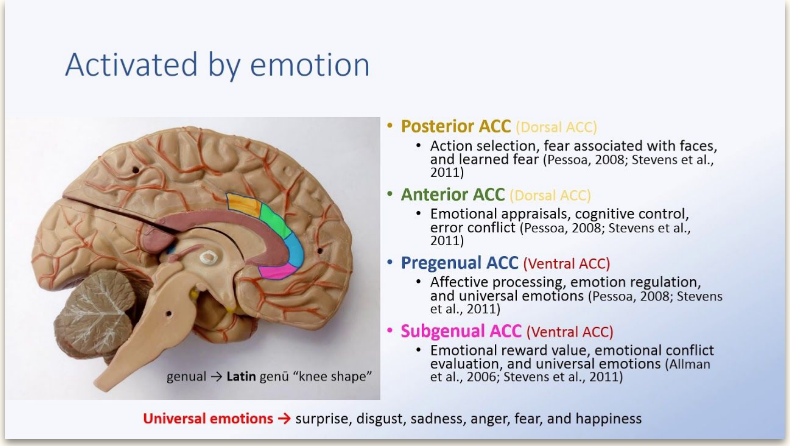
Music and Depression

Jada Brown, Kiera Carey, Amanda Chen, Emily Chen, Mia Iqbal, Ephie Michael-Schwarzinger, Nathan Skinner, Bryce West

Background

- Music therapy has been heavily researched as treatment for depression
  - Music serves as a strong emotional stimuli
- Anterior Cingulate Cortex (ACC) known for involvement in emotional circuitry
- Different types of musical stimuli provoke different responses in ACC
- Depressed individuals show increased activity towards negative cognitive stimuli
- Non-depressed individuals show increased activity towards positive cognitive stimuli



Main Study - *Neural Processing of Emotional Musical and Nonmusical Stimuli in Depression*

- **Participants:** 19 MDD patients and 20 never-depressed (ND) participants (control group)
  - MDD participants were all unmedicated, experiencing a current depressive episode determined using SCID-I/NP
  - All had at least a high school ed. + were at average or above average IQ
  - No significant difference in age, sex, years of ed., musical training

Main Study - Stimuli

- **Musical stimuli:** 10 second clips of 36 positive (18) and negative (18) samples
  - Music clips started at musical phrases, mimicking sentences
  - Phrases were long enough to provoke emotional response and fit to limitations of fMRI imaging
  - Differed in arousal, either high or low
- **Non-Musical Stimuli:** 10 second clips of 24 different IADS
  - Provoked either a positive or negative response
  - Stimuli included sounds like a hiccup, sob, alarm clock, dog, doorbell, etc.
  - Also differed in arousal
- **Neutral Stimuli:** <u>Pure tones</u> used as a baseline control, neither musical nor nonmusical

Main Study - procedure

- **Procedures:** fMRI analyses and emotion rating
  - fMRI → stimuli presented in blocks of three clips, with 12 stimuli total for each run (6 samples from positive and 6 samples from negative). 5 runs total: 3 for alternating pure tones and musical stimuli, 2 for alternating pure tones and nonmusical stimuli.
    - Statistical contrasts, regressors, and ROI masks were conducted
  - Emotion ratings → Multiple questionnaires used **before** experiment : BAI, BDI-II, AIM. **After** each run, participants asked to rate blocks of clips as either negative or positive.

