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Assessment of the motivation to use artificial sweetener among individuals with an eating disorder

Janet Schebendach [a, d, e, *, 1], Diane A. Klein [b, 1], Laurel E.S. Mayer [a, d, e], Evelyn Attia [a, d, e], Michael J. Devlin [a, d, e], Richard W. Foltin [c, d, e], B. Timothy Walsh [a, d, e]

[a] Eating Disorders Research Unit, New York State Psychiatric Institute, USA
[b] New York University, Langone Medical Center, Department of Psychiatry, USA
[c] Division on Substance Abuse, New York State Psychiatric Institute, USA
[d] New York State Psychiatric Institute, 1051 Riverside Drive, Unit 98, New York, NY 10032, USA
[e] Columbia University Medical Center, New York, NY 10032, USA

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ABSTRACT

Eating disorders are associated with a range of abnormalities in eating behavior. Some individuals consume large amounts of non-caloric artificial sweeteners, suggesting abnormalities in appetitive responding. The current study aimed to quantify hedonic and motivating effects of artificial sweetener in individuals with and without an eating disorder. Two laboratory studies were conducted. Hedonic preference was estimated using the number of artificial sweetener packets (0–10) added to unsweetened cherry flavored Kool-Aid (study 1). Motivation to obtain sweetener was assessed by a progressive ratio (PR) work task (study 2). Ninety-three participants (25 anorexia nervosa restricting type (AN-R), 23 AN binge/purge type (AN-B/P), 20 bulimia nervosa (BN), and 25 normal controls (NC)) completed the study. No significant difference in hedonic preference was found among participant groups. Work completed at the PR task ranged from 0 to 9500 key-board presses. The AN-B/P group had a significantly higher breakpoint and performed significantly more work for sweetener compared to the BN and NC groups. Among AN-B/P and AN-R participants, the preferred number of Equal packets was significantly correlated with the breakpoint and total work. The increased amount of work for sweetener among individuals with AN-B/P supports an enhanced reward value of sweet taste in this population, and suggests that the characteristic food avoidance in AN cannot be accounted for by decreased reward value of all taste-related stimuli. This study also supports the novel application of a PR ratio task to quantify the motivating effect of sweet taste among individuals with an eating disorder.

1. Introduction

Anorexia Nervosa (AN) is a severe psychiatric illness characterized behaviorally by self-starvation. While the name “anorexia,” literally referring to “loss of appetite,” is understood to be a misnomer (American Psychiatric Association, 1994), few studies have documented appetite or appetitive responding in AN. Most studies measuring food intake among individuals with AN report that there is reduced food intake (Hadigan et al., 2000) with smaller meal size (Mayer, Schebendach, Bodell, Shingleton, & Walsh, 2012) and reduced intake of energy dense foods (Rolls et al., 1992; Schebendach, Mayer, Devlin, Attia, & Walsh, 2012; Schebendach et al., 2008). Self-reported hunger and fullness have been found to respond abnormally and inconsistently to food intake. Cognitive factors appear to be important, and fear of fatness likely serves as a strong inhibitor of food intake (Heaner & Walsh, 2013). Thus, although patients are preoccupied with food (Blechert, Feige, Joos, Zeeck, & Tuschen-Caffier, 2011), they actually eat little.

One possible exception to this behavioral pattern is that of artificial sweetener intake. We reported (Klein, Schebendach, Devlin, Smith, & Walsh, 2006) and others later substantiated (Brown & Keel, 2013; Klein, Boudreau, Devlin, & Walsh, 2006; Marino et al., 2009) use of large amounts of low-calorie sweetened products, such as diet beverages, chewing gum, and packets of artificial sweetener, among at least a proportion of patients with

* Corresponding author. New York State Psychiatric Institute, 1051 Riverside Drive, Unit 98, New York, NY 10032, USA.
E-mail address: js2202@cumc.columbia.edu (J. Schebendach).
[1] These authors contributed equally to this work.

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AN. While this behavior is consistent with the desire to avoid calories, it also implies that patients desire sweet tastes, raising the question of whether artificial sweetener use represents a marker