Suppressing Auditory Background Speech: a Link to Auditory Hallucination in Schizophrenia

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Introduction
Schizophrenia is a severe brain disorder, where a hallmark symptom is auditory hallucination. The origin of auditory hallucination, which dissociates auditory perception from acoustic stimuli, may be a fundamentally a bottom-up problem, caused by erroneous processing of diverse external auditory inputs, or a top-down problem, caused by erroneous processing of an internally-generated thought. The origin of auditory hallucination, which disregards/communicates internally-generated content with the externally-oriented primary auditory pathway, may be a fundamentally a bottom-up problem, caused by erroneous processing of stimuli, or a top-down problem, caused by erroneous processing of an internally-generated thought. Schizophrenia is a severe brain disorder, where a hallmark symptom is auditory hallucination.

Methods
Participants
• 24 schizophrenia patients, age 21-61, 17 male
• 28 healthy controls, age 22-61, 20 male

Auditory Hallucination Index
• Evaluated for patients via Psychotic Symptom Rating Scales (PSYRATS-AH)

Stimulus Paradigm
• 60 s duration segments of a story
• Narrated by separate male and female adults
• Digitally mixed into a single channel
• Presented diotically (identical stereo channels)

MEG Recording
• 154 channel KIT/Eagle MEG Scanner
• 1 kHz sampling frequency
• Denoised by Time-Shift PCA (TSPCA),¹
• Denoising Source Separation (DSS)²,³ enhances response reliability over trials (D=6).
• Neural responses bandpass filtered 2-8 Hz.

Temporal Response Function Analysis
• Temporal Response Function (TRF): a temporal measure that uses a stimulus acoustic envelope to optimally predict neural responses.
  • Separate TRFs computed for Attended and Unattended speech stimuli.
  • M50TRF and M100TRF (peaks with latency ~50 ms and ~100 ms respectively) tabulated.

Results
Representative Attended & Unattended TRFs
Attended (upper) and Unattended (lower) TRFs from a representative schizophrenia patient. The amplitude and timing of the two M50TRF's are typically similar, regardless of attention. The Attended M100TRF, in contrast, is typically larger and earlier than Unattended.

References
⁶ Hoffman, RE et al. (2007) Probing the pathophysiology of auditory/verbal hallucinations…, Cereb Cortex 17, 2733.

Discussion
• Recent results from Puschmann et al. connect neural activity in right temporoparietal junction (TPJ) to successful selectively listening in speech, e.g., successful suppression of unattended speech.
• Auditory hallucinations are likewise connected to activity in both TPJ and auditory cortical areas whose activity strongly locks to speech.
• Deficits in speech-rate (delta band) auditory oscillations are associated with schizophrenia in general, and verbal working memory symptoms in particular.

Auditory Hallucination Severity vs. M100TRF Latency Enhancement
The M100TRF latency advantage of the Attended over Unattended is significantly reduced (population shifted left) for schizophrenia patients (red) relative to healthy controls (green). p = 0.032 (permutation test, N = 100000)

Temporal Response Function Analysis
M100TRF Attentional Gain

<table>
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<tr>
<th>Subjects</th>
<th>M100TRF Attentional Gain</th>
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<td>Healthy Controls</td>
<td>Schizophrenia Patients</td>
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Results
Hand-drawn graph of M100TRF Attentional Gain over subjects for healthy controls and schizophrenia patients. In schizophrenia patients, M100TRF peak enhancement (gain) is correlated with Auditory Hallucination Index. r = 0.557, p = 0.016.

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