VISUALIZING THE MEDIAL FOREBRAIN BUNDLE USING HIGH ANGULAR RESOLUTION DIFFUSION IMAGING (HARDI) MRI

Yashar Rahimpour[1,2], Ron Killiany, Ph.D.[1,2,3]

1 Department of Anatomy & Neurobiology, Boston University School of Medicine, 72 East Concord Street, Boston, MA, USA
2 Center for Biomedical Imaging, Boston University School of Medicine, 650 Albany Street, Boston, MA, USA
3 Boston University Alzheimer's Disease Center, Boston, MA, USA

Objective

Introduction

Pseudobulbar affective syndrome (PBA) is a neurological condition characterized by episodes of involuntary laughing and/or crying that are disproportionate or inappropriate to the social context. There are approximately two million individuals in the United States who suffer from PBA. It is often a misunderstood disorder that is commonly misdiagnosed as a form of a mood disorder such as bipolar disorder or manic episode. Seemingly diverse neurological disorders such as Alzheimer's disease, amyolateral sclerosis, stroke, Parkinson's disease and Traumatic Brain Injury have all shown some linkage to PBA. Because the main features of PBA are emotional in nature, our understanding of it cannot be advanced through the use of animal models. Case studies have suggested that damage to brain structures such as the corticobulbar tract, brainstem, lateral hypothalamus, cerebellum and medial forebrain bundle (MFB) produce an increased risk for PBA. As an initial step in gaining a better understanding of the etiology underlying PBA we set out to see if the MFB can be visualized with magnetic resonance imaging (MRI).

Participant Information

Participants were part of the Health Outreach Program for the Elderly (HOPE) study run through the Boston University Alzheimer's Disease Center (BU-ADC). were scanned at the Center for Biomedical Imaging (CBI) at the BU School of Medicine on a 3T Philips Achieva System with a 32-channel head coil. We used the images from five subjects to attempt to reconstruct the MFB.

* $p < 0.05$

Methods

T1-Weighted: A T1-weighted structural image were acquired on all subjects (TR=6.7 ms, TE=3.1 ms, flip angle=1°, voxel size=1.05X1.05X1.2 mm). The T1-weighted structural images contain the anatomical information necessary to co-register each subjects' MRI data to his/her own common anatomical space.

HARDI: Tractography was conduced on the 64 direction HARDI scan with a diffusion weighting of b=3000. All MRI data was converted to FSL-NIfTI prior to analysis.

- A high resolution T1-Weighted image and HARDI scan were acquired on each subject.
- T1-Weighted was used to co-register individual data.
- Tract density, volume, mean diffusivity (DA), and quantitative anisotropy (QA) were generated.
- The regions of interest identified were the ventral tegmental area (VTA), nucleus accumbens, and lateral hypothalamic area.

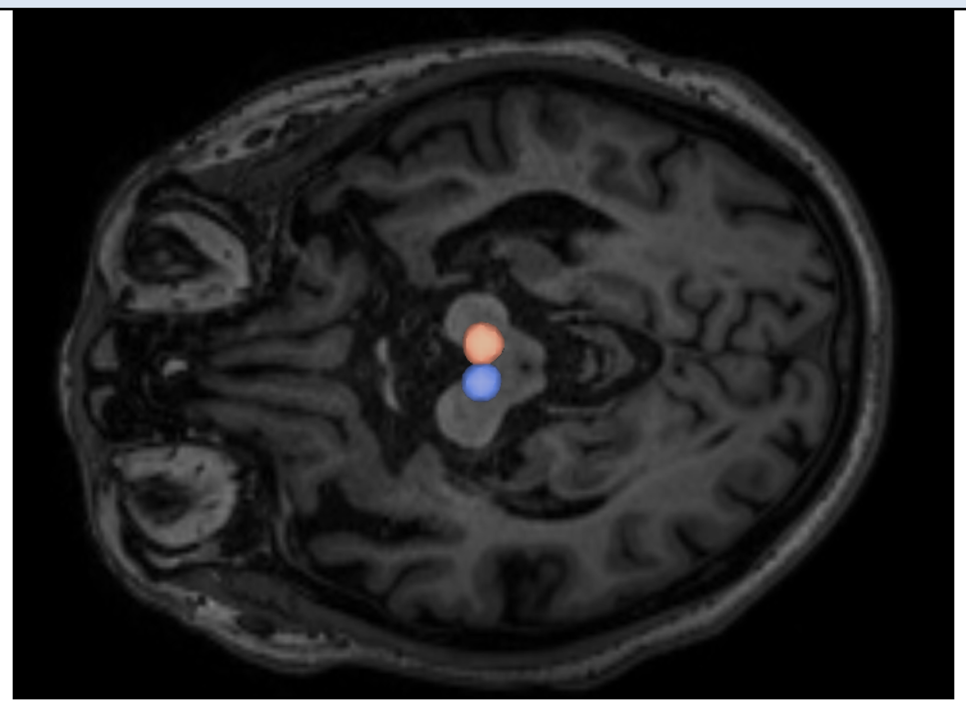


Figure 1.The left and right ventral tegmental areas shown in blue and orange. These regions of interest were defined based on anatomical descriptions by creating spheres around MNI coordinates. VTA Spheres were defined as 4mm.

