Investigating Delayed Reward Discounting and its Neural Correlates as Predictors of Smoking Cessation Outcomes

Michael Amlung1,2; Tegan Hargreaves2, Carly McIntyre-Wood2, Joshua Gray3, Max Owens4, James MacKillop2, Lawrence Sweet5

1. Cofrin Logan Center for Addictions Research, University of Kansas; 2. Peter Boris Centre for Addictions Research, McMaster University; 3. Medical and Clinical Psychology, Uniformed Services University of the Health Sciences; 4. Department of Psychiatry, University of Vermont; 5. Department of Psychology, University of Georgia;

BACKGROUND

Delayed reward discounting (DRD) measures preferences for smaller-immediate vs. larger-delayed rewards. Steeper DRD is an index of impulsivity, with a recent systematic review indicating steeper DRD consistently predicts smoking relapse (Sun et al., 2021). Neuroimaging studies have characterized the neural correlates of DRD in a range of addiction samples, including cigarette smokers (MacKillop et al., 2012). Less is known about how the neural correlates of DRD relate to smoking cessation. Studying these processes may reveal novel mechanisms and improve prediction of relapse.

Purpose of this study: This study used a functional MRI (fMRI) task to investigate behavioral and neural correlates of relapse in adult smokers following a 9-week cessation protocol.

METHODS

Participants

- 41 smokers (32% female, M age = 40.5, M cigarettes/day = 22.2, M FTND = 4.9) who were motivated to quit (>5 on a 10-point scale)
- Exclusions: Smoking cessation treatment in past 90 days; major medical or psychiatric disorder; >6 alcoholic drinks/day; >weekly cannabis use or >monthly other drug use; MRI contraindications; estimated IQ <70

Behavioral Task and fMRI Scanning

- Monetary DRD fMRI paradigm (Figure 1) (Amlung et al., 2012)
- 120 DRD trials coded by choice difficulty (i.e., hard vs. easy choices based on proximity to indifference points)
- DRD rate quantified using area under the curve (AUC)
- 1.5-hour fMRI scan in a GE 3-Tesla MRI scanner including 3 runs of DRD task, anatomical scan, resting state, and other neurocognitive tasks
- fMRI data analyzed using disjunction (OR) mask approach and Group (2) x Choice Type (3) mixed ANOVAs

Smoking Cessation Protocol

- Following the fMRI scan, participants completed a free 9-week smoking cessation protocol combining nicotine replacement therapy and weekly counseling
- Smoking relapse defined as self-reported smoking (≥1 cigarette/day for week), expired CO >10 ppm, or dropping out of the treatment protocol.

RESULTS

Smoking Cessation Treatment Outcomes

After treatment, 23 participants resumed smoking and 18 did not.

DRD Behavioral Results

Participants in relapse group had significantly lower AUC (more impulsive DRD) than the non-relapse group (Figure 2).

Functional MRI Results

Hard DRD choices engaged frontoparietal and frontostriatal brain networks, as well as bilateral anterior insula and posterior cingulate. Deactivation of brain’s default mode network was also observed. Easy choices were associated with less activation in a smaller number of these regions (see Figures 3 & 4 and Table 1). No group main effects were found; however, significant group x choice interactions were observed for 4 regions (Figure 4).

CONCLUSIONS

These results further characterize the neural correlates of DRD in smokers. Individuals who discounted more steeply were more likely to resume smoking following treatment. Despite limited statistical power, there were promising interaction effects that should be further examined in future studies to inform neural and behavioral models of relapse.