Multidimensional Imaging Of Affective Prosodic Perception

D. I. Leitman[1], J.C. Edgar[2], L. Bloy[2], S. Liu[2] and T.P.L. Roberts[2]

[1]Department of Psychiatry, University of Pennsylvania, Philadelphia, PA, 19104
[2]Department of Neuroradiology, Children's Hospital of Philadelphia, Philadelphia PA, 19104
davidileitman.com

Applied Social Neuroscience and Perception Laboratory

Research support: NIH K01MH094689-03 & Brain Behavior Research Foundation

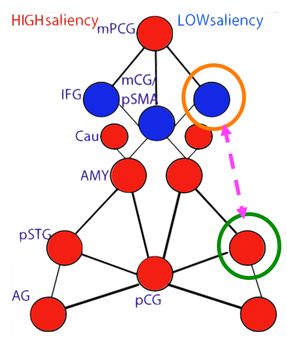
BACKGROUND & RATIONALE

- **Dysprosodia** - impairment in perceiving social intent via vocal intonation, features prominently in a number of neurological/psychiatric disorders (e.g. Depression, Parkinson's Disease, Autism Spectrum Disorder, and Schizophrenia). **The neural mechanisms of prosody are poorly understood**
- **Cue saliency** refers to the relative presence or absence of particular acoustic features that serve as cues for differentiating emotion. For example, high pitch variability ($F0_{SD}$) is a powerful cue for identifying happiness, while low $F0_{SD}$ signals fear. Similarly, high spectral energy (HF_{500}) is strongly correlated with anger perception
- Previously, using fMRI and a parametric mode, we delineated a temporo-frontal reciprocal circuit for prosodic processing
- We observed that cue saliency (ZCUE) increases were correlated with increased BOLD activation in superior temporal /middle gyrus and amygdala, while decreases in ZCUE correlated with increased frontal activity within IFG

APPROACH

1. **Tempro-spectral ROI analysis:** A cue-salience weighted temporo-spectral map at each component
2. **ROI-2-ROI Connectivity:** Reciprocal activation pattern and connectivity within 9-component prosody network

➔ Here we show right Superior Temporal and Inferior Frontal Gyrus (**rSTG rIFG**)



Hypothesis: The more emotionally salient the prosodic signal is the more consistent the brain response➔ high cross trial phase synchrony (PLV see box below). The more ambiguous the stimulus is the more variable the response across trials ➔low PLV

Target- Gamma band oscillations (30-80Hz)

Rationale: 1) Computational models suggest that gamma frequency reflects excitatory-inhibitory balances that allow for local cortical pyramidal columns to act in unison. 2) Prior studies link fMRI-BOLD activation to Gamma synchrony

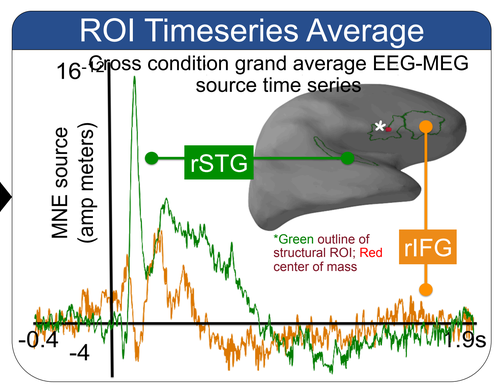
Subjects: 18 healthy controls (13 males 24.86±7.31 years of age; Education: 14.86±1.81 years)

Task: EEG&MEG:15 repetitions of 26 (8, happy and fear 10 anger) stimuli = 390 stimuli, divided into five 5-minute blocks Stimuli: sentence 0.8 to 2 seconds long (i.e "its eleven o'clock")(see figure above)

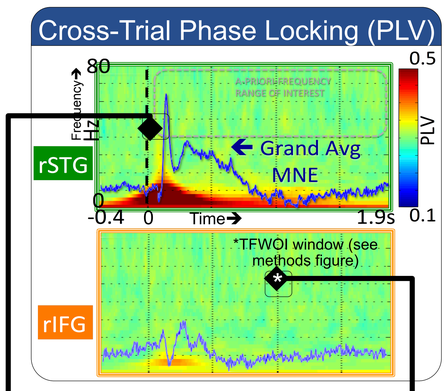
Analysis Pipeline: Data: 2.3 second epochs reflecting individual trials (Max N=390) and decimated to 500HZ. Source modeling: **MNE L2 min-norm** sources weighted by fMRI (see handout or web for further methods)

RESULTS

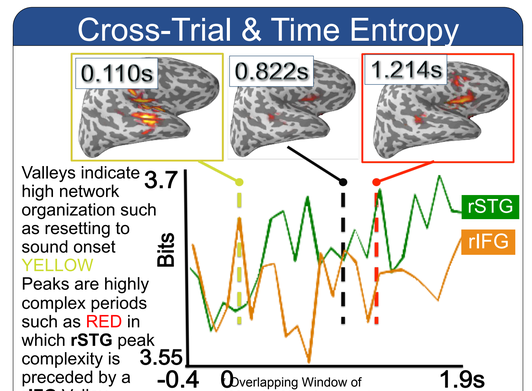
ROI Timeseries Average



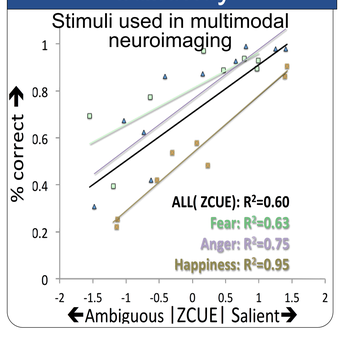
Cross-Trial Phase Locking (PLV)