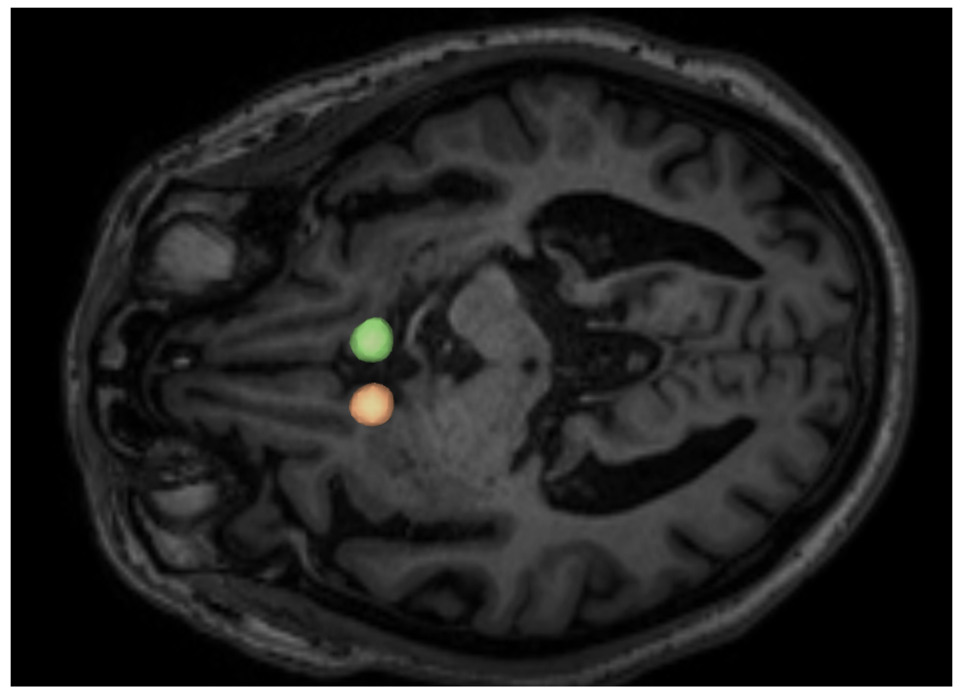


Figure 2.The left and right Nucleus accumbens shown in blue and orange. These regions of interest were defined based on anatomical descriptions by creating spheres around MNI coordinates. Nacc Spheres were defined as 5mm.

