

Can Brain Waves Redefine Schizophrenia? From Distinct Clusters to a Continuous Spectrum

Gabriel Nicola¹, Melissa Faggella¹, Dario Gordillo¹, Maya Roinishvili^{2,3}, Eka Chkonia⁴, Michael H. Herzog¹

¹ Laboratory of Psychophysics, Brain Mind Institute, Swiss Institute of Technology (EPFL), Switzerland ² Laboratory of Vision Physiology, Beritashvili Centre of Experimental Biomedicine, Georgia ³ School of Science and Technology, University of Georgia, Georgia ⁴ Department of Psychiatry, Tbilisi State Medical University, Georgia

Why it matters?

- **A Clinical Challenge:** Schizophrenia affects ~1% of the global population, causing **altered reality perception, cognitive deficits**, and **behavioral changes**.

What's the problem?

- **The Diagnostic Gap:** Currently diagnosed via **clinical observation** (DSM-5). It lacks **objective biological markers**.

Research Goal

- Is schizophrenia a set of distinct categories (**clusters**) or a continuous clinical gradient (**spectrum**)? We use **EEG** data to find out.



Our Approach: Dual EEG Analysis

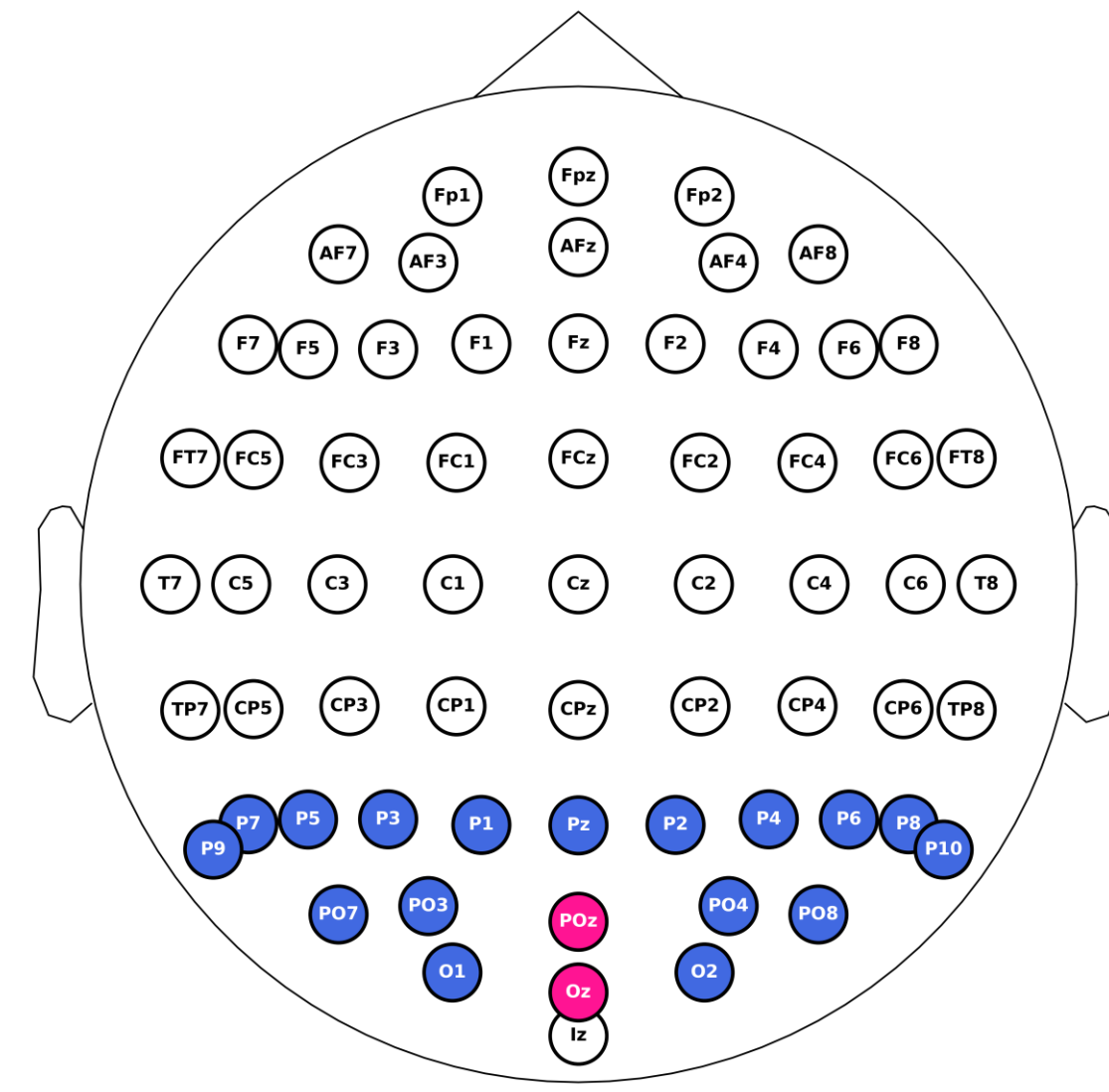
- **Resting-State EEG** : Capturing baseline, spontaneous **brain wave activity** to find global neural signatures.
- **Task-Evoked EEG (VBM)**: Measuring **specific** temporal resolution **deficits**, which are well-documented in schizophrenia patients.

