

PLOS Science Wednesday: Hi reddit, we're Selena and Arnauld and our research shows short- and long-term sugar consumption can alter the reward circuits of the brain that are associated with addiction – Ask Us Anything!

PLOSScienceWednesday¹ and r/Science AMAs¹

¹Affiliation not available

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Abstract

Hi Reddit, My name is Selena Bartlett and I am a Professor of Neuroscience and Group Leader at the Translational Research Institute, Institute for Health and Biomedical Innovation at the Queensland University of QUT. My research focuses on developing innovative approaches to prevention and treatment of addictions. We focus on trying to develop strategies to help people overcome addiction to sugar that drives obesity and alcohol for alcoholism. And my name is Arnauld Belmer and I am postdoctoral researcher at the Queensland University of QUT. My research focuses on identifying the brain circuitry underlying the development of dependence and addiction, including to sugar or alcohol. My (Selena's) laboratory focuses on dissecting the molecular signaling and neural circuitry pathways that have been changed by long-term overconsumption of sugar and/or alcohol. At the lab, we focus on two important areas associated with addiction, the amygdala that processes fear, stress and reward and the prefrontal cortex, that is important for impulse control and decision making. My lab has shown, that overconsumption of sucrose changes the neuronal circuitry in both the amygdala (which this paper is about) and the prefrontal cortex. The shocking finding for my lab, was that sugar changes the brain in exactly the same way that long-term consumption of alcohol does. Today, we will discuss the changes happening in the amygdala from overconsumption of sucrose. We hypothesize that these maladaptive changes in the BLA lead to changes in signalling activity in the amygdala, that is the basolateral amygdala becomes more sensitive to stress and fear signaling over the long-term. The consequence is that the reward/motivation circuits become down-regulated, this leads to people using high calorie rewards, such as sucrose, to reduce activity in the over-reactive amygdala. We recently published a paper titled Binge-like sucrose consumption reduces the dendritic length and complexity of principal neurons in the adolescent rat basolateral amygdala in PLOS ONE, showing that chronic binge-like sucrose consumption elicits maladaptive changes in the morphology of neurons in the amygdala. We will be answering your questions at 1pm ET – Ask Us Anything!

[REDDIT](#)

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PLOSSCIENCEWEDNESDAY [R/SCIENCE](#)

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CORRESPONDENCE:

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To what extent does the source of the sugar matter in terms of how it impacts neuronal plasticity and other behavioral traits related to addiction? It looks like in your study, you supplied the rats with 5% sucrose laden drinking water. Do you think you would have seen similar results if the rats had been fed a fruit-based diet that is high in sucrose.

Also, I am having a hard time understanding exactly how sugary 5% sucrose water would be. What is the sucrose content of a soda, for example, by comparison?

[SirT6](#)

September 13, 2017

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Hello, this is Selena here. A standard can of soda in the U.S is 12 fl oz or around 355mLs and it contains around 39 grams of sugar. This is about 10%. It is a great question about exactly how much sucrose is needed to change the brain's structure. We have not addressed this yet. Also, in terms of natural sugars. I think in large enough quantities we would see a similar effect, but it would be good to answer this. It is the fructose and not the glucose component of sucrose that has a pronounced effect on the brain. We are exploring these questions. Thank you asking.

To what extent does the source of the sugar matter in terms of how it impacts neuronal plasticity and other behavioral traits related to addiction? It looks like in your study, you supplied the rats with 5% sucrose laden drinking water. Do you think you would have seen similar results if the rats had been fed a fruit-based diet that is high in sucrose.

Also, I am having a hard time understanding exactly how sugary 5% sucrose water would be. What is the sucrose content of a soda, for example, by comparison?