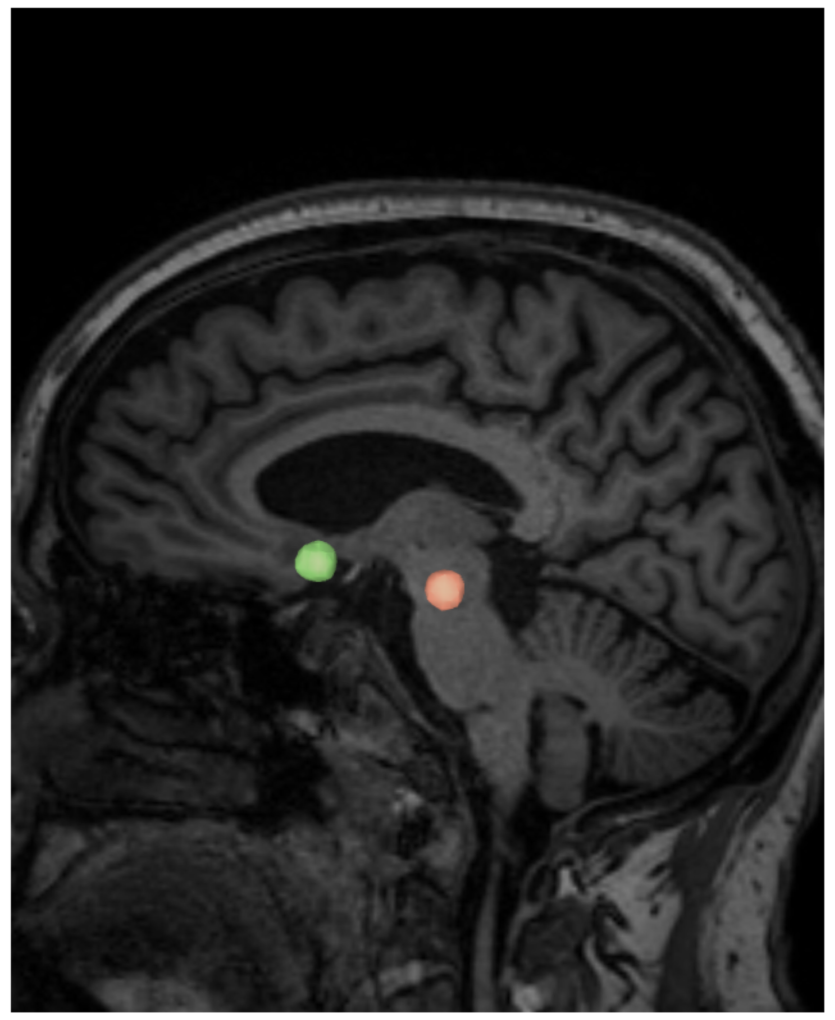
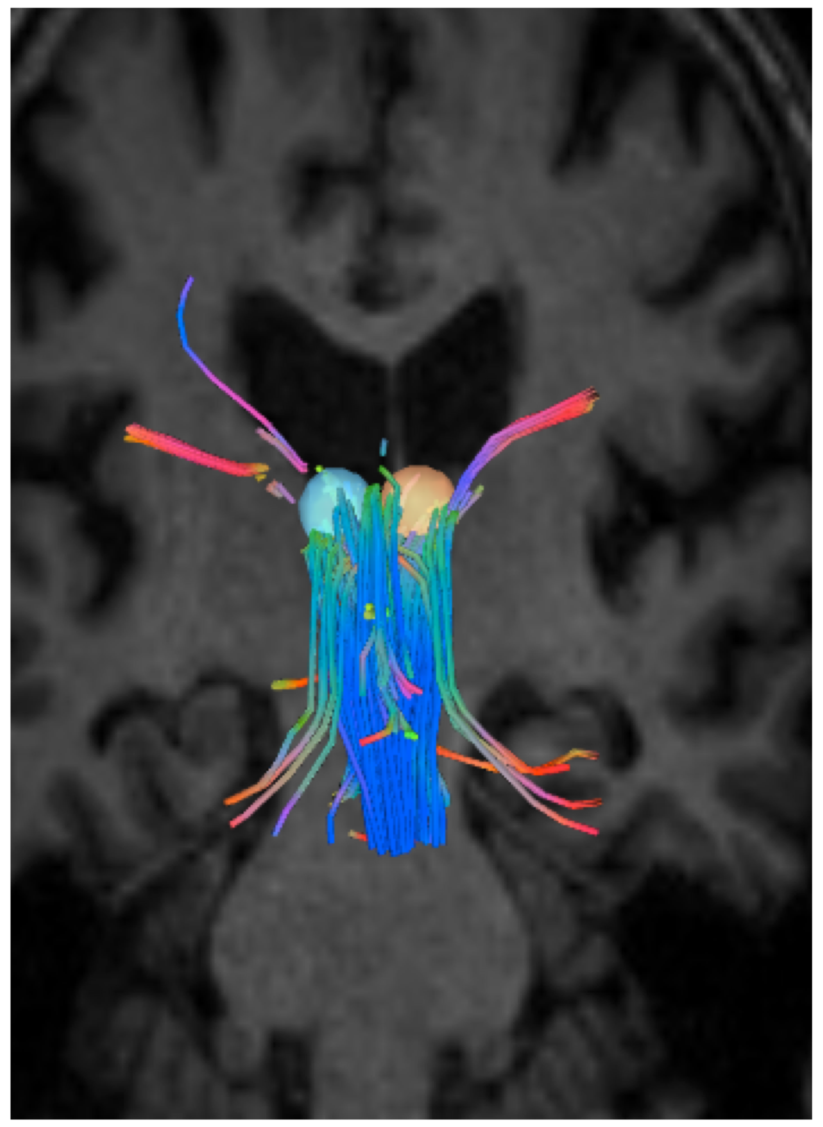
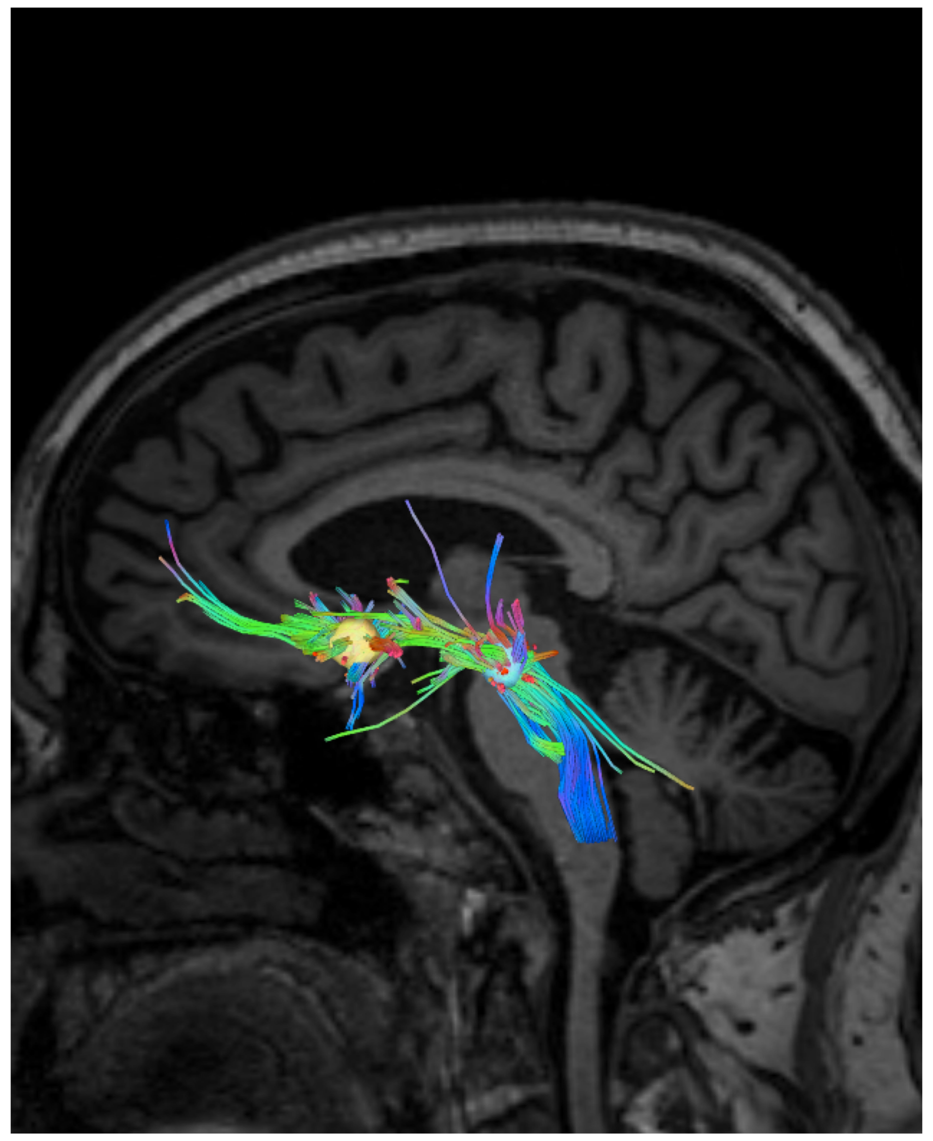


