Sucrose intake lowers μ-opioid and dopamine D2/3 receptor availability in porcine brain

BraiNY Bunch Presentation for Sunday May 2

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Article | Open Access | Published: 15 November 2019

Sucrose intake lowers μ-opioid and dopamine D2/3 receptor availability in porcine brain

Michael Winterdahl, Ove Noer, Dariusz Orlowski, Anna C. Schacht, Steen Jakobsen, Aage K. O. Alstrup, Albert Gjedde & Anne M. Landau

Scientific Reports **9**, Article number: 16918 (2019) | Cite this article

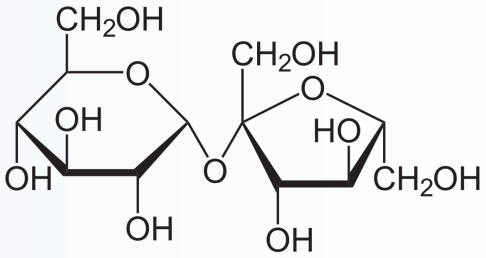
14k Accesses | **6** Citations | **433** Altmetric | Metrics

Abstract

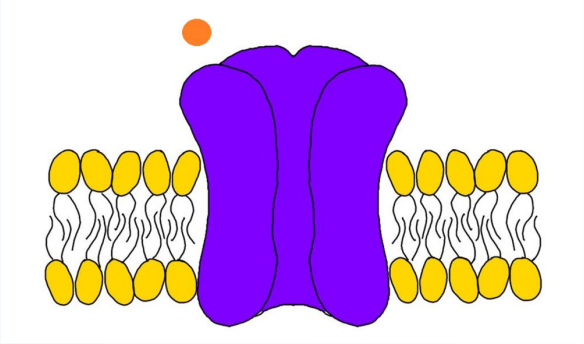
Excessive sucrose consumption elicits addiction-like craving that may underpin the obesity epidemic. Opioids and dopamine mediate the rewarding effects of drugs of abuse, and of natural rewards from stimuli such as palatable food. We investigated the effects of sucrose using PET imaging with [^{11}C]carfentanil (μ-opioid receptor agonist) and [^{11}C]raclopride

Important Terms

Sucrose - type of sugar found in many foods, associated with obesity and considered addictive

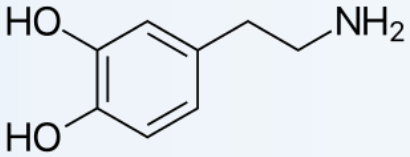


Receptor - a chemical structure that responds specifically to a particular substance or neurotransmitter



Porcine - having to do with pigs

Dopaminergic - relating to or releasing dopamine



μ-opioid receptor

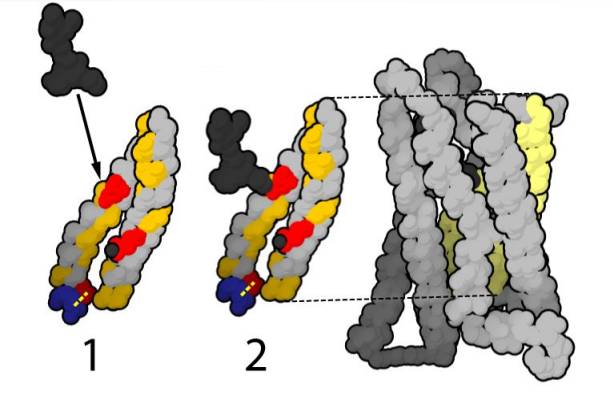
Protein that's part of the endogenous opioid system that helps regulate reward and addictive behaviors

