

Simultaneous EEG-fMRI Reveal Temporal-Spatial Bias

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Introduction

- The use of simultaneous EEG-fMRI in neurobiological research yields information on both the temporal and spatial indices of cognition (Snyder & Raichle, 2010).
- The neural correlates of hate remain relatively unexplored (Zeki & Romaya, 2008).
- We hypothesized that former white supremacists would exhibit distinct neural activation patterns compared to the control group of non-extremists (Mixed Martial Artists; MMA) when viewing symbols and images with racially and politically charged characteristics.
- Combining data from simultaneously acquired EEG-fMRI data has, to date, relied heavily on separate analyses, instead of using a unified framework or multivariate analysis (e.g. PLS)

Methods

- Life history interviews were conducted on a sample of 100 former US white supremacists. Self-report data suggest that substantial unwanted and involuntary beliefs, feelings, and behaviors continue to characterize the individuals (Simi et al 2017).
- This study presented three stimulus conditions: symbols, violent imagery, and images depicting romantic couples (interracial). Stimuli were either “neutral”, or specifically designed to elicit racial prejudices (“Experimental”).
- Imaging data were collected in ten participants (five per group) using Simultaneous EEG+fMRI with in-scanner EGI 256 electrode nets and a Siemens Skyra 3T MRI in an event-related design.
- fMRI data were processed in AFNI (Cox, 1996) using in afni_proc.py using the “best practices” pipelines.
- EEG data were processed using EGI’s Net Station (version 5.4, EGI, Inc.): MR Gradient Artifact Removal, BCG regression using PCA, bandpass filter of 0.1-30Hz, segmented, screened for artifacts, baseline corrected, and adjusted to the average reference before being averaged in like categories. Statistical analyses were performed using the PCA Toolkit (Dien, 2010).
- In addition to these separate analyses on both EEG and fMRI data, we conducted a joint analysis using Partial Least Squares (PLS), implemented in NiLearn and Scikit-Learn (Abraham et al., 2014).

