Delta vs. Gamma synchronization in Schizophrenia

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Schizophrenia

- Mental disorder
- Affects 1% of general population
- Heterogeneous symptoms
  - Abnormal perceptions, thoughts
  - Poor executive function
  - Reduced verbal working memory
  - Speech disorganization
  - Hallucinations
    - Auditory and visual
Schizophrenia

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Schizophrenia

• Electrophysiological abnormalities (EEG)
  – Mismatch negativity, steady state responses etc.

• Auditory Steady State Responses (ASSRs)
  – Response to a periodic stimulus
    • Clicks, AM, etc.
  – Typically studied at 40 Hz (gamma band)
    • Strongest response (in humans)
    • Association of gamma band synchrony with cognition
Example of ASSR at 40 Hz

Kwon et al. 1999
Example of ASSR at 40 Hz

Healthy controls

Kwon et al. 1999
Example of ASSR at 40 Hz

Healthy controls

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Example of ASSR at 40 Hz

Healthy controls

Schizophrenic patients

Kwon et al. 1999
Hypothesis

• Auditory hallucinations, a hallmark symptom
• Slow temporal modulations (delta 1-4 Hz, theta 4-8 Hz) are important for perception of speech and natural sounds.
• Delta & theta band abnormalities may be a better indicator!
Methods

• Click train at \(2.5, 5, 10, 20, 40, 80\) Hz rates
• Responses recorded using EEG
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• 108 Healthy controls
• 128 Schizophrenic patients
• 55 First degree relatives
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• ASSR measure: Power at stimulus frequency, normalized by baseline power.
Whole head EEG auditory response

Normalized ASSR power

Healthy Controls

Schizophrenia Patients

40 Hz

2.8 12.0
Whole head EEG auditory response

Normalized ASSR power

Healthy Controls

2.5 Hz

40 Hz

Schizophrenia Patients

6.4  14.0

2.8  12.0
Whole head EEG auditory response

Normalized ASSR power

Healthy Controls

First degree relatives

Schizophrenia Patients

2.5 Hz

40 Hz

6.4  14.0

2.8  12.0
Whole head EEG auditory response

Normalized ASSR power

Healthy Controls

First degree relatives

Schizophrenia Patients

2.5 Hz

5 Hz

10 Hz

20 Hz

40 Hz

80 Hz

6.4

14.0

0.8

6.7

0.4

7.1

2.1

5.5

2.8

12.0

-2.6

0.6
ASSR differences by rates

![Graph showing ASSR differences by rates for Healthy Controls and Schizophrenia Patients. The y-axis represents normalized ASSR power, and the x-axis represents different frequencies (2.5, 5, 10, 20, 40, 80 Hz). The graph includes error bars and statistical significance markers (* p < 0.01, ** p < 0.001).]
ASSR differences by rates

- Significant difference between Healthy Controls (↑) and Schizophrenic Patients (↓) at 2.5 Hz, 5 Hz, 10 Hz and 40 Hz

[Graph showing normalized ASSR power across different frequencies and groups, with asterisks indicating statistical significance (*) and very significant difference (**) at p < 0.01 and p < 0.001 respectively.]
ASSR differences by rates

- Significant difference between Healthy Controls (↑) and Schizophrenic Patients (↓) at 2.5 Hz, 5 Hz, 10 Hz and 40 Hz
- Largest difference at 2.5 Hz
ASSR differences by rates

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ASSR differences by rates

- Significant difference between Healthy Controls (↑) and Schizophrenic Patients (↓) at 2.5 Hz, 5 Hz, 10 Hz and 40 Hz
- Largest difference at 2.5 Hz
- 40 Hz difference between Healthy controls and non-schizophrenic First degree relatives
Cognitive measure

• Verbal working memory task
Cognitive measure

- Verbal working memory task

Schizophrenia Patients

2.5 Hz

$r = 0.36, p < 0.001$
Cognitive measure

- Verbal working memory task

Schizophrenia Patients

$r = 0.36, p < 0.001$

$r = -0.95, p = 0.004$
Cognitive measure

- Verbal working memory task

Schizophrenia Patients

2.5 Hz

\[ r = 0.36, p < 0.001 \]

All rates

\[ r = -0.95, p = 0.004 \]

Normalized 2.5 Hz ASSR Power

Correlation Coefficients of Working Memory vs. ASSR

Stimulation Frequency (Hz)
Cognitive measure

- Verbal working memory task

Schizophrenia Patients

2.5 Hz

- Weaker auditory response \( \iff \) verbal working memory problems
- Holds only for slower frequencies
Behavioral measure

- Auditory Perceptual Trait and State scale (APTS)
  - Self reported questionnaire
  - “hallucination index”
    - ‘hearing my name called but realizing that it must have been my imagination’
    - ‘I have experiences that I cannot suppress or ignore the voices or sounds in my head’
Correlation with APTS

Schizophrenia Patients

2.5 Hz ASSR

\[ r = -0.26 \]
\[ P = 0.009 \]

40 Hz ASSR

\[ r = 0.42 \]
\[ P = 0.001 \]
In delta band, weaker auditory response is associated with more severe hallucinations.
Summary

• Delta ASSR
  – shows better separability between healthy controls and schizophrenia patients than gamma
  – shows stronger association with working memory deficits

• Delta ASSR linked to behavioral auditory symptoms of schizophrenia
  – Gamma ASSR linked to susceptibility, not symptoms
Thank you