Flavor-Nutrient Learning in Selectively Bred Obesity Prone Versus Obesity Resistant Rats

Program for Undergraduate Research Proposal (10 Weeks)

Hannah Goldberg, Class of 2022

Major: Psychology; Minor: Legal Studies

Professor Kevin Myers, Psychology Department, kmyers@bucknell.edu

Advisor signature: I (Kevin Myers) have read the proposal and my letter of support indicates approval.

Student signature: Hannah Goldberg

Introduction

Obesity, while prevalent throughout the world, has become an epidemic in the United States. Nearly one in three American adults are affected by obesity. (National Institutes of Health). Why is this concerning? Obesity poses severe health consequences that could be otherwise avoided. Many factors, both genetic and environmental, contribute to one's risk for obesity. My research will look at a combination of these factors, specifically how one's genetic predisposition to obesity interacts with a specific psychological factor, which is learned preferences for specific foods and flavors. This phenomenon is called flavor-nutrient conditioning and has been linked to obesity in past work. As explained below, there has been past research on this topic, it is preliminary and has not yet determined the exact relationship between flavor-nutrient conditioning and obesity. Determining the direct relationship between these two variables will be the focus of my research, as it can provide important insight into the causes of obesity in humans.

Background

Preference for high calorie foods, especially those higher in refined carbohydrates and fat, is influenced by learning and other psychological phenomena. Flavor-nutrient conditioning is one important psychological influence in that preference. As defined by Wald and Myers, "'flavor-nutrient conditioning' is one such Pavlovian learning process through which individuals associate initially-arbitrary (or even mildly aversive) flavors in a food with rewarding physiological effects that follow as nutrients are detected in the gut and/or metabolized postabsorptively" (2015, 103). Animals and humans alike therefore learn to prefer certain flavors by learning associations with their nutrients' rewards. A common example of this is the case of vanilla, a relatively neutral flavor at first. As the vanilla flavor is consumed, though, the body experiences reward due to the intake of calories coming from the sugar and fat in the foods. This creates an association between vanilla and the postingestive rewards, which makes vanilla more appealing. The preference for the vanilla flavor, then, is a learned behavior.

Flavor-nutrient conditioning (FNC) plays a rather important role in individual food preferences. Studying this learning process can help us understand the motivation behind our food choices and why we have a preference for high calorie, unhealthy foods. Individual differences in FNC could help explain why some individuals are more likely to seek out high calorie foods than others. Previous research conducted by Wald and Myers found that after long-term access to a high fat, high carb diet, the rats that became most obese also showed stronger flavor-nutrient conditioning than those who did not gain as much weight. These findings show a link between the two variables, but cannot determine the directionality of this cause-effect relationship. As they stated, "this correlation between degree of obesity and flavor-nutrient conditioning does not establish the direction of causality" (2015, 107).

For my proposed summer research, I would like to establish the directionality of this relationship. In other words, do preexisting differences in FNC impact obesity or does a history of obesity impact sensitivity to FNC? We can address this by studying rats that have been selectively bred for obesity proneness. Studying these selectively bred rats when they are young and not yet on a high-calorie diet and not yet obese, as I intend to do, will help us better understand the differences in sensitivity to flavor-nutrient learning and can provide insight to the direction of causality.

Method

The rats used in this proposed research project will be from selectively bred strains (known as Levin DIO and Levin DR rats) that are either highly prone to diet induced obesity (DIO) or resistant to dietary obesity (DR). In order to originally create these strains, rats were fed a high fat, high carb diet to see the rate of weight and fat gain. From there, the rats at the highest and lowest ends of the spectrum (i.e., those who gained the most and those who gained the least) were chosen to mate and create two groups for breeding over several generations--obesity prone or obesity resistant-- leading to the selectively bred strains we will be working with (Levin, Dunn-Meynell, Balkan, Keesey 1997). These DIO rats are a relatively normal weight until given a higher calorie diet, at which point they quickly become obese. The DR rats remain lean, even when fed this higher calorie diet.

