ADDICTION

How sugar and cocaine affect the brain

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Evidence suggests that addictive drugs such as cocaine hijack the brain's natural reward system and activate brain regions that usually respond to natural rewards such as food. A new study comparing brain activity in mice after sugar or cocaine exposure provides new insights into the processing of natural and addictive rewards. These findings could improve our understanding of the neural causation of addiction.

To examine how sugar and cocaine affect the brain and compare the effects of acute and prolonged exposure, the investigators exposed mice to sweet water or cocaine — either once, or for 7 consecutive days. For sugar exposure, mice received either sweet water (7.5% sucrose solution) or fresh water (control); while for cocaine exposure, mice were injected with cocaine or saline (control). Two hours after the last reward exposure, the researchers collected the brains of the animals and used tissue clearing combined with immunohistochemistry (iDisco+) to detect c-Fos positive cells in the whole brain.

To discover which brain regions were activated by the different rewards, the team compared c-Fos signal density in the brains of sucrose- or cocaine-treated groups with their respective controls. The results showed that, although both rewards produced a widespread activation of distant neuronal networks, the pattern of activation was different for sugar and cocaine. While a single exposure to sugar triggered a massive c-Fos expression throughout the brain that declined with repeated exposure, cocaine exposure potentiated c-Fos expression with repeated injections, and activated more structures than sucrose treatment.

Functional connectivity analysis revealed an increase in brain modularity — a marker of global neuronal reorganization — after the initial exposure to both types of rewards. This modularity was also increased after repeated cocaine, but not sucrose exposure, highlighting further differences in reward processing between sugar and cocaine exposure.

Further experiments revealed that both cocaine and sucrose treatments triggered identical cellular changes in the nucleus accumbens, including the formation of silent synapses in the D1 and D2 cells of this brain structure deeply involved in reward processing.

"These results strengthen the hypothesis that in the nucleus accumbens drugs of abuse cause maladaptive neuronal plasticity in the circuitry that typically processes natural rewards," write the investigators in their report.

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