Why this specific task?

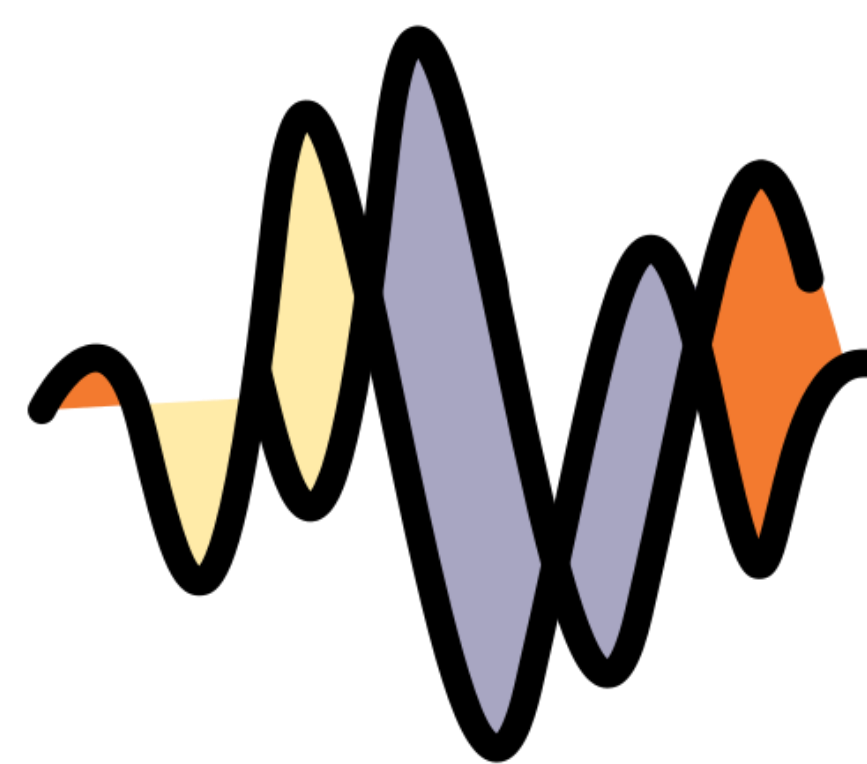
- **Visual Deficits:** Patients with schizophrenia often show specific impairments in early visual processing.