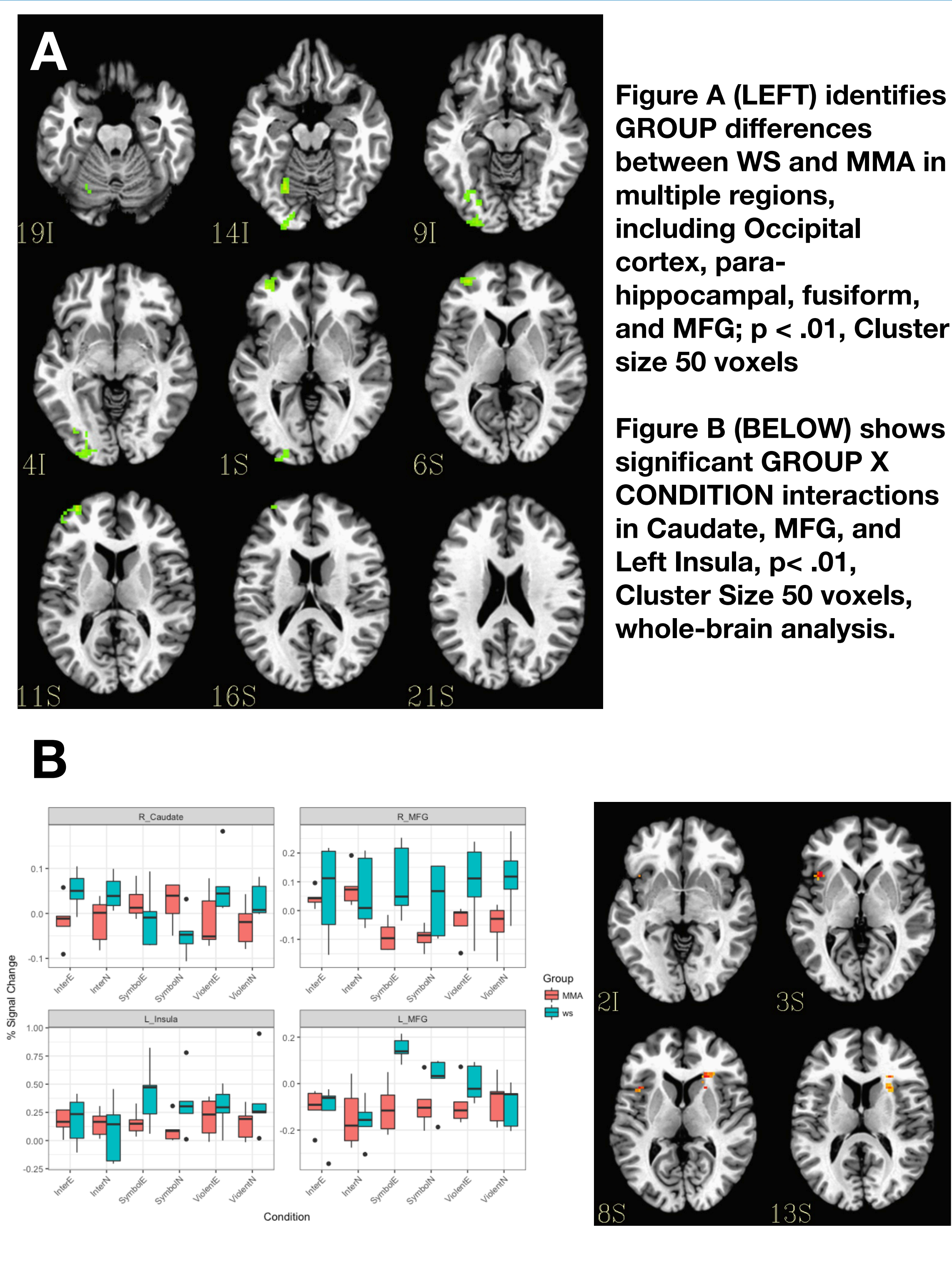
Results

- Activation analyses in fMRI found Group differences (White Supremacists > MMA; Figure A) in occipital cortex, left fusiform, para-hippocampal gyrus, and left Middle Frontal Gyrus (MFG). No regions showed greater activation in the MMA group.
- Significant Group X Condition interactions were found in Caudate, MFG, and Insula regions. These interactions found that white supremacists more strongly activated these regions in the experimental conditions (Figure B).
- The temporal-spatial PCA detected 5 temporal components and 7 spatial components. Group differences were identified at 200 milliseconds over the left posterior electrodes $F(1, 8)=5.26, p<.05$. The different stimulus conditions were differentiated at 500 milliseconds $F(5, 40)=5.22, p<.001$.
- The joint EEG-fMRI PLS analysis identified spatial components that substantially overlap with the group differences identified in fMRI analyses, Figure E, while also identifying the temporal component differences in the ERP analyses, shown in factor loadings between 200-400ms, and 600-650ms (Figure F).