[SirT6](#)

Arnauld: Hi SirT6, The source of sugar matters a lot, especially if the sugar is simple (monosaccharide) or complex (di- or polysaccharide) or a mix of both. In our study, we used sucrose, a disaccharide metabolized in glucose and fructose. Fructose is actually the worse because, unlike glucose, it stimulates the rewarding pathways in the brain without producing a feeling of satiety. This consequently reinforces the overconsumption of sugar. We are now investigating the effects of glucose or fructose, individually, on neuronal plasticity and believe that fructose will elicit more profound changes in the brain (than glucose). Regarding your question about a fruit-based diet: fruits not only contain sugar but also fibres that slow the rate of carbohydrate absorption, vitamins and minerals that are important for many metabolic reactions, and therefore, are likely to cause less damages. Common sodas usually contain around 10% of sugar (10g/100ml with 2/3 of fructose + 1/3 of glucose).

What about non-caloric sweeteners? Is it simply the sensory experience of "sweet" or does it also require a caloric component?

[postdochell](#)

Hello-Selena here. Yes we have found similar effect from saccharin. We cannot answer the question about "sweet" definitively. We have found that sucrose mimic unsweetened alcohol. This has the caloric component to it. We published a paper on this last year. see <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0150270>

Regarding your study itself, I'm curious to hear a bit about your choice to use adolescent rats. Is this effect likely to be any different at different developmental stages?

More generally, I'd be interested to know how you approach sugar consumption in your day-to-day life. It's certainly more ubiquitous than alcohol.

[divvyflax](#)

Hello- Selena here- thank you for your question. The age of rats was chosen as this is when the majority of sugar and alcohol consumption commences. This is the age when the brain's neuroplasticity is most vulnerable to changes. We know that the 75% of food has become embedded with sugar, especially fructose. For me personally, I have completely reduced my sugar intake, this led to a significant reduction in waistline for example. This is where the energy from fructose ends up-

visceral fat cells. Further, I regained my feelings of being full again. We know that fructose activates the hypothalamus and can increase hunger. This was my personal experience- we plan to do more research in this area also. You can learn more about this at www.miggimatters.com.

Would there be any merit to testing the sucrose solution with a soluble fiber like inulin to measure if the presence of an indigestible carbohydrate in any way mitigates the effect the fructose has on the brain?

[forgetremembering](#)

Yes, I think this is a great suggestion. We would have to see whether this is palatable. This is important, all experiments are free drinking choice experiments.

Hi and thanks for joining us today!

This may be quite a reach but with countries implementing sugar taxes and seeing lowered consumption levels, do you think we might also see a correlated uptick in depression and suicide?

[PHealthy](#)

Hello- Selena here. That is actually not a stretch at all. There is evidence that suggests people are addicted to something to self-medicate stress/trauma. From a brain/neuroscience perspective, stress or trauma continually activates the amygdala and then sugar, alcohol etc activate the reward centers of the brain to in effect calm the amygdala. The brain is always trying to find a way to handle stress. It has been known for at least 30 years that adverse childhood experiences (ACE) lead to obesity and addiction later in life. I refer you to www.acestudy.org to see all the research in this area. Addiction is really a symptom of how the brain was wired by stress/trauma since the day the brain started developing. This is a really important area of research that has not received enough attention yet. This is an area that I am actively working in now, trying to use the principles of neuroplasticity to reduce the effects of trauma on the brain.

Hi and thanks for joining us today!

This may be quite a reach but with countries implementing sugar taxes and seeing lowered consumption levels, do you think we might also see a correlated uptick in depression and suicide?

[PHealthy](#)

Arnauld: Hi PHealthy, It is known that stopping sugar "cold turkey" can induce severe emotional deficits, especially after chronic consumption for a long period of time. It is possible that decreasing the content of sugar in the food chain affects the emotional health of many people...

Can these changes be reversed by ceasing or reducing consumption? Would the brain try and replace the "soothing" with something else until the underlying traumas are dealt with?

[VoidsIncision](#)

Thank you for your question- it is a really great one. Yes- we are starting trials with the hypothesis that these effects can be reversed with reducing consumption, increasing exercise, and doing training that improves working memory, focus and memory. See more at www.miggimatters.com.

Hi there! I'll ask what I think is the most obvious follow up question.