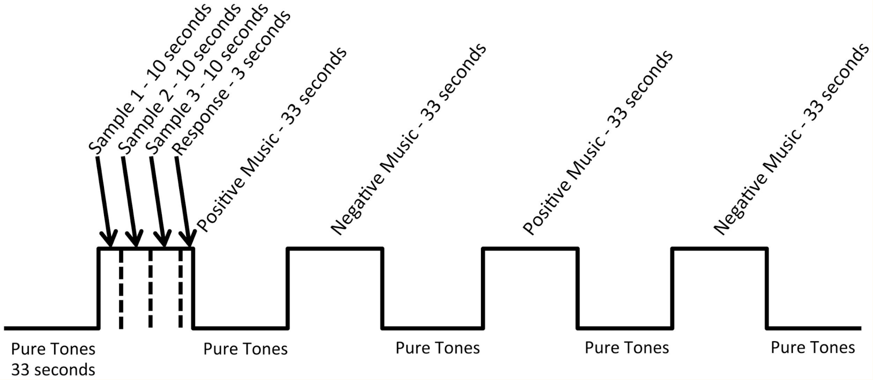
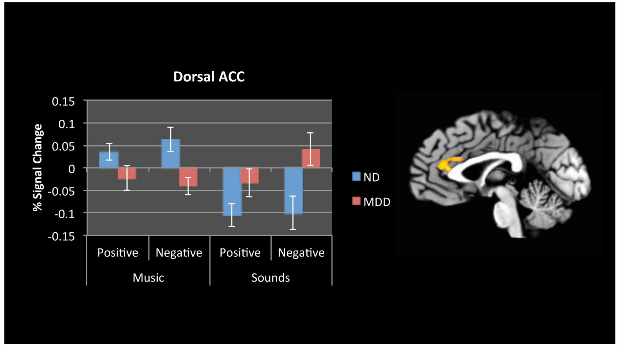
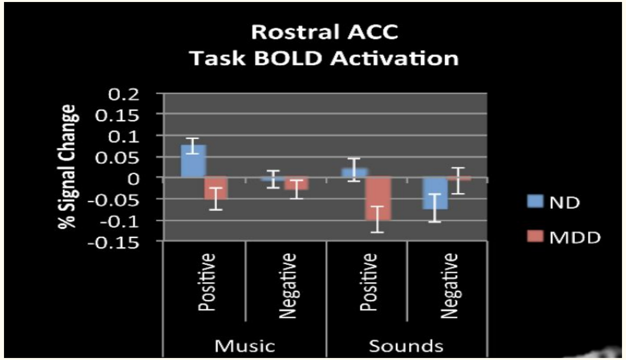


Fig.: Example of a functional run.

Main Study - results

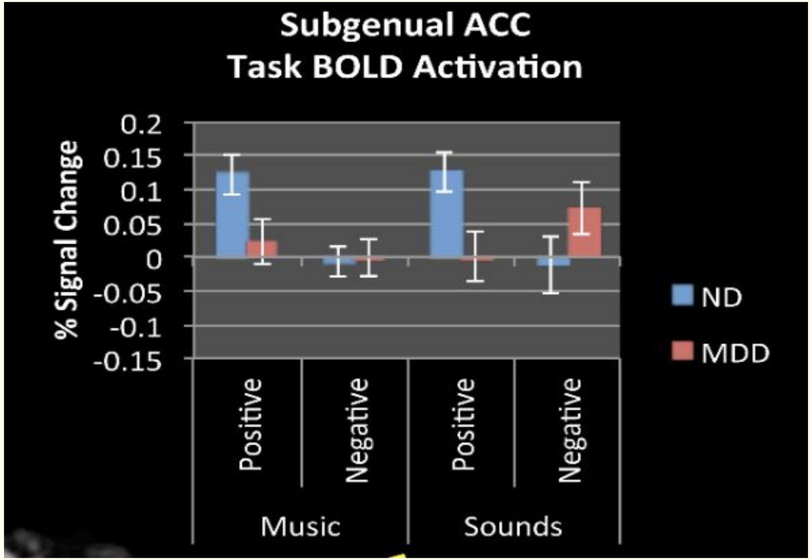
- **Significant Results of ACC**
    - Dorsal
        - <u>ND</u> showed increase response to musical stimuli and decreased response to non-musical stimuli.
        - <u>MDD</u> showed increased response to negative non-musical response, and decreased activity during all musical stimuli.
    - Ventral → Rostral
        - <u>ND</u> showed increased response to positive stimuli, and a decreased response to negative non-musical stimuli.
        - <u>MDD</u> showed decreased response to all musical stimuli as well as positive non-musical stimuli.





