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Amygdala Structural Connectivity is Associated with Impulsivity and Nicotine Dependence

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Introduction

The amygdala has been shown to play a role in nicotine dependence by mediating reward and impulsivity. Here we demonstrate the structural connectivity of the amygdala to a broader brain reward network using probabilistic tractography. We hypothesized that amygdala connectivity with other reward-related structures correlates with impulsivity and nicotine dependence.

Methods

Diffusion and structural MRI was obtained from 197 randomly selected healthy subjects from the human connectome project dataset. Probabilistic tractography (using FSL) was performed between the amygdala and the brainstem, dorsolateral prefrontal cortex (DLPFC), hippocampus, insula, NAc, OFC, and rostral anterior cingulate cortex (rACC) (Figure 1). Seed masks were generated using automated segmentation (FreeSurfer software). Statistical maps of amygdala connectivity were generated. Impulsivity was determined using the area

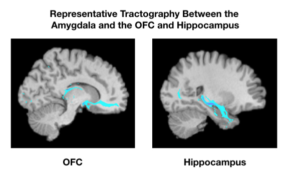
Results

Structural connectivity of the amygdala to the specified structures was spatially segregated (Figure 2). The amygdala showed highest connectivity with the hippocampus, OFC and brainstem ($p < 0.001$) (Figure 3). There was a significant correlation between connectivity with the hippocampus, OFC, insula and rACC and impulsivity ($p < 0.001$ for hippocampus and OFC, $p < 0.05$ for insula and rACC). Higher connectivity with the hippocampus was associated with decreased impulsivity while higher connectivity with the OFC was associated with increased impulsivity (Figure 4). Subjects with greater nicotine dependence displayed significantly decreased hippocampal but increased brainstem and rACC connectivity ($p < 0.05$) (Figure 5).

Conclusions

The amygdala displays spatially segregated subregions with high connectivity with the hippocampus, OFC and

Figure 1



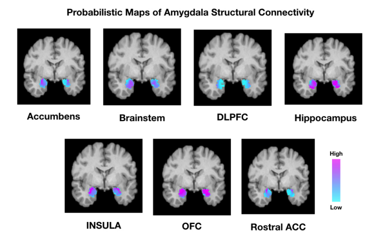
Representative single subject probabilistic tractography between the amygdala and the OFC and hippocampus.

Learning Objectives

The learning objectives are to understand: 1) the use of diffusion tractography to estimate structural connectivity of the amygdala 2) how connectivity of the amygdala influences impulsivity and 3) the role of the amygdala in nicotine dependence.

References

Figure 2



Coronal view of probabilistic maps of the amygdala averaged over 197 subjects. Magenta represents higher connectivity. Connectivity values ranged from 0 to 1 and represent probability of structural connectivity between the amygdala and each target structure. For example, while the OFC showed uniformly high connectivity with the amygdala, the rACC and nucleus accumbens show more restricted connectivity.

Figure 5

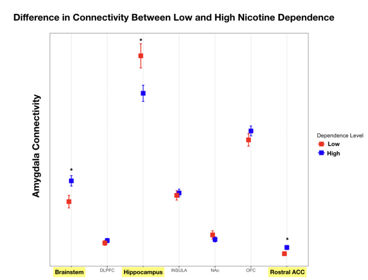
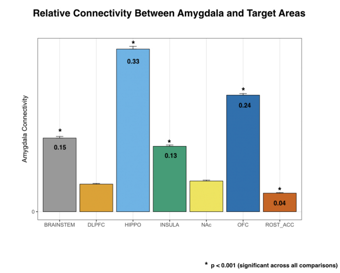
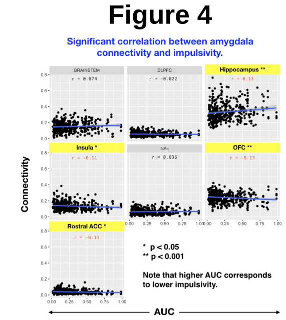


Figure 3



Structural connectivity of the amygdala to cortical and subcortical regions implicated in reward-related behavior. The y-axis represents the average structural connectivity between the amygdala and each structure as determined by probabilistic tractography. Values represent the average probability that a voxel is connected to a given target area.

Figure 4



Correlation between structural connectivity of the amygdala and impulsivity. The y-axis represents the area under the curve (AUC) of the temporal discounting function as determined by a monetary task. Higher AUC represents low impulsivity. Yellow labels represent areas with significant correlations.