Methods

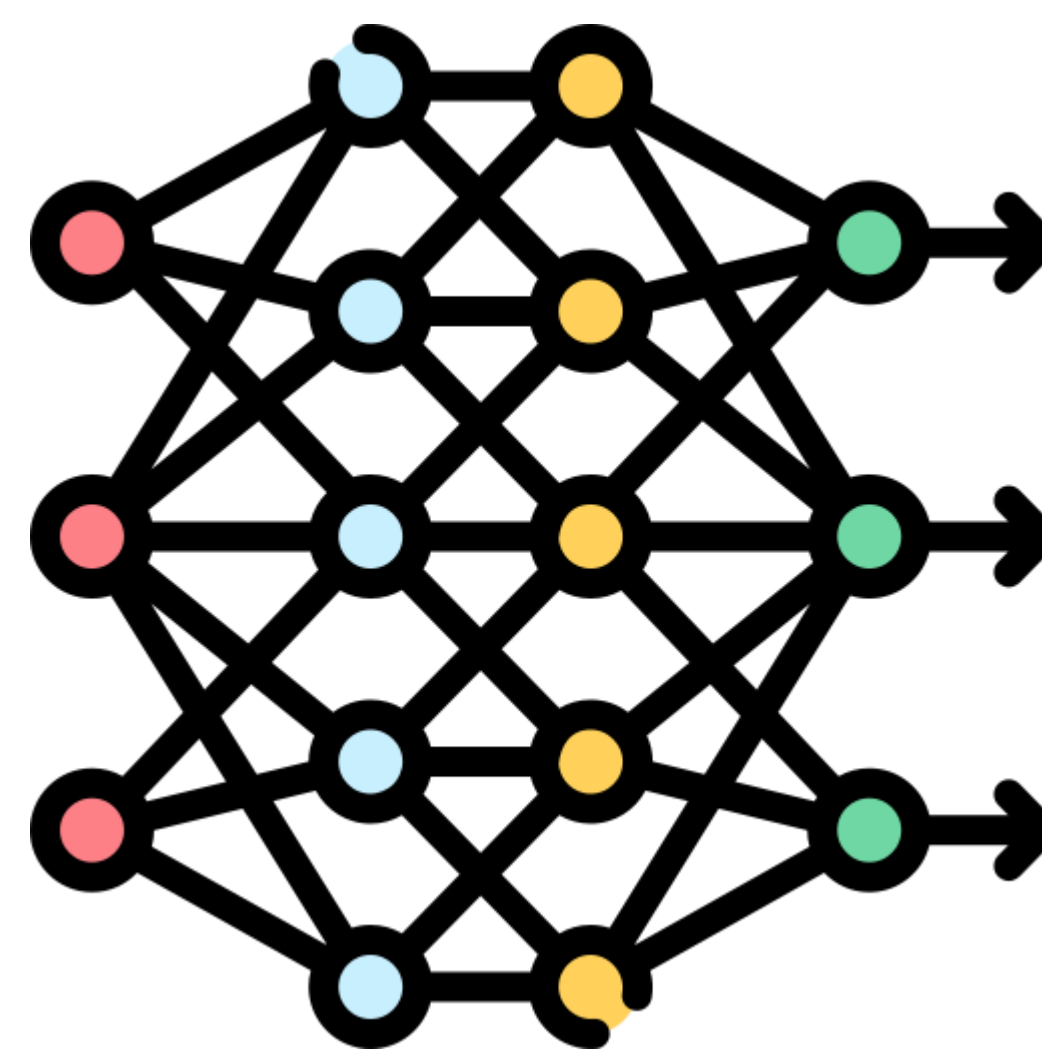
EEG Datasets



Feature Extraction



Unsupervised Machine Learning



Key Findings

- **A Continuous Spectrum:** Unsupervised learning shows **no clear boundaries**. Patients and controls form a **continuous spectrum** rather than isolated disease clusters.
- **Group-Level Shift:** Despite the massive overlap at the individual level, the shift in centroids **confirms a measurable biological difference** between the groups.

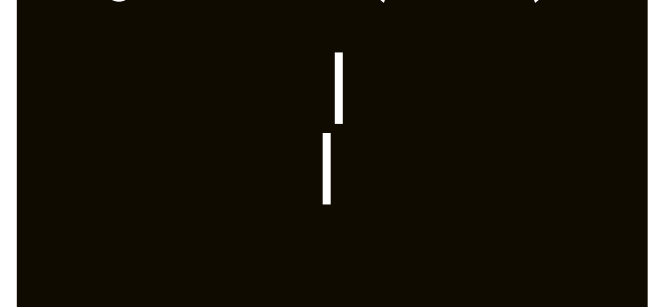
Discussion: Rethinking Diagnosis

- **Challenging the DSM-5:** Our findings support the hypothesis that schizophrenia is rather a dimensional disorder (**a spectrum**) than a strict categorical illness.
- **Clinical Impact:** Relying purely on observable symptoms may force patients into rigid **categories that biology doesn't support**.
- **Precision Psychiatry:** Moving away from "one-size-fits-all" treatments towards **personalized therapies** based on a patient's specific position on the biological spectrum.
- **Redefining Clinical Trials:** Future drug efficacy should be tested **along a continuous EEG spectrum** rather than on rigid, binary categories (Patient vs. Control).

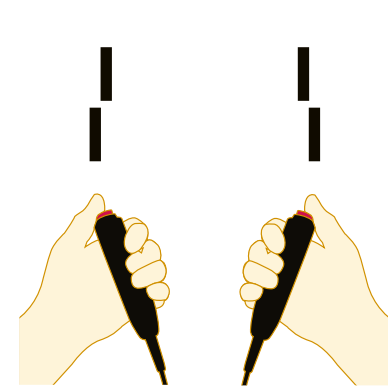
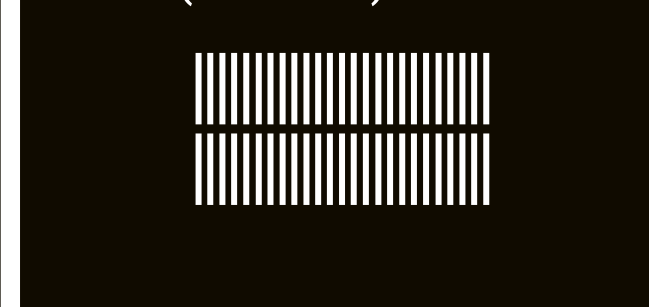
Task

Visual Backward Masking (VBM)

Target vernier (30 ms)



Mask (300 ms)



Next Steps / What Remains

- **Advanced Modeling:** Explore **supervised machine learning** or **deep learning** to identify hidden, non-linear biomarkers.
- **Cross-Validation:** Compare our findings with other biomarker studies to **identify potential correlations** and **shared biological patterns**.