Main Study - results

- **Significant Results of ACC**
  - Ventral → Subgenual
    - <u>ND</u> showed increased response to all positive stimuli.
    - <u>MDD</u> showed a small increase in response to positive musical stimuli and a small increased response to negative non-musical stimuli.
    - No significant response change to negative musical stimuli



Research Questions:

1. **Can we create a model to discriminate between MDD and ND participants using the contrast between positive and negative stimuli?**

2. **Can we see the differences between MDD and ND participants when processing the same audio clip?**

MVPA

Multivoxel Pattern Analysis

Proposal

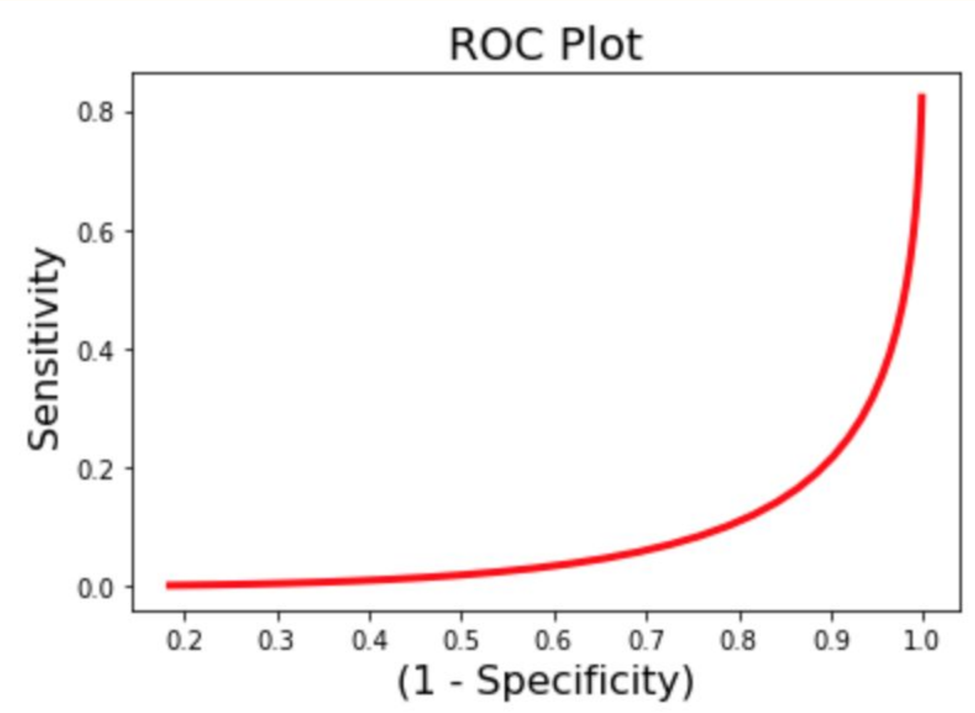
This classification model should be able to discriminate between MDD and control subjects after training it with the contrasts in brain regions in response to positive vs. negative stimuli.

Methods

- Obtained music clips used in original study
- Ran First-Level GLM
  - Separate regressor for every audio clip for every subject
    - Regressors convolved with HRF Function
- Contrasts
  - Positive vs. negative music stimuli conditions
- Trained Model
  - Created vectors of 1's (depressed) and 0's (controlled)
- 5 Fold Cross Validation
  - Determine how well our model will generalize to new data