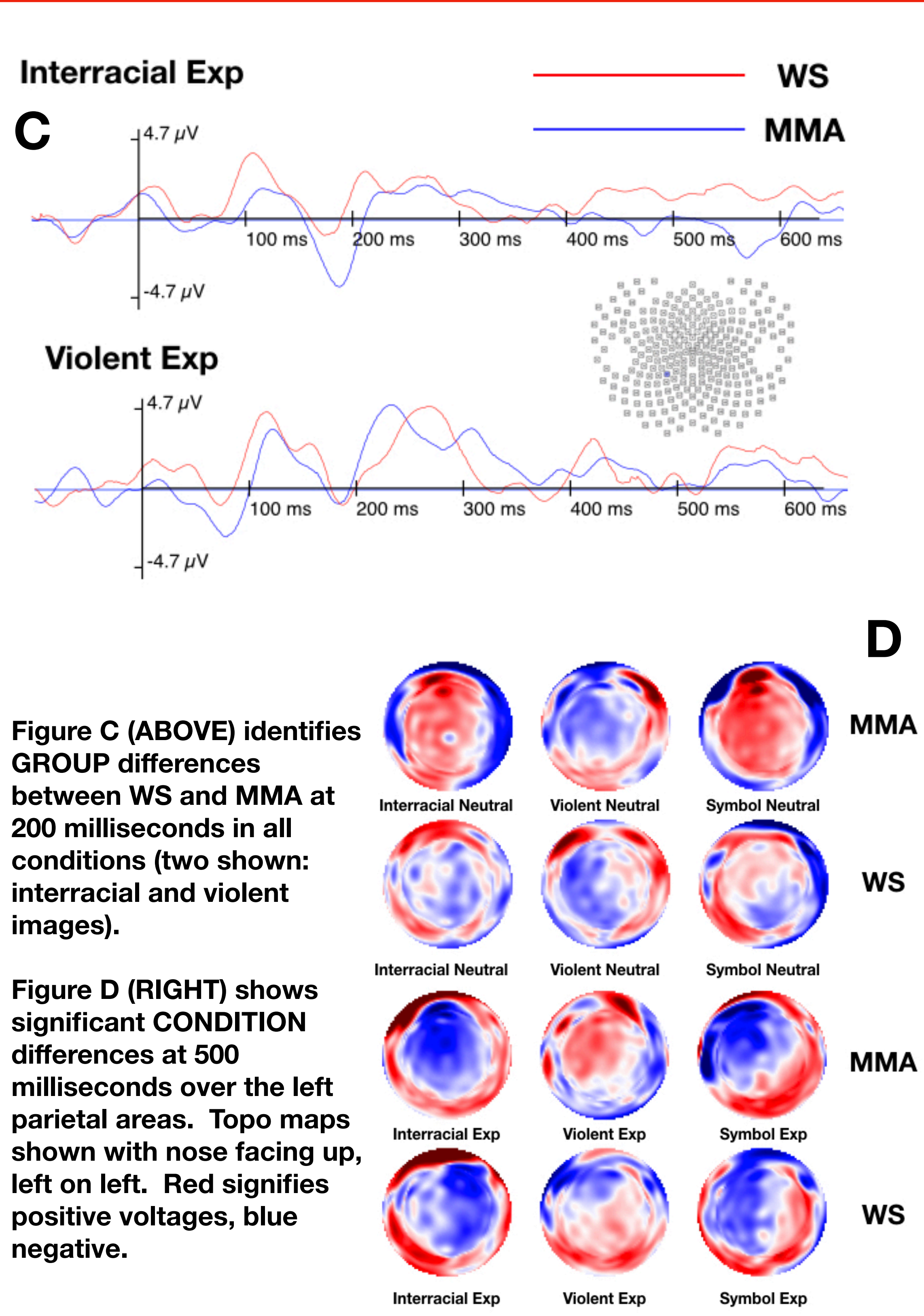
Conclusions

- Group comparisons found higher activation in the white supremacist group. Increased activations were also found as part of a Group X Condition interaction, where regions respond differentially reflecting experimental stimulus content that white supremacists are more sensitive to.
- Simultaneous EEG data show that the two groups’ neural responses diverge as early as 200 milliseconds after stimulus onset, before active cognitive processing (Donchin, et al., 1978), suggesting racial bias in white supremacists (even reformed ones) has a rapid, bottom-up component.
- The PLS implementation in NiLearn/Sci-kit Learn shows promise in identifying temporal and spatial differences in groups with substantial overlap of findings from multiple modalities.
- PLS findings within the EEG/ERP data substantially overlaps temporally with those identified through spatial-temporal PCA.
- PLS findings were also found to substantially overlap with fMRI analyses processed through standard group analysis tools (e.g. AFNI’s 3dttest++, Figure F), while also identifying potentially other brain areas that related to the EEG data and task.