Widely expressed in structures that modulate eating and reward processes

Important in rewarding and relapsing cocaine

Linked with the liking of substances

[^{11}C]Carfentanil is an agonist for this receptor



Dopamine D2/D3 receptor

Dopamine is released at the intake of sucrose

Dopamine is necessary for rewards from drugs and behaviour

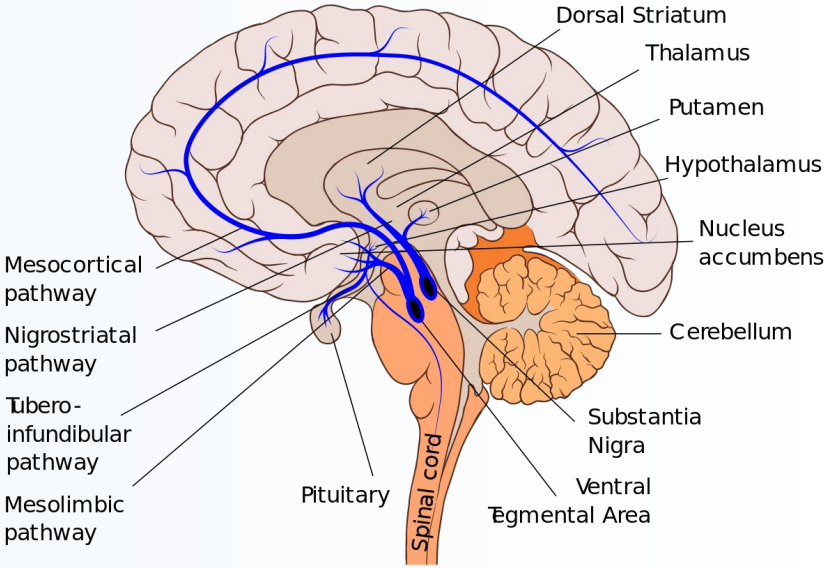
Regulates mood

Plays a role in movement

Dopamine binds to these receptors

Certain types of addictive drugs hijack this pathway

[^{11}C]raclopride is the antagonist



Introduction

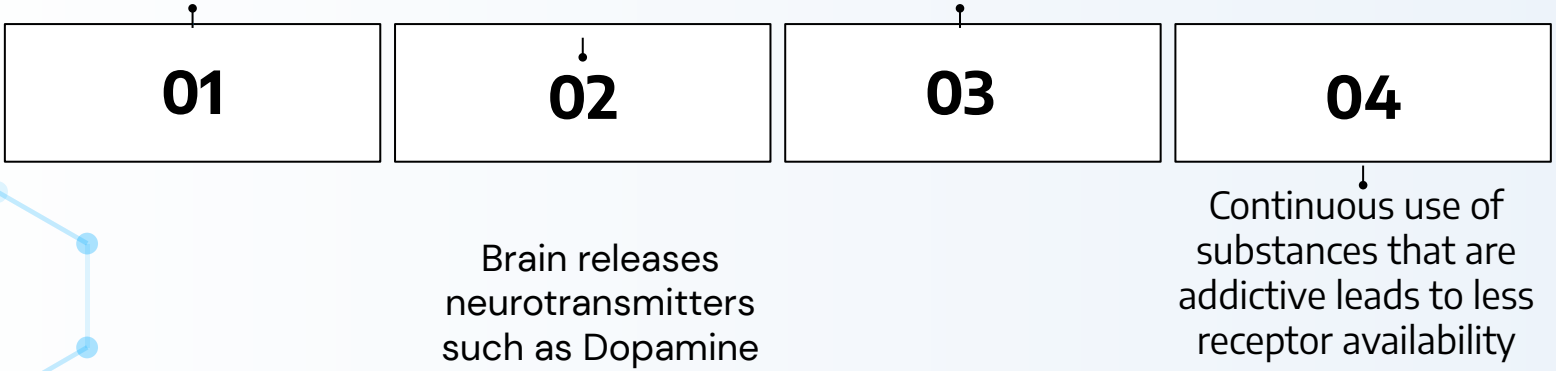
Sucrose consumption is linked with obesity

5% of the world population is clinically obese, which is associated with Type 2 Diabetes, Cardiovascular Disease

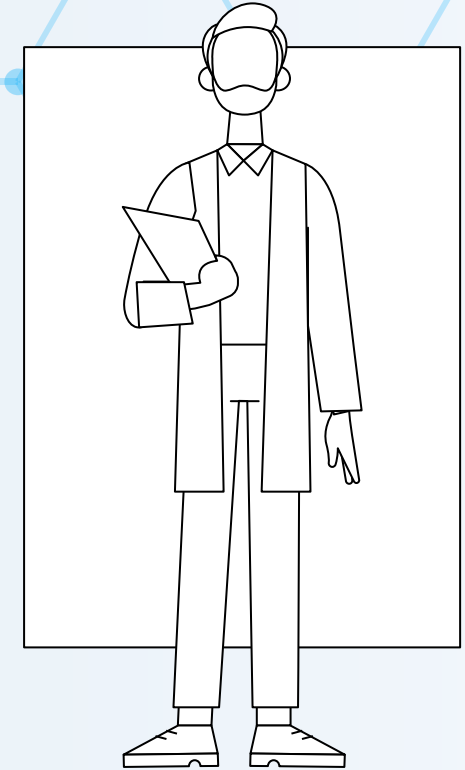
Sucrose induces a reward system which is comparable to those induced by addictive drugs