Our experimental design will consist of two separate groups --one group from the DIO strain and one from the DR strain. Each will have both males and females to determine any sex differences. Before the obesity prone rats actually become obese, we will test the rats for flavor-nutrient conditioning. Then, all rats will be given a high fat, high sugar diet, and obesity prone rats will become obese while the resistant rats remain lean. We will then test for flavor-nutrient conditioning again, this time to see if there were any changes in sensitivity.

To test flavor-nutrient conditioning, there will be two distinct, novel flavors--grape and cherry. When initially tested for FNC before going on the diet, rats should have no preference between the grape and cherry flavors. For each rat, one flavor (e.g., grape) will be mixed in sugar water (high calorie), and the opposite flavor mixed in water with artificial sweetener, which is equally sweet but has no calories. After giving the rats several opportunities to consume each flavor separately, we will test for FNC again by giving the rats a choice between grape and cherry--this time each mixed with only plain water. If they learned an association between the flavor paired with postingestive rewards from sugar, they will show a preference for that flavor over the opposite. The strength of the preference will allow us to determine sensitivity to FNC.

Anticipated Outcomes

The rationale for this experimental design is that by measuring FNC in selectively bred rats before they become obese, and then measuring it again after, we can determine a directional

link between the two, thereby clarifying whether FNC sensitivity is a preexisting factor in obesity or vice versa. This methodology is feasible because these measures of FNC have already been used in previous studies by Professor Myers and by other researchers, so this is considered a valid and reliable test.

I anticipate that the data will allow us to determine a correlational relationship between obesity and flavor-nutrient conditioning. The relationship we discover will then be shared, both at the Kalman Symposium and other national conferences, like the Society for Study of Ingestive Behavior and the Eastern Psychological Association.

Discussion

This research has the potential to bolster our understanding of obesity. As discussed earlier, the obesity epidemic is only getting worse and more widespread. This research could help identify a new psychological link to obesity.This research won't prevent obesity altogether, but could give additional knowledge towards understanding this complex issue and an explanation as to why we as a society are drawn to sugary, fatty foods. Eventually knowledge about this problem could possibly alter the treatment of obesity is valuable and worth the investment, and my proposal has the potential for real impact.

During the course of the ten weeks, I expect to spend a minimum of forty hours per week on this project, both in the laboratory handling the rats and conducting procedures and in the library analyzing data and interpreting results. We will also read relevant literature and scholarly journals that allow us to connect our results to broader scientific literature. Professor Myers' lab already has the necessary equipment we will need and the right setting for the rats, so little resources will be needed from the University. Since ten weeks is a relatively short amount of time for this research, I plan to get preliminary experience in the lab throughout the spring semester, so that I will already be trained to work in the lab and we could use our time over the summer effectively.

Professor Myers and I already have a great working relationship, as he was my professor and I am now one of four students who does research with him during the year. We regularly communicate via Zoom, and GroupMe, and I feel comfortable enough to send him a text with any quick questions. With this in mind, I anticipate a strong mentoring relationship. Along with this, Professor Myers plans to be working on campus all summer and frequently in the lab. This allows for many opportunities to see each other informally, and we will have formal meetings in person at least once a week, likely more. We expect to be doing in person work, but this experiment is feasible with only one person in the lab at a time if need be. If unable to have in-person meetings due to COVID-19, Zoom can be our primary method of communication. We hope to be able to continue building on this research into next year, as I feel this has the potential to become the focus of my honors thesis throughout my senior year.

Works Cited

Levin, B. E., Dunn-Meynell, A. A., Balkan, B., & Keesey, R. E. (1997). Selective breeding for diet-induced obesity and resistance in Sprague-Dawley rats. *The American Physiological Society,* 725-730.

Understanding adult overweight & obesity. (n.d.). Retrieved February 23, 2021, from https://www.niddk.nih.gov/health-information/weight-management/adult-overweight-obesity

Wald, H. S., & Myers, K. P. (2015). Enhanced flavor–nutrient conditioning in obese rats on a high-fat, high-carbohydrate choice diet. *Physiology & Behavior, 151*, 102-110. doi:10.1016/j.physbeh.2015.07.002