Figure 3.Sagittal view of the brain showing the locations of both the VTA in orange and the Nacc in green.

Results





These figures demonstrates the bifurcation of the medial forebrain bundle caudal to the VTA and the trajectory of the slMFB & imMFB. slMFB originates laterally and traverses below the thalamus, the imMFB follows the wall of the third ventricle until reaching the lateral hypothalamus. Shown are the various connections of the MFB including the Ventral Tegmental Area (VTA) and Nucleus Accumbens (NAcc).

Tract Name	MFBROI
number of tracts	920
tract length mean(mm)	29.2285
tract length sd(mm)	15.8659
tracts volume (mm^3)	24892
qa mean	0.222546
qa sd	0.170974
fiber_ratio mean	0.492861
fiber_ratio sd	0.241939

The goal of this study was to apply methods developed with DTI to HARDI data using the MFB to identify and visualize the MFB. Results from this study show that imaging techniques such as HARDI, is able to resolve complex fiber structures (e.g the differentiation of crossing fibers vs. kissing fibers), lend itself well to visualizing and examining the complexity of the MFB.

Summary

- Ability to visualize the MFB using HARDI in 5 subjects
- Utilizing anatomical ROIs to reconstruct the tract
- Bilaterally assessed structural connectivity between the VTA and the Nacc