Addiction

Addiction subverts the brain's pleasure registration



Question



What is the effect of access to Sucrose on the brain, specifically on DA and μ-opioid neurotransmission in the mammalian brain? How can the addictive potential of Sucrose be explained?

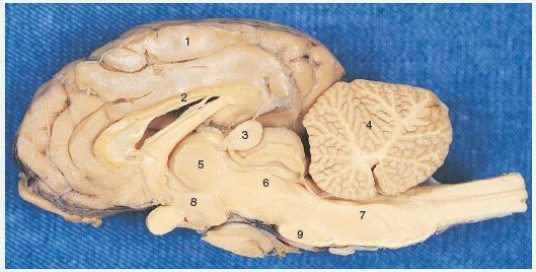
Methodology

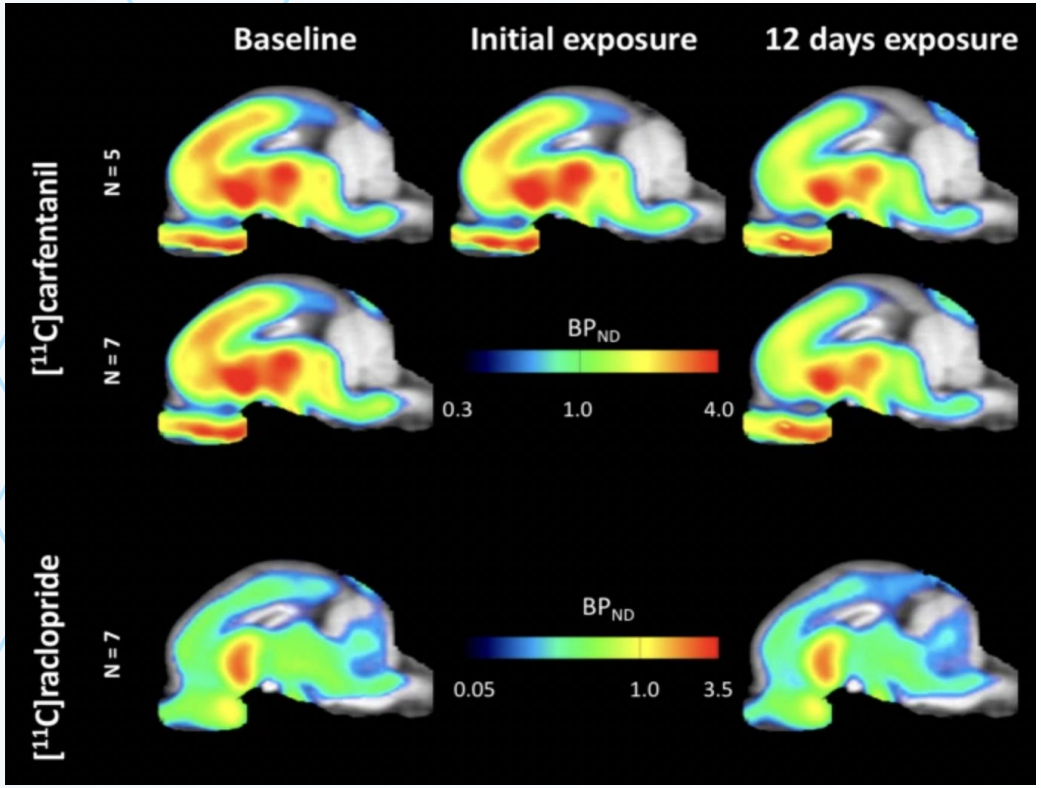
- 7 female mini pigs were given sucrose water for one hour, 12 days consecutively
- PET imaging of [^{11}C]carfentanil (μ-opioid receptor agonist) and the [^{11}C]raclopride (dopamine D2/3 receptor antagonist) was used on the pig brain before and after sugar intake