Do you think that this similarity between sugar and alcohol is due to some specific biochemical similarity in the substances or because of similarities in the addiction mechanism, which can involve many addictions, even unrelated to "drugs" (e.g.: problematic gamblic).

[lucaxx85](#)

Hello Selena here- great question. We hypothesize that sugar and alcohol is increasing the release of acetylcholine, the endogenous neurotransmitter that activates the nicotinic receptors. Nicotine is one of the most addictive drugs. We know this happens in the case of alcohol but we have not shown this yet for sucrose. We hypothesize that fructose not glucose will increase the release of acetylcholine. Since publishing this work, I have had many people write and say they are addicted to sugar and experience all the symptoms that you would see for alcohol dependence. The difference, there are few people they take them seriously. This is a really important area for people doing obesity and diabetes research to consider. The brain and neuroscience really need to be included in research into the treatment and prevention of obesity and diabetes.

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[lucaxx85](#)

Arnauld: Hi Lucaxx85, I think sugar and alcohol are not only acting on the "common" dopaminergic reward/addiction pathway but also sharing a lot of other biochemical similarities. We initially used sucrose-fed rats as controls in our experiments on alcohol dependence and we quickly realised that drugs that modulate alcohol consumption also modulate sucrose consumption. In our recent papers (Klenowski et al, 2016, Front Behav Neurosci. and Shariff et al, 2017, PLoS One), we also found that sucrose and alcohol triggers similar changes in the brain, with alterations in the same brain regions (ventral striatum and amygdala). We believe that the cholinergic system within those brain areas play a pivotal role in both alcohol and sucrose dependence (Shariff et al, 2016, PLoS One). Whether the cholinergic system also plays an important role in other addictions, like gambling, I don't know...

Wasn't there research being done on obese people and the number of sweet taste receptors on their tongues? I've known some morbidly obese people that seemed to get more of a kick from sugar than is normal.

I agree with your hypothesis about sugar and alcohol. I think alcoholism is really an eating disorder and can be treated as such. I know from personal experience that if one eliminates sugar from their diet, you will stop craving sweets.

I have also noticed that a high protein snack alleviates cravings for sugar. What could be the mechanism for this?

[6thGenTexan](#)

Hi 6thGenTexan, I would hypothesize it is replacing the dopamine surge that would otherwise come from sugar and alcohol or smoking for example. I do not know whether you can get addicted to high protein snacks yet- but we know you can get addicted to high fat foods. As I mentioned earlier-there is evidence that suggests people are addicted to something to self-medicate stress/trauma. From a

brain/neuroscience perspective, stress or trauma continually activates the amygdala and then sugar, alcohol etc activate the reward centers of the brain to in effect calm the amygdala. The brain is always trying to find a way to handle stress. It has been known for at least 30 years that adverse childhood experiences (ACE) lead to obesity and addiction later in life. I refer you to www.acestudy.org to see all the research in this area. Addiction is really a symptom of how the brain was wired by stress/trauma since the day the brain started developing. This is a really important area of research that has not received enough attention yet. This is an area that I am actively working in now, trying to use the principles of neuroplasticity to reduce the effects of trauma on the brain. I hope this partly answers your question.

Very interesting. I am curious, will you be measuring the blood levels of glucose/fructose to get a better relationship to the levels occurring in the brain? Ingested sugar can have varying rates of absorption which is contingent on many things. So, doesn't it stand to reason that the concentration achieved in the brain is the only way to make a convincing argument.

[insanelylogical](#)

Yes- we would like to do this-it is not only concentrations of fructose or glucose in the brain that lead to these changes. There are multiple signalling pathways being activated before, during and after the ingestion of sucrose. There are so many avenues to explain what is causing the changes we are finding in the brain. One consistent finding from my lab over the last 10 years both in the US and Australia. Over-consumption of sucrose or alcohol lead to structural changes in the circuitry of the amygdala and prefrontal cortex. Specifically we are able to map changes in nicotinic receptors. This is where we now start from to begin to unravel what is leading to the changes. We were not expecting to find this effect from sucrose as it was originally our control experiment.