Mathematical Biology Seminar

Monday, October 23, 2023

3 pm MDT - 457 CAB (virtual)

Join Zoom Meeting

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Meeting ID: 984 9769 5684
Passcode: 32123

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Mathematical modeling of the neurobiology of drug addiction

Drug overdose deaths continue to increase in the United States, reaching a record of more than 100,000 deaths in 2021, driven mostly by fentanyl and methamphetamines. We propose a mathematical framework to describe the neurobiology of drug addiction. Substances of abuse are known to activate and disrupt neuronal circuits in the brain reward system. To quantify these disruptions, we incorporate the psychiatric concepts of drug-induced incentive salience (IST), reward prediction error (RPE), and opponent process theory (OPT) in a simple and easily interpretable dynamical system model. Drug-induced dopamine releases activate a biphasic reward response with pleasurable, positive ``a-processes" (euphoria, rush) followed by unpleasant, negative "b-processes" (cravings, withdrawal symptoms). Neuroadaptive processes triggered by successive intakes enhance the negative component of the reward response, against which the user compensates by increasing drug dose and/or intake frequency. This positive feedback between physiological changes and drug self-administration eventually leads to full addiction. Our model gives rise to qualitatively different pathways to addiction that allow us to represent a diverse set of user profiles (genetics, age) or drug potencies. Finally, we include possible mechanisms to mitigate withdrawal symptoms, such as through methadone or other auxiliary drugs used in detoxification and offer a brief discussion on relapses.