Recovery of reward function in problematic substance users using a combination of robotics, reward-related biomarkers, and TMS

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Background: Theoretical and empirical work suggest that addictive drugs potentiate dopaminergic reinforcement learning signals and disrupt the reward function of its neural targets, including the anterior midcingulate cortex (aMCC) and the basal ganglia (Baker et al., 2013, Holroyd and Umemoto, 2016). Here, we aimed to use prefrontal 10-Hz robot-assisted TMS to enhance aMCC reward activity and reward learning by the basal ganglia in problematic substance users.

Methods: 22 problematic substance users were randomized into an Active and SHAM (coil flipped) TMS group. We recorded the reward positivity—an electrophysiological signal believed to index sensitivity of the aMCC to rewards—while participants engaged in 4 blocks (100 trials per block) of a reward-based choice task. A robotic arm positioned a TMS coil over a prefrontal cortex target, and 50 pulses were delivered at 10-Hz before every 10 trials of blocks 2-4 (1500 pulses, 400 trials). Participants then completed the Probabilistic Selection Task (Maia and Frank, 2011), a decision-making task that is diagnostic of striatal dopamine dysfunction.

Results: The present study revealed three main findings. First, both groups failed to elicit a reward positivity during the first two task blocks. Second, applying robot-assisted TMS enhanced the amplitude of the reward positivity in the Active group, but not the SHAM group, across the last two task blocks. Third, the Active group performed relatively better at reward-based learning than the SHAM group.

Conclusion: These results demonstrate that 10-Hz TMS is successful in modulating the reward function of the aMCC and basal ganglia in problematic substance users, which may have utility in the treatment of reward-related neural dysfunction commonly associated with substance use disorders.

References: Baker, T. E., Stockwell, T., and Holroyd, C. B. *Cogn Affect Behav Neurosci* 13:417-36 (2013); Holroyd, C. B., and Umemoto, A. *Neurosci Biobehav Rev* 71:418-43 (2016); Maia, T. V., and Frank, M. J. *Nat Neurosci* 14:154-62 (2011).

Funding was provided by a NIH-NIDA grant DA049574-01A1, and Departmental Research Start-up Funds, Rutgers University.