howes, O. D. (2020). Schizophrenia—an overview. JAMA Psychiatry, 77(2), 201.
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3. Ćurčić-Blake, B., Ford, J. M., Hubl, D., Orlov, N. D., Sommer, I. E., Waters, F., Allen, P., Jardri, R., Woodruff, P. W., David, O., Mulert, C., Woodward, T. S., & Aleman, A. (2017). Interaction of language, auditory and memory brain networks in auditory verbal hallucinations. *Progress in Neurobiology*, *148*, 1–20.

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