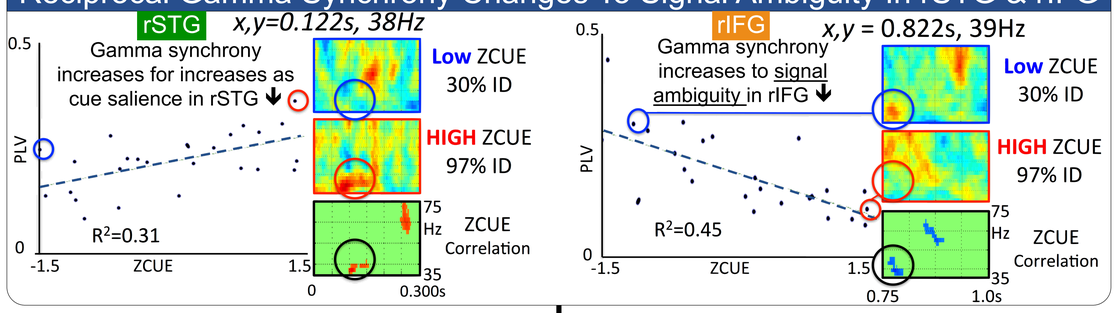
Cross-Trial & Time Entropy



Behavior X Cue Saliency

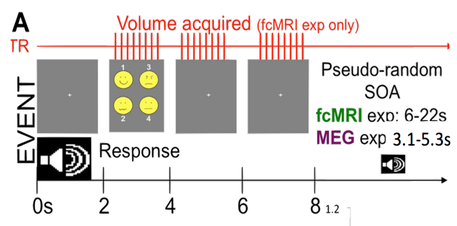


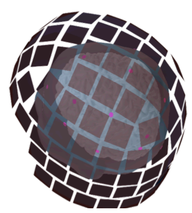
Reciprocal Gamma Synchrony Changes To Signal Ambiguity In rSTG & rIFG



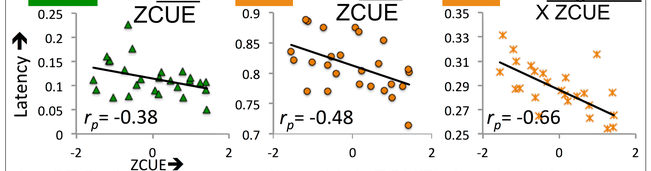
EEG-MEG & fMRI paradigm

306 MEG & 20 EEG sensors



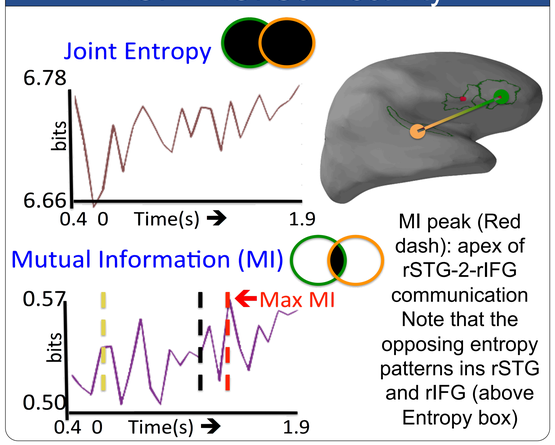


What do ZCUE X PLV changes mean?



- In **rSTG**, the more cue salient (high ZCUE) the signal is the earlier peak gamma PLV occurs
- In rIFG, the more ambiguous the signal ambiguity (low ZCUE) the greater the delay and higher phase alignment (PLV) is

ROI-2-ROI Connectivity



MI peak (Red dash): apex of rSTG-2-rIFG communication Note that the opposing entropy patterns ins rSTG and rIFG (above Entropy box)

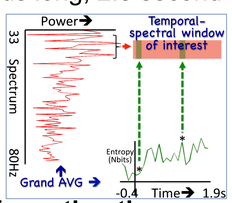
Phase Synchrony across trials(PLV)

- PLV is a coefficient reflecting the degree frequency specific alignment across trials relative to stimulus onset.
- High PLV across trials suggests a high fidelity / reliable response by the neural network. Low PLV would indicate a highly variable response to stimulus.

Reducing Data Complexity

Problem: Stimuli and Data are complex: Sentences 2.3 seconds long; 2.3 second TF maps

Solution: 1) **Brute Force** cluster correct TF maps at a p<0.01 level using Monte Carlo simulation. 2) Use **information theory** (**entropy** and **mutual information(MI)**) along with overall spectral information to generate TF windows of interest



for EEG-MEG Prosody MOVIE go to davidileitman.com/multimodal-neuroimaging-of-prosody/

REMARKS

5-D ROI Activity: Cue-salience weighted temporo-spectral modulations in gamma band in both rIFG and STG consistent with our temporo-frontal reciprocal circuit model

ROI-2-ROI connectivity: 1) Mutual information between rSTG and IFG were maximal at ~1.2s PSO; 2) MI Peak corresponded to decreased IFG entropy and increased STG entropy consistent with IFG exerting a modulating role on STG

To dos: 1) Extend analysis to all network ROIs; **2)** Use diffusion imaging to examine structural-functional relationships