Functional Assessment of a Language-Based fMRI Brain Network: The Extraction of Meaning Network

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Introduction

Task-based functional magnetic resonance imaging (fMRI) reliably detects a brain network that simultaneously engages Broca's and Wernicke's areas [1]. This network has emerged during some language tasks as a predominantly left-lateralized network [2,3]. While an anatomical description of this network is known [2,3], its specific functions remain unclear. Therefore, this study aims to elucidate the functions of this network by examining its activation over several cognitive fMRI tasks which were administered to healthy participants and patients with schizophrenia.

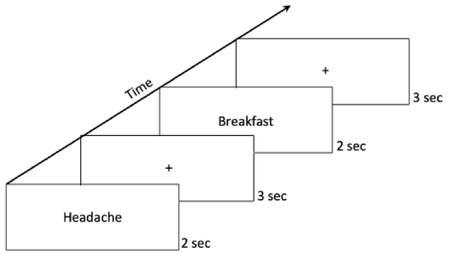
Methods

- Previous works extracted functional brain networks using constrained principal component analysis for fMRI (fMRI-CPCA) [4].
- Classifications were subsequently performed to identify networks with similar anatomical patterns to a prototype of this language-based network [1].
- Four networks with strong similarities to the prototype were selected for this study, and the corresponding hemodynamic responses (HDR) were analyzed and interpreted for each involved task to determine this network's functions.

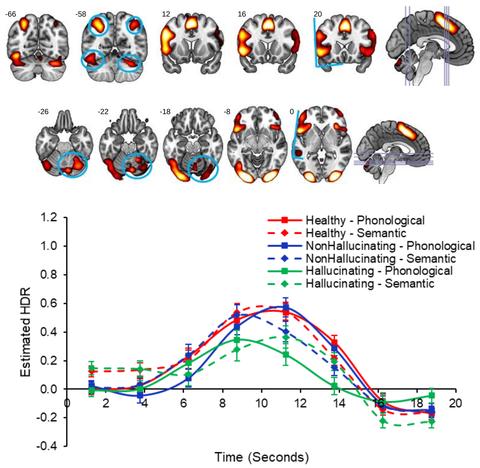
Results

Syllable Stress (SS) Task

- Participants (n=32 healthy controls, n=26 non-hallucinating patients with schizophrenia, n=21 hallucinating patients with schizophrenia) were shown a 2-syllable word and were asked about its metrical stress placement (Phonological condition) and connotation (Semantic condition).

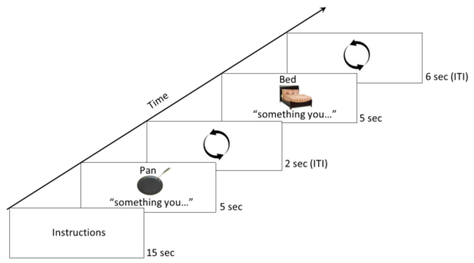


- Equivalent levels of activation are observed in the Phonological and Semantic conditions.
- Hypoactivation is observed in hallucinating patients with schizophrenia.

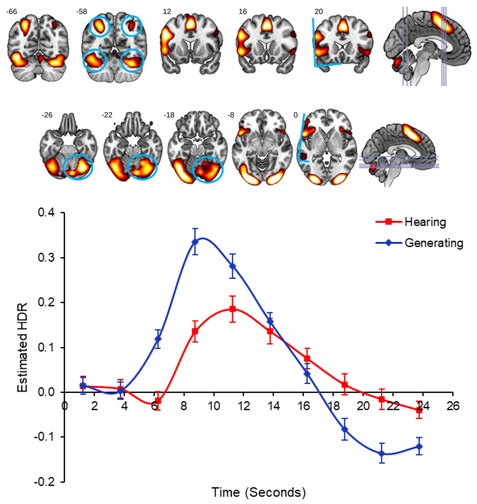


Thought Generation (TG) Task

- Participants (n=26 healthy controls, n=23 patients with schizophrenia) were presented with a word and its image, and were asked to either listen to, or generate, a definition for the word.

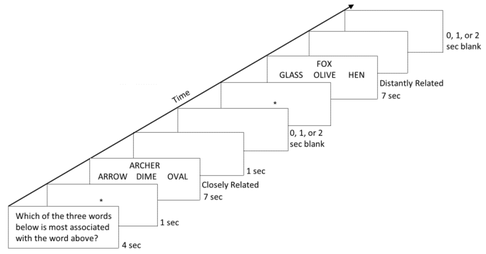


- More activation is observed in the Generating than Hearing condition.
- The network below was obtained from merging [4] the SS, TG, and SA Tasks.

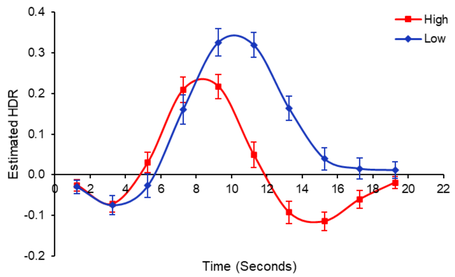


Semantic Association (SA) Task

- Participants (n=30 healthy controls, n=27 patients with schizophrenia) were shown three match options for a prompt word, and they were asked to select the match option that most closely relates to the prompt word.



- More activation is observed in the Low (distantly related) than High (closely related) semantic association condition.

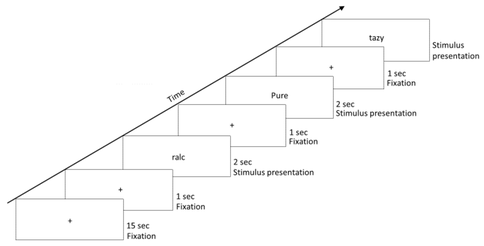


Highlighted Replicable Network Patterns

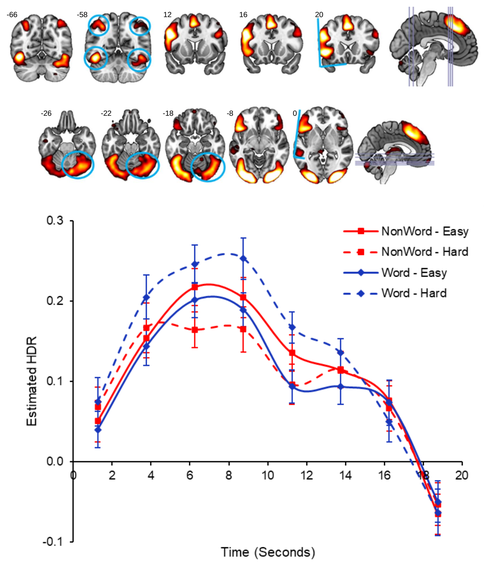
Orientation	Slice Number(s)	Activation Pattern Description
Coronal	20	Left-lateralized inferior frontal and frontal orbital activations
	-58	Temporal occipital and lateral occipital cortex activations
Axial	0	Left-lateralized middle and superior temporal gyrus, inferior frontal gyrus, and frontal pole activations
	-26, -22, -18	Lateral occipital cortex (inferior division) activations

Lexical Decision Task [3]

- Participants (n=59 healthy controls) decided whether four-letter sequences represented a real English word or not.

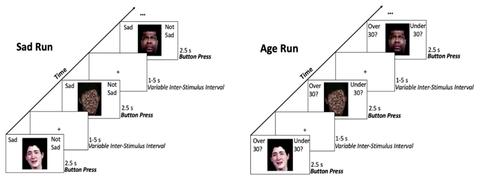


- Suppression of this network is observed when linguistic information is required to be ignored.

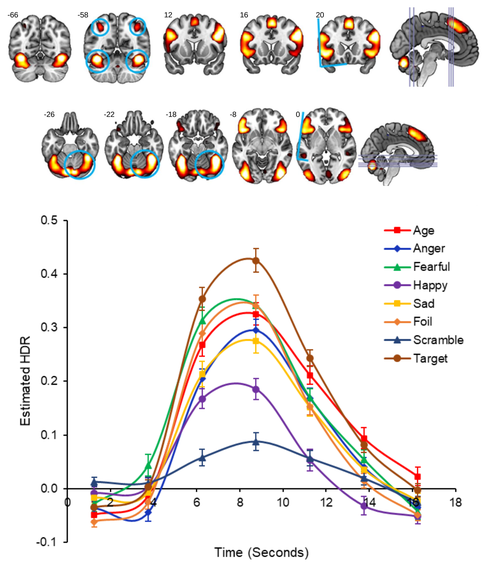


Facial Discrimination Task [5]

- Participants (n=21 healthy controls, n=24 patients with schizophrenia, n=25 relatives of patients) evaluated whether a presented face reflected a particular emotion or age.



- Minimal activation is observed for Scramble (blurred) faces. More activation is observed for Target than Foil (non-target) faces.
- Minimal activation for Happy faces, and maximal activation for Fearful faces.



Conclusions

- Predominantly left-lateralized brain networks were observed during language tasks, but an equivalent network configuration with a bilateral representation was observed during emotion recognition.
- This network's overall function is likely related to the extraction of linguistic- and emotion-based meaning.
- For hallucinating patients with schizophrenia who are completing the Syllable Stress Task, hypoactivated internal linguistic processing may pair with hyperactivated speech perception networks to produce the hallucinations they experience.

References

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