Altered Neural Processing in Middle Frontal Gyrus and Cerebellum During Temporal Recalibration of Action-Outcome Predictions in Schizophrenia Spectrum Disorders

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Sensorimotor Temporal Recalibration

- A central function of the perceptual system is to **predict the (multi)sensory outcomes** of our own actions and to flexibly **recalibrate** these predictions in response to changes in the environment - such as increases in action-outcome delays [1,2].
- In individuals with **schizophrenia spectrum disorders (SSD)**, deficits in these predictive mechanisms have been associated with impairments in self-other distinction and alterations in the sense of agency [3,4].

Research Aims

1) Identify the **neural correlates** underlying the recalibration of action-outcome predictions following delayed sensory feedback
2) Examine the **neural correlates** for the **transfer** of recalibration effects **across sensory modalities**
3) Investigate whether **patients with SSD** show alterations in these neural processes, potentially reflecting impairments in predictive sensorimotor processing

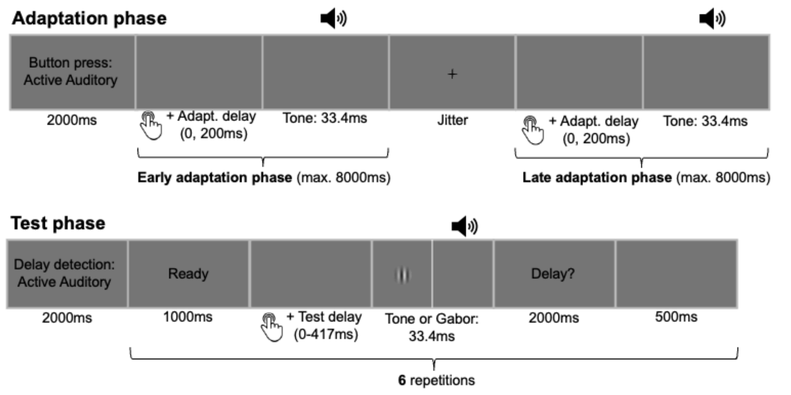
Temporal Recalibration Paradigm

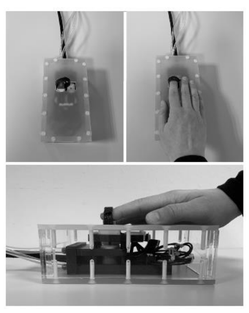
Adaptation phases:

- During fMRI, temporal recalibration was induced by introducing a constant delay of either **0ms or 200ms** between **actively or passively** executed button presses and a resulting auditory stimulus.

Test phases:

- To assess recalibration effects, active or passive button presses triggered an **auditory (unimodal) or a visual (cross-modal) stimulus.** Participants were required to detect variable delays between the action and the sensory outcome.