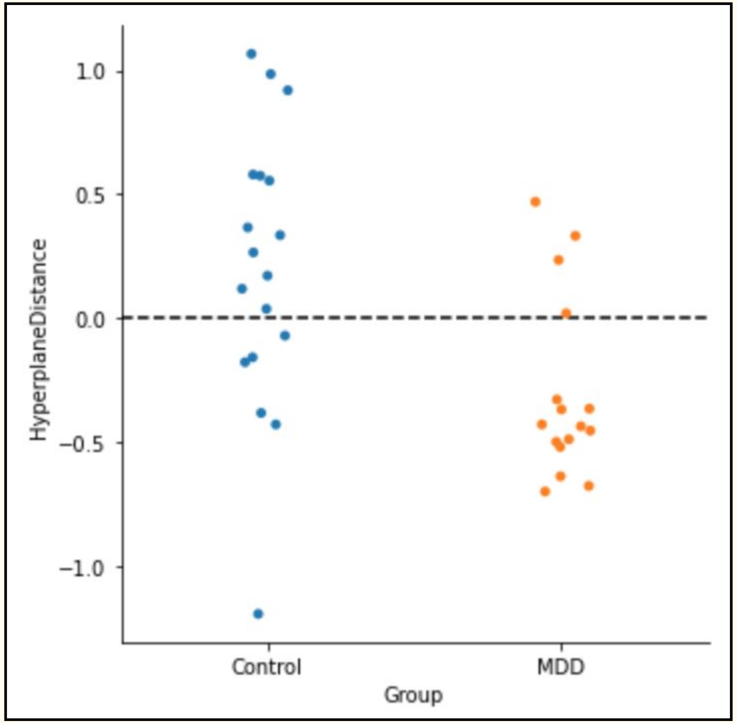
Results: Evaluating the Model

Figure 1: ROC Plot of the trained model



The CV accuracy was **71%**, meaning that the model we created had a 71% accuracy of predicting if the subjects were depressed or not depressed.

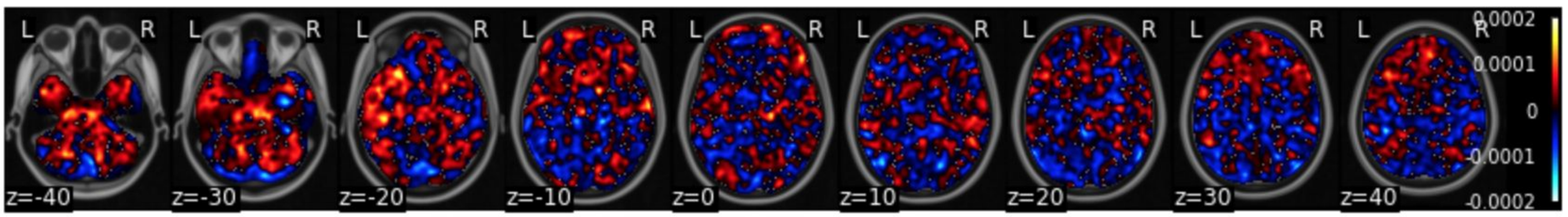
Figure 3: Plot of the hyperplane distance by group



The figure plots the hyperplane distance for each control and MDD subject. A positive hyperplane distance means that the model classifies the subject as control, and a negative hyperplane distance means that the model classifies the subject as MDD.