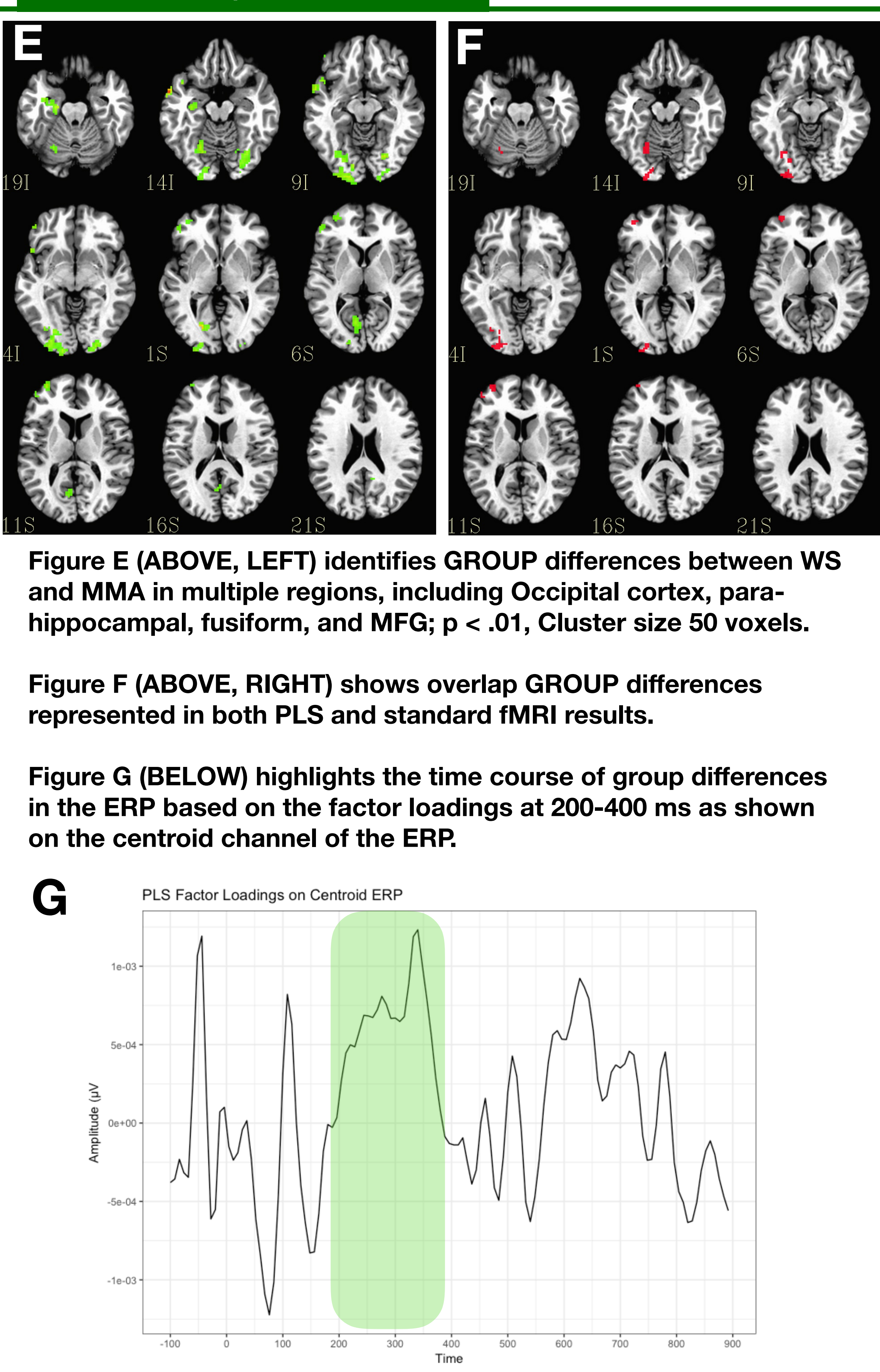
fMRI Results



EEG/ERP Results



PLS: Group Differences



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