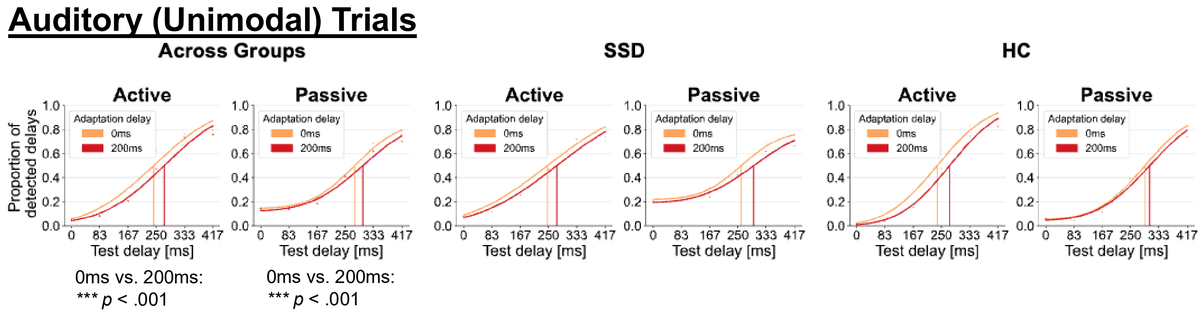


MR-compatible passive button device

Behavioral Results

N_{SSD} = 22; N_{HC} = 19

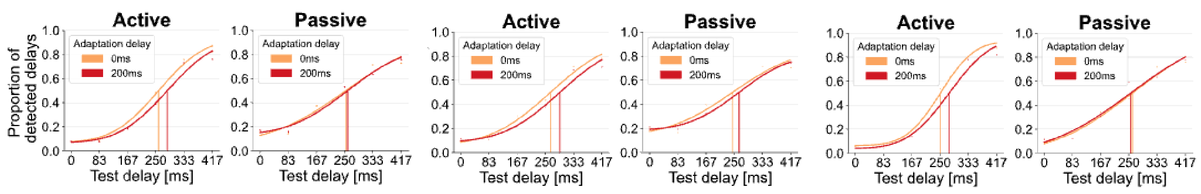
Auditory (Unimodal) Trials



0ms vs. 200ms: *** p < .001

0ms vs. 200ms: *** p < .001

Visual (Crossmodal) Trials

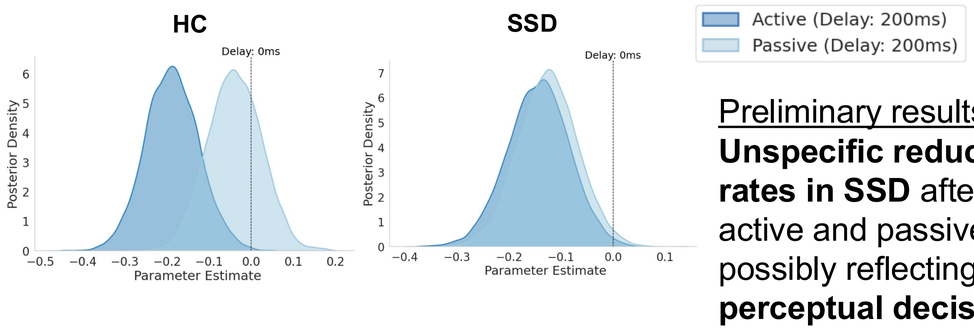


0ms vs. 200ms: *** p < .001

0ms vs. 200ms: p < .406

- **Auditory**: Significant temporal recalibration effects (TRE; Threshold 200ms > Threshold 0ms) across groups for both active and passive movements
- **Visual**: Significant TRE across both groups specifically for active movements

Outlook: Hierarchical Sequential Sampling Modeling (HSSM):

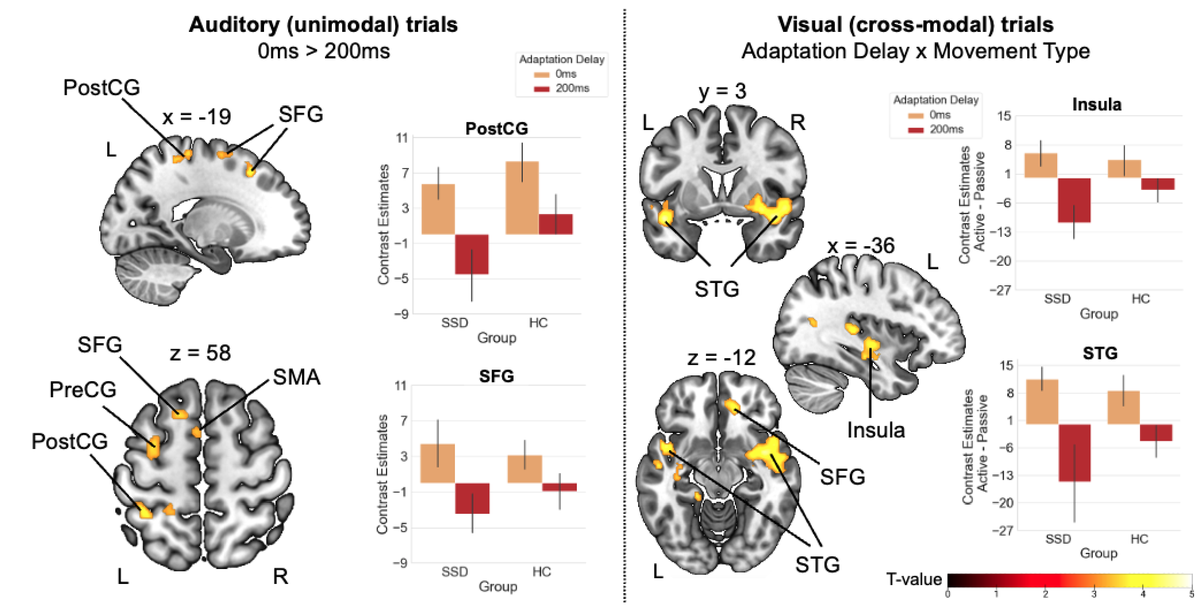


Preliminary results:

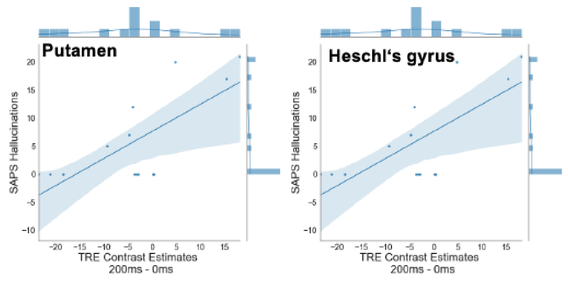
Unspecific reduction in drift rates in SSD after adaptation in active and passive conditions, possibly reflecting **altered perceptual decision-making**

fMRI-Results: Commonalities

N_{SSD} = 14; N_{HC} = 18

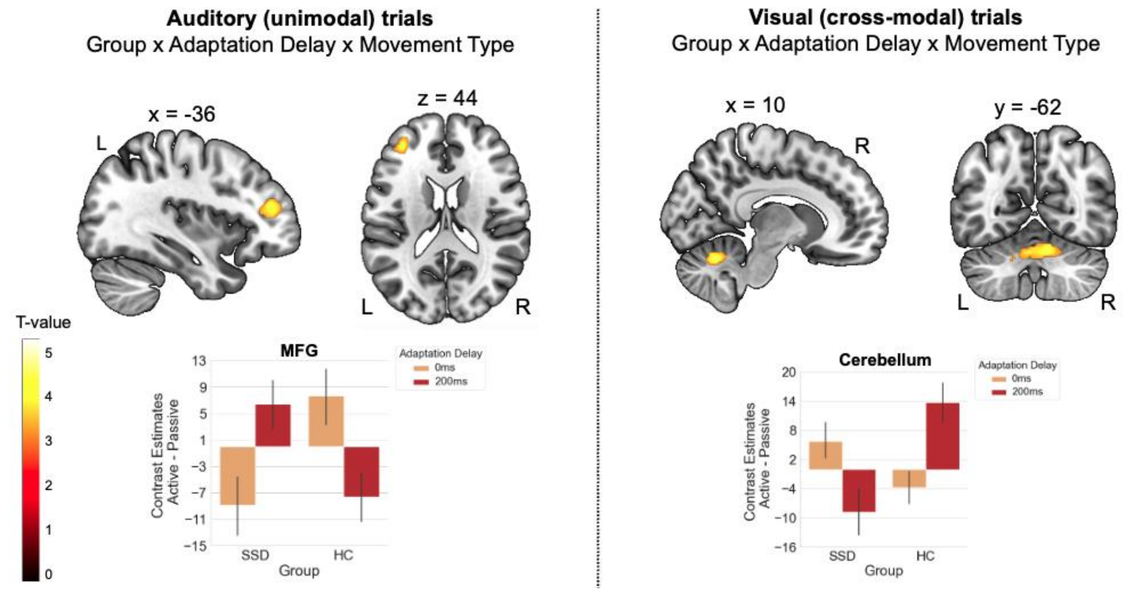


- **Auditory test phases**: Reduced activation after delayed-tone adaptation in sensorimotor and frontal regions across both groups
- **Visual test phases**: Reduced activation after delayed-tone adaptation in temporal, frontal, and subcortical regions, with a stronger effect in active compared to passive conditions



Patients with **higher SAPS total and hallucinations scores** deviated most from the overall activation pattern in active conditions, showing a negative neural TRE in the putamen and Heschl's gyrus for the visual test modality.

fMRI-Results: Group Differences



- **Auditory test phases**: Group differences in delay-related activation in left MFG, with HC showing reduced activation in active conditions, while SSD exhibited the opposite pattern
- **Visual test phases**: Group differences in delay-related activation in cerebellum, with HC showing increased activation in active conditions, and with the opposite pattern in SSD

Conclusions

- SSD is associated with specific **alterations in the neural correlates** of sensorimotor temporal recalibration, despite preserved behavioral performance in delay detection.
- Patients with SSD did not exhibit **reduced prediction error-related activity** in the **middle frontal gyrus (MFG)** after recalibration, unlike HC, suggesting a marker for unimodal recalibration deficits.
- SSD patients showed **reduced cerebellar engagement** during the **transfer** of temporal recalibration effects to another sensory modality.
- Replication of these effects in larger and more diverse samples is needed to validate the link between neural recalibration markers and symptom severity.

References

[1] Stetson et al., 2006, *Neuron*
[2] Arikan et al., 2021, *Scientifi c Report*
[3] Pynn & DeSouza, 2013, *Vision Research*
[4] Uhlmann et al., 2020, *Schizophrenia Bulletin*

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