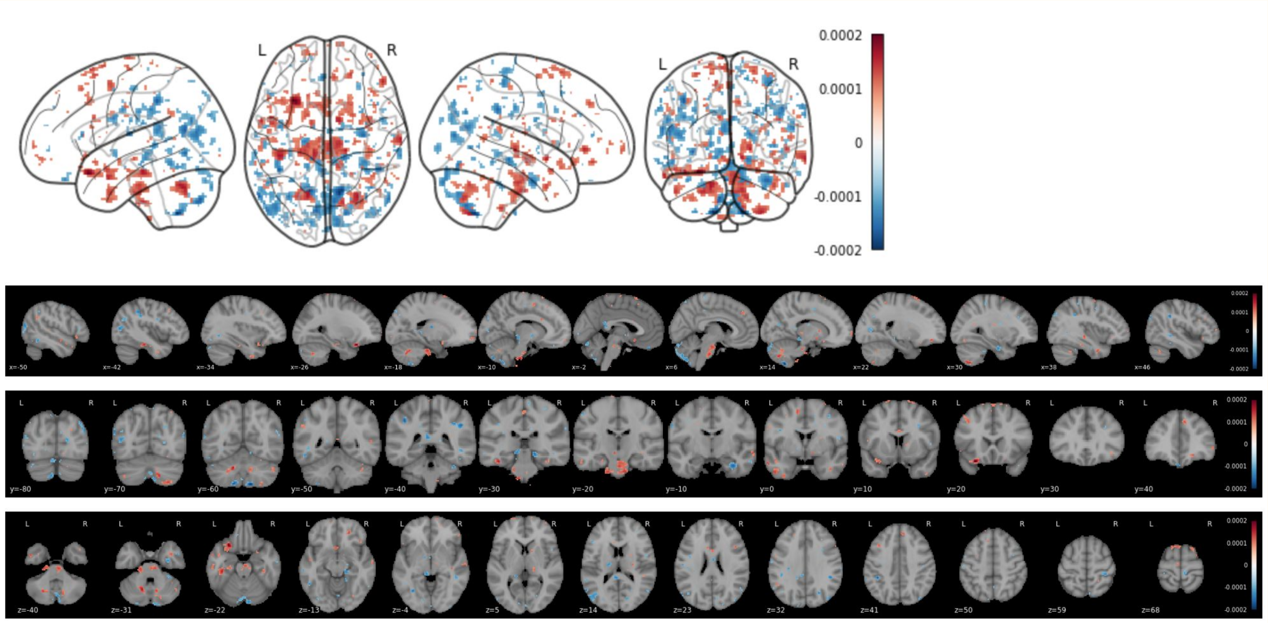
Results: Evaluating the Brain Regions

Figure 2: Non thresholded weight map of all brain regions implicated in discriminating between MDD and control subjects.

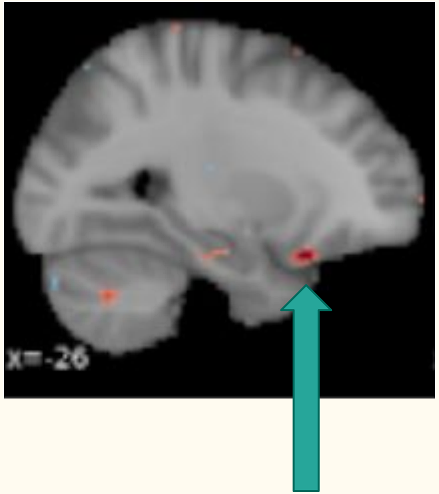


Red regions are indicative of a greater difference in brain activity in these regions that can be correlated with greater likelihood of *being classified as depressed*

Figure 4: Thresholded weight map for the top 1% of voxels contributing to classification.



One of the regions highlighted is the **subgenual anterior cingulate cortex (sgACC)**



Discussion

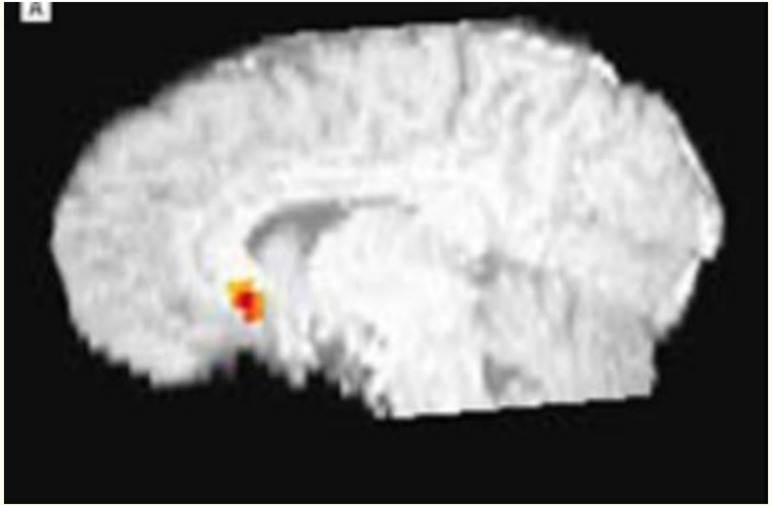
- Subgenual Cingulate
    - Implicated in depression
- Siegle et al.: activity in sgACC predicts **cognitive therapy effectiveness**
- Model applicable to other datasets?

Sep 2012

Toward Clinically Useful Neuroimaging in Depression Treatment

Prognostic Utility of Subgenual Cingulate Activity for Determining Depression Outcome in Cognitive Therapy Across Studies, Scanners, and Patient Characteristics

Greg J. Siegle, PhD; Wesley K. Thompson, PhD; Amanda Collier, BS; et al



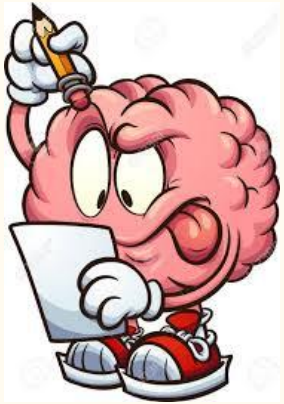
RSA

Representational Similarity Analysis

RSA

Can we see differences between MDD and ND participants when processing the same audio clip?

RSA can help!



RSA(First Level Model/ Same as MVPA)

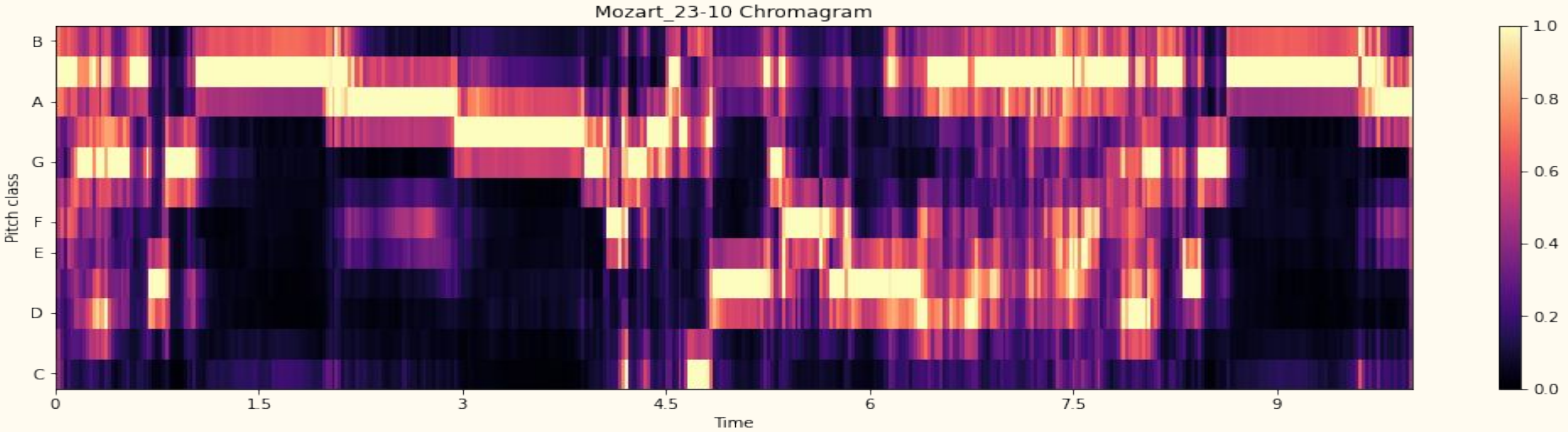
- Obtained music clips used in original study
- Fixed the data
    - Coded so that the correct time matched the stimulus
    - Coded a “tone counter” to distinguish runs
    - Took out the runs that did not have audio data
- Ran First-Level Model
- Obtained Beta Values

RSA(Applying Librosa Features)

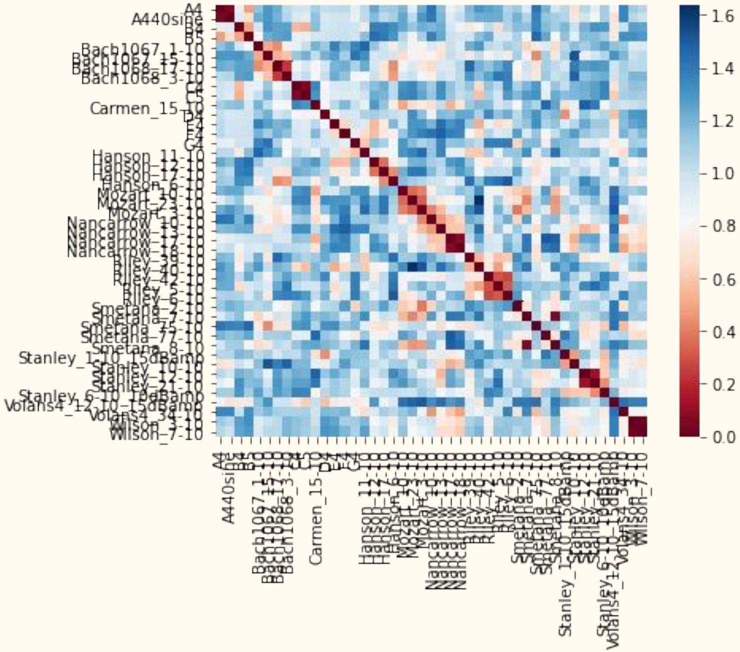
- Spectral Roll-off
- Zero-Crossing Rate (ZCR)
- Mel-Frequency Cepstral Coefficients (MFCC)
- Spectral Bandwidth
- Spectral Centroid
- Chromagrams

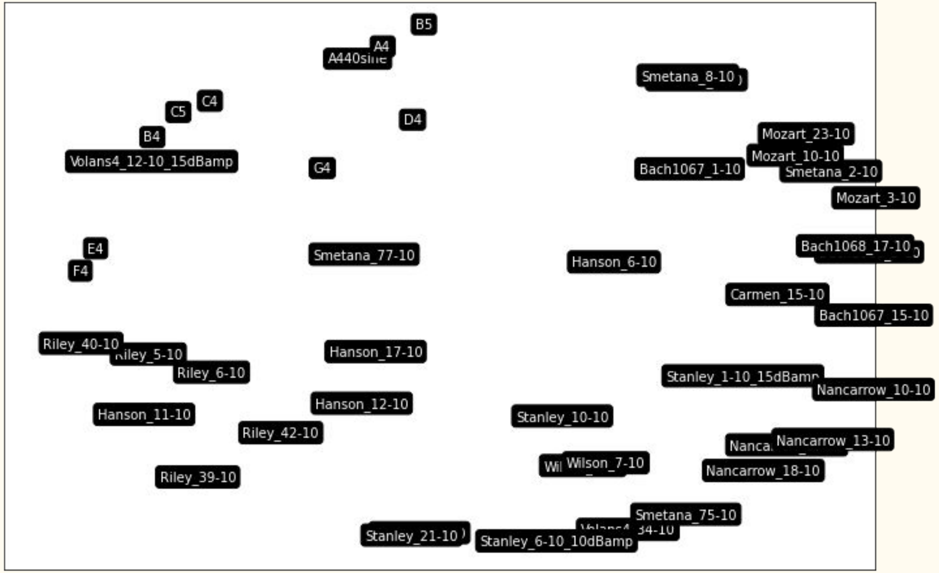
RSA(Librosa Features Cont./Examples of features)

Chromagram



RSA(Librosa Features Cont./ DM and MDS)



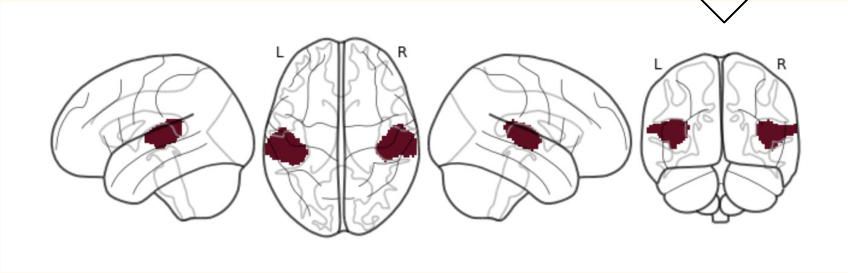


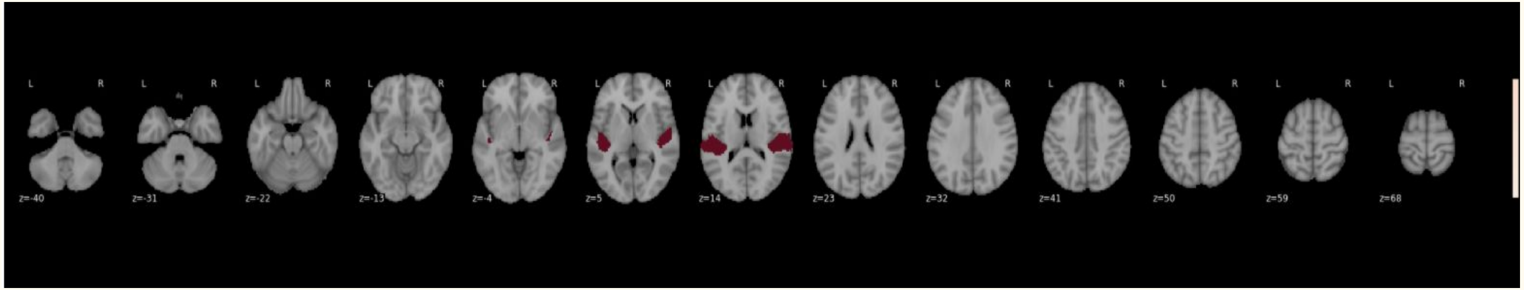
Results

RSA(T-Tests and Results)

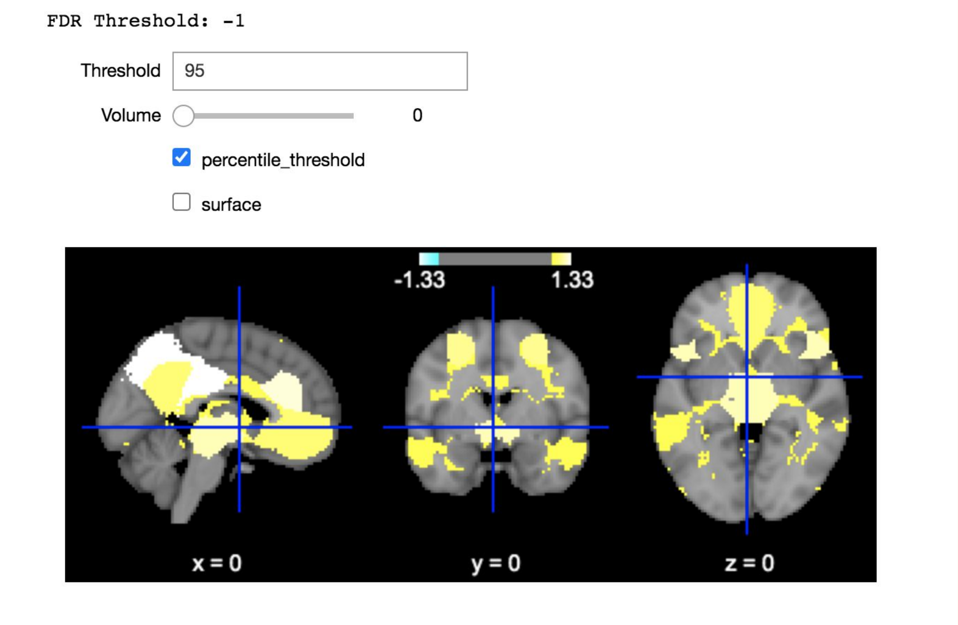
Wanted to see which areas of the brain were consistently active across all subjects:

Primary Auditory Cortex Active





RSA(T-Tests and Results Cont.)



Wanted to see which areas of the brain were active for MMD patients in comparison to ND patients

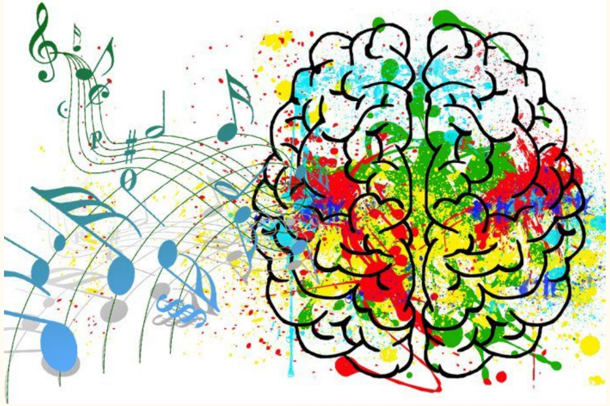
Discussion

RSA: Regions of insignificant activation were potentially caused by emotional auditory stimulus.

Potential future research:

- How different tones of music effect MDD subjects.
- Target other emotions such as tension or excitement, etc.
- If a distinction is found between MDD and ND patients
  - tones of music could be used as a form of treatment or mood regulation.

Conclusion



MVPA: Able to predict which patients were MDD and ND, with the subgenual ACC being a region of high variation.

RSA: There was no significant difference in MDD and ND patients listening to the same audio.

Future: We believe these analysis could affect the way see the signs of the MDD and even diagnosis in the future.