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Learning without contingencies induces higher order asynchrony in brain networks in schizophrenia

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Abstract

Schizophrenia (SCZ) is characterized by both cognitive and reward impairments. A recent study suggests that SCZ is associated with a loss of synchrony *between* learning and reward circuits (Robison et al., 2019) and higher levels of dis-organization of functional brain networks may underpin failures in learning that characterize SCZ (Hütt et al., 2014). Therefore, here we examined inter-group (HC \neq SCZ) 4th order differences in statistical regularity across a connectome of cognition and reward brain circuits. The analyses were conducted on fMRI time series data from a previous learning paradigm (Stanley et al., 2017) with periods of Encoding and Retrieval. 75 participants (46 SCZ, $18 \leq \text{Age} \leq 50$) consented for fMRI. Time Series were extracted from eight bilateral *a priori* nodes (across learning and reward sub-networks). 2nd order undirectional functional connectivity was characterized across all nodal pairs during Encoding, Retrieval, and their subsequent rest periods. From this, a 4th order cross-correlation matrix was produced within each group and condition. Significant 4th order differences were projected to chords in the 4th order connectomic rings for Encoding and Retrieval (Figure 1). Two effects are evident: 1) SCZ are characterized by a massive loss of 4th order synchrony during both Encoding and Retrieval and 2) Retrieval evokes a greater loss in 4th order statistical synchrony than does Encoding. These results appear to validate the idea the SCZ is characterized by a loss of synergy between cognition and reward circuits, and that this loss of synergy is evident at higher order scales.

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Figure 1

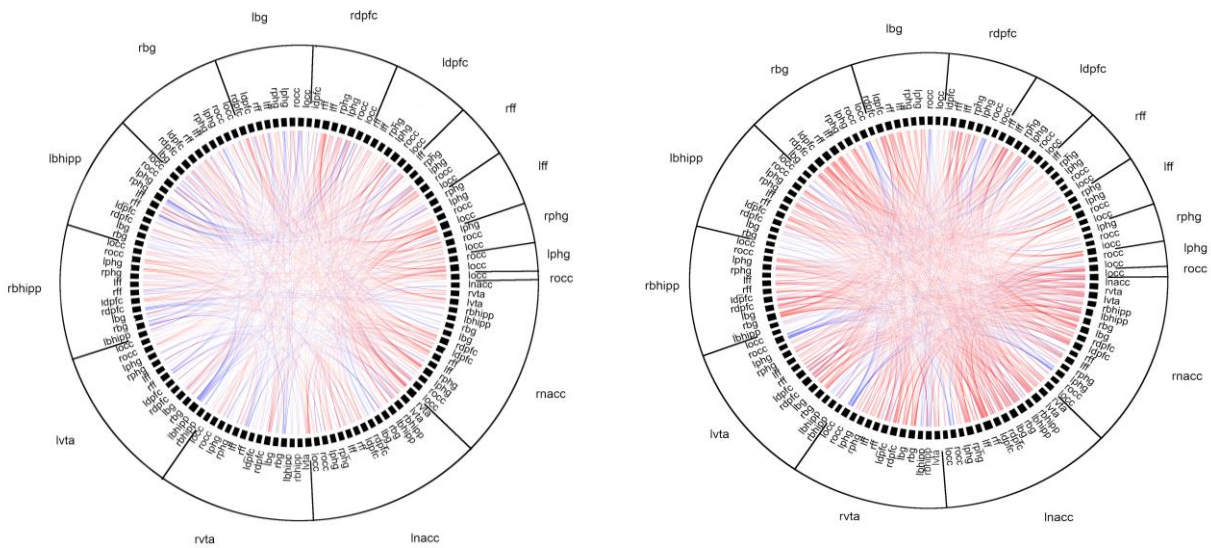


Fig 1 4th Order Analysis using circled chords during Encoding (left) and Retrieval (right). fMRI collected from 8 recorded regions including both right and left sides for a total of 16: Nucleus Accumbens (NACC), Ventral Tegmental Area (VTA), Body Hippocampus (BHipp), Basal Ganglia (BG), Dorsal Prefrontal Cortex (DPFC), Fusiform (FF), Parahippocampal Gyrus (PHG), Occipital Lobe (OCC). Chords represent significant differences in predictability of co-activity between groups of subnetworks. Red indicates true significance in HC and blue indicates true significancs in SCZ.