Key Findings

Dopamine and μ-opioid receptor availability decreases with sucrose intake

7 minipigs imaged at baseline and after 12 days of sucrose access are shown





Receptor availability decreases in multiple brain regions

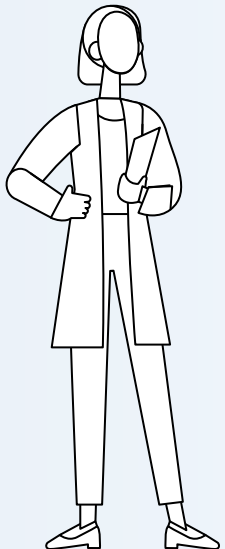
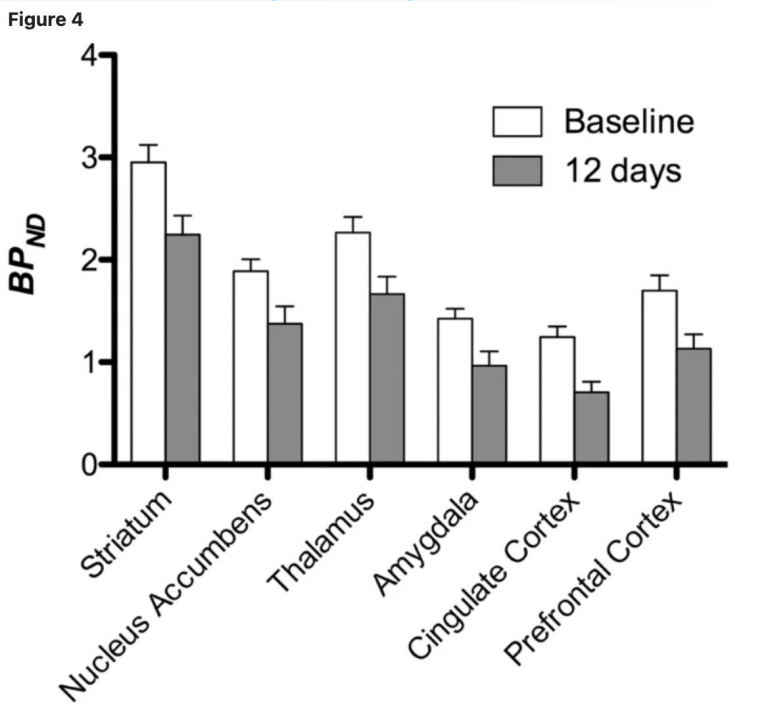


Figure 4



Discussion

This study found that sucrose leads to the release of dopamine and opioids that lowers the availability of receptors available in certain areas of the brain

Foods high in sucrose influence brain reward circuitry in ways similar to when addictive drugs are consumed

- Chronic cocaine use has been found to inhibit Dopamine signaling
- Dopamine D1 and D2/3 receptor levels are altered by nicotine in pig brain
- Downregulation of D2/3 receptors in the brains of people with cocaine addiction

Brain regions involved in reward process

Prefrontal cortex - decision making and assigning value

Decreased receptors in this region might explain increase in addictive potential i certain foods and an altered evaluation, as well as impaired decision making skills and reward processing skills

Striatum - regulates motor behaviour and regulates responses to rewards

Nucleus Accumbens - mediates reward and reinforces behaviour

Thalamus - relays motor and sensory signals

Amygdala - involved with the expression of emotions

Hippocampus - plays a role in learning memory, supports habit like behaviour

Activated in response to craving, there were also decreased receptors here

explain that since each part of the brain is in a different action, the receptors

Limitations

PET Scan

Minipigs as model organism

Future Experiments

-Do the results vary with different amounts of sucrose consumed/is there a relationship between amount of sucrose consumed and decrease in receptor availability

Give the subjects access to different amounts of sugar from each other to see if there are differences in receptor availability

-Does the craving for sucrose outweigh potential adverse consequences/Will the subjects still consume the sucrose despite adverse consequences

Insert a nauseating component to some of the sugar while keeping a control with normal sugar to see if they consume same amounts

Other papers to check out

Moore et al. (2020) Reward sensitivity deficits in a rat model of compulsive eating behavior. *Neuropsychopharmacology.*

Lenoir, Serre, Cantin, and Ahmed (2007) Intense sweetness surpasses cocaine reward. *PloS One.*

Thank You!