Trait impulsivity is distinctively associated with functional connectivity of ventral striatum circuits in smokers versus nonsmokers

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Background: Impulsivity is a multi-facet trait and high impulsivity is often observed in individuals with substance abuse disorder (SUD) including nicotine addiction. Ventral striatum (VS) is a key structure implicated in impulsivity, and its interactions with other brain regions might modulate impulsive behaviors. However, little is known about how VS circuits underlie impulsivity and whether such relationship is altered in SUD. In this study, we used resting state functional connectivity (rsFC) to investigate the association between impulsivity and intrinsic connectivity of VS circuits, and the potential alterations in smokers versus nonsmokers.

Methods: Sixty smokers and 60 matched nonsmokers underwent resting-state functional MRI (fMRI) scans and their impulsivity was assessed. Voxel-wise rsFC between bilateral VS and all other brain regions were computed for each subject. Analysis of covariance was then conducted to identify the effect of smoking status, correlation with trait impulsivity and their interactions.

Results: Significant interactions were found in the dorsal anterior cingulate cortex (dACC) and bilateral amygdala. Specifically, significant positive correlation between impulsivity and rsFC of VS-amygdala circuit was found in smokers but not in nonsmokers, whereas significant positive correlation between impulsivity and rsFC of VS-dACC circuit was found in nonsmokers but not smokers. To further examine functional roles of these brain circuits in impulsivity, a subset of the participants underwent fMRI scans while performing Go/NoGo and emotional memory tasks. VS-amygdala connectivity positively correlated with the activation in the amygdala (negative vs. positive condition); and VS-dACC connectivity positively correlated with the activation in the dACC during failed inhibition (losing impulsive control). Additionally, VS-dACC connectivity negatively correlated with nicotine dependence severity and VS-amygdala connectivity positively correlated with anxiety in smokers.

Conclusions: These results provide novel evidence supporting the notion that the striatal-frontal circuits are involved in impulse control, while striatal-limbic circuits in impulse drive.