PSB6351 – Cognitive Neuroimaging Methods II

# *Materials & Methods*

**Participants**

A single 42-year-old right-handed male participant with corrected to normal vision was selected for extended neurocognitive testing. The local IRB approved study procedures and the participant completed informed consent and assent. The participant was screened for major medical and major psychiatric comorbidities (e.g., current depressive episode, bipolar disorder, post-traumatic stress disorder, attention-deficit/hyperactivity disorder, conduct disorder, oppositional defiant disorder, psychotic disorders, obsessive compulsive disorder).

**Localizer Task Procedures**

An independent localizer task was used to identify our regions of interests (ROI). The task was composed of a block designed task where participants observed 7 blocks of faces, followed by math equations (neutral stimulus), then scenes, followed by another math equations. Each block lasted about a total of 26 s. For the scene blocks participants were instructed to indicate whether the scene contained water or not with one of the buttons on a response box. For the face blocks participants were instructed to indicate whether the face was male or female with one of the buttons on a response box. Each scene was presented in the middle of the screen for 0.5 seconds followed by an inter-stimulus-interval (0.75) during which a white fixation cross in the middle of a black screen was presented before the next trial. Participants saw a total of 840 stimuli (240 faces, 240 scenes, 240 math equations) divided across two equal runs lasting approximately 3.5 minutes each.

**Functional Task Procedures**

A functional visual conditioning associative task was completed to assess the brain activity of memory for visual stimuli. The task was comprised of a matched paired design where 5 distinct shapes were paired with two objects next to the shape. Shapes 1 – 4 were considered the fixed trials and Shape 5 was considered the conditional trail consisting of a shape paired with a face and a scene For the fixed trials participants were tasked with correctly matching the corresponding object to the shape that they were presented by pressing one of the buttons on a response box. For the conditional trials participants were tasked with correctly selecting either a face or a scene based on what type of fixed trial preceded the conditional trial. If shapes 1 & 3 preceded the conditional trail participants would select the face stimuli, and if shapes 2 & 4 preceded the conditional trial participants would select the scene stimuli. For each trial a white fixation cross on a black background would appear in the center of the image then the shape will appear in the center of the screen for 1 second and replaced with a white fixation cross until the message “Go!” appears in the center of the screen where the participants would then make their response with a button on the response box. On correct responses a green “Yes!” would appear whereas on incorrect responses a red “No!” would appear. If participants did not respond within the 1 second allotted time a white question mark would appear on a black background. Baseline trials were implemented to ensure the participant is responding and to assess a baseline response time. The baseline trials consisted of a grey noise static background with two light boxes beside a white fixation cross, and participants were tasked to identify which of the two boxes was brighter. For the baseline trials the static background would appear on screen between 1-4 seconds then the word “Go!” would appear on screen in the center which is when the participants would make their response. Each trail was presented for a duration of 0.5 seconds with a variable inter-stimulus-interval (2 – 6 s) during which a white fixation cross in the middle of a black background was presented before the next trial. Participants completed a total of 720 trails (120 baseline, 400 fixed trials, and 200 conditional trials) from two separate image sets across four runs lasting approximately 10.5 minutes each.

**Neuroimaging Data Collection & Preprocessing**

Neuroimaging data was collected using a 3T Siemens MAGNETOM Prisma scanner with a 32-channel head coil at the Center for Imaging Sciences located at Florida International University. A structural T1-weighted magnetization-prepared rapid gradient echo sequence (MPRAGE: TR = 2500 ms, TE = 2.9 ms, flip angle = 80°, FOV = 256\*256 mm, 176 sagittal slices, voxel resolution = 1mm isotropic) images, a T2\*-weighted EPI sequence (TR = 1760 ms, TE = 35 ms, flip angle = 52°, FOV = 1800\*1800 mm, 66 axial slices, slice acceleration = 3, voxel resolution = 2 mm isotropic), and diffusion weighted images (monopolar multishell diffusion scheme with b-values of 500, 1000, 2000, and 3000 s/mm2, diffusion sampling directions were 6, 15, 15, and 60, respectively, TR = 4200 ms, TE = 89 ms, flip angle = 90°, FOV = 2160 \* 2160 mm, 81 sagittal slices, voxel resolution = 1 mm isotropic) were collected. During each run of a functional task acquisition began after the first 4 volumes were collected to allow for T1-equilibriazation. A total of 1420 whole brain volumes were acquired during the study portion, and a total of 103 diffusion weighted imaging volumes were acquired.

The following software packages were utilized for neuroimaging data preprocessing using a custom Neuroimaging in Python pipeline (Nipype version 0.12.1; Gorgolewski et al., 2011): Analysis of Functional Neuroimages (AFNI version 20.1.00 Cox, 1996), FMRIB Software Library (FSL version 6.0.1; Smith et al., 2004), FreeSurfer (version 6.0.0; Fischl, 2012). Functional scans were motion corrected using FSL’s MCFLIRT, aligning all the volumes to the volume with the least number of outliers across the first run, then slice timing corrected using a Fourier interpolation method. Functional volumes were co-registered from EPI space into FreeSurfer space. Motion & intensity outliers were then identified (global threshold = 10, z-intensity = 2.0, norm threshold = 0.5 mm), and then both spatially (2.5mm fwhm isotropic kernel) and temporally smoothed (adaptive mean of 5 & 3-point linear filters) in order to improve the signal-to-noise ratio as much as possible.

All DWI data was preprocessed using version 6.0.1 of FSL’s FDT software tool. The susceptibility-induced off-resonance field was estimated for the first b0 volumes from both phase encoding directions using a method similar to that described in as implemented in FSL and the two images were combined into a single corrected image. A brain mask was constructed by computing the average image from the susceptibility-induced off-resonance field corrected b0 image using the fslmaths function and then skull-stripped the image using the brain extraction tool (BET) from FSL. The results from the TOPUP correction were then used to facilitate in eddy current-induced distortion and subject motion correction through the use of a quadratic field estimation in the eddy tool for FSL. Eddy corrected data was then run through an automated QC program eddyqc to identify areas of high motion correction and incorporate it into our model as a nuisance regressor. Diffusion tensor models were then fitted into each voxel using the DTIFIT tool from FSL to obtain the scalar DTI metrics such as fractional anisotropy (FA) and mean diffusivity (MD) along with fiber orientation information.

# *MRI Data Analysis*

**Regions of Interest**

Our study was interested in analyzing regions of the brain that encode for both facial stimuli as well as scenic stimuli. The fusiform gyrus (FG) comprises a large region located in the inferior temporal cortex and has been shown to be activated with the recognition of both faces and object. Thus, our regions of interests were defined by binarizing FreeSurfer cortical regions to create an anatomical mask. Then the anatomical masks were registered to functional space and a group linear model analysis on spatially smoothed neuroimaging data from an independent localizer task that had participants observe faces, places, and neutral stimuli (math equations) was conducted. Any voxels within the anatomically defined masks above a threshold of *p* < 0.005 were selected as our ROI’s.

**Task Neuroimaging Data Analysis**

Functional neuroimaging data was analyzed using a general linear model approach in FSL to evaluate the neurobiological correlates of facial and scenic perception. The study included the following regressors of no interest: motion (x, y, z translations; pitch, roll, yaw rotation), the first and second derivatives of the motion parameters, normalized motion, first through third order Lagrange polynomials to account for low frequency changes in the signal, as well as a regressor for each outlier time-point that exceeded outlier thresholds. The functional task model included 5 regressors of interest: Correct Condition (CC), Incorrect Condition (IC), Remain Events (RE), Face before Baseline (F\_BL), and Scene before Baseline (S\_BL).