Beta band oscillations during basic sentence comprehension in patients with schizophrenia

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Introduction

Beta band oscillations during language processing

- In language comprehension we bind words together into a coherent message-level representation and predict which words are likely to come up next.

"It was windy so the children went out to fly their …"

- Reading sentences compared to random wordlists elicits larger responses in the lower beta frequency range[1]
- This has been attributed to unification, combining words into an overall representation of the sentence[1], as well as to a steady increase in expectation across the sentence[2].
- A left inferior frontal source for a beta band modulation in semantic processing has been reported in a previous MEG study[8].

Language processing and oscillations in patients with schizophrenia

- A 'loosening of association' is a core feature of schizophrenia that can manifest clinically as incoherent and disorganized language output[10].
- These abnormalities may be driven by an impairment in the use of context to predict and facilitate the processing of words that are semantically congruous with this context[3,4].
- Patients with schizophrenia can show abnormal increases in neural activity to words that are semantically unrelated to their preceding context[11].
- Language and semantic abnormalities in schizophrenia have been linked to abnormal activity within the left inferior frontal cortex[3,12] and to abnormal connectivity between frontal and temporal cortices[9].
- Abnormal modulation in the beta frequency band has been reported in schizophrenia[5].

Present study:

How is the beta frequency band modulated in patients with schizophrenia when we contrast coherent sentences with strings of unrelated words?

Design

Sentences:
"The gray mouse quickly scurried underneath the dusty rug"
Wordlists:
"the during flour five the paintings fireworks were sea"

- Word by word presentation
- 300 ms/word, 100 ms blank
- No task

- 20 sentences/condition/subject
- Half of the items taken from Rogalsky & Hickok (2009)

Methods

Demographic and Clinical Information

	Controls	Patients
Total	**17**	**19**
Male/Female	14/3	17/2
Age, y	45.4 ± 7.09	43.4 ± 9.59
Hollingshead Index	2.58 ± 0.087	2.72 ± 0.82
Education (years)	12.88 ± 2.82	12.68 ± 1.88
Premorbid Verbal IQ	111.68 ± 9.01	100.78 ± 11.66
CPZ Equivalent	N/A	485.45 ± 309.35
Duration of Illness, y	N/A	18.94 ± 8.16

Recording:

- Neuromag Vectorview MEG system, 102x3 sensors, only planar gradiometers reported

Preprocessing:

- Removal of bad channels
- ICA to remove eye blink, heartbeat and muscle artifacts

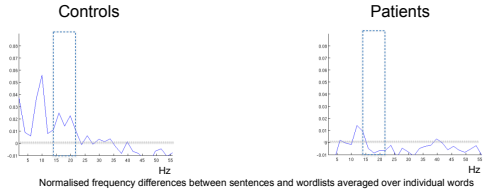
Analysis:

- FieldTrip[6] toolbox and MNE[7] toolbox
- Analysis of power in the lower frequency bands (4-30Hz): Multitapers, 2 Hz half-bandwidth
- Time window: 500 ms around each word, and full length of sentence from 3rd word onwards
- Statistical inference within and between groups with permutation tests and clustering
- Source localization in the frequency domain using DICS beamformer[8]

Results

Sensor level analysis (Sentences vs. Wordlists):

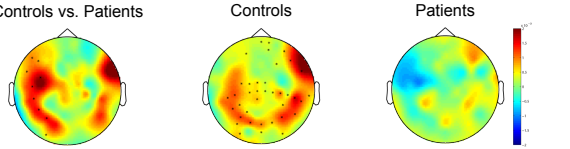
Power spectrum (over all sensors)



Normalised frequency differences between sentences and wordlists averaged over individual words

Controls: Power increases in the beta frequency band to sentences (> wordlists)
Patients: No such increases to sentences (> wordlists). A hint of increased beta activity to wordlists (> sentences).

15-20 Hz (beta) topographies (over the entire sentence)

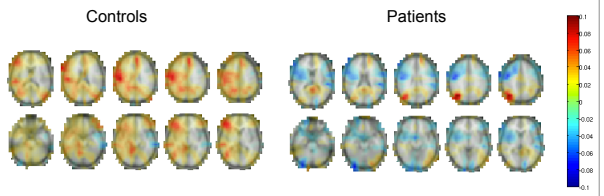


* Significant sensors, non-parametric cluster statistics

Controls: Beta increases to sentences (> wordlists) over frontal and temporal/parietal sensors in controls.
Patients: Beta increases to wordlists (> sentences) over left frontal sensors

Beamformer source analysis (Sentences vs. Wordlists):

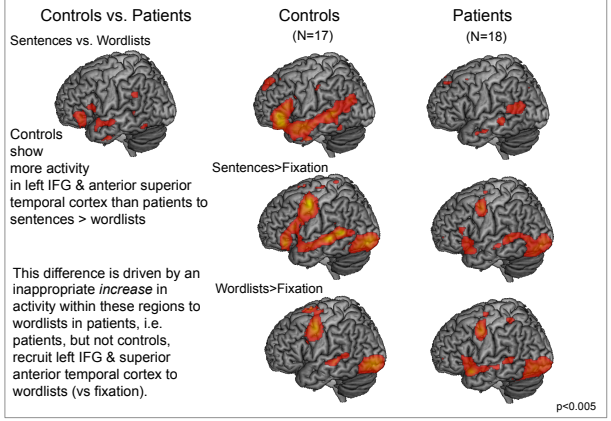
Beta Frequency band (taper around 18Hz, 4 Hz smoothing)



Preliminary analysis, no statistics yet

The beta increase in sentences (> wordlists) in controls localizes to frontal and temporal/ parietal regions.
The beta increase in wordlists (> sentences) in patients localizes to the left frontal cortex.

A parallel fMRI study (same participants, same stimuli)



Conclusions

- Patients with schizophrenia show an abnormal reduction in beta band activity within temporal & parietal regions to coherent sentences but an abnormal increase in beta band activity to lists of unrelated words.
- The abnormal increase in beta band activity to wordlists localizes to the left IFG—the same region that shows an abnormally increase in BOLD activity to the wordlists in fMRI, and that is thought to mediate semantic unification.
- Patients may inappropriately engage the left IFG to combine and unify the incoherent wordlists into a coherent whole.
- These abnormal patterns of beta activity may contribute to the disorganization of thought and language that characterizes schizophrenia.

Future directions

- Characterize and verify the localisations of beta band modulation obtained with the spatial filter.
- Investigation of the alpha band modulation to sentences > wordlists
- Analyses of functional connectivity (fMRI) between frontal and temporal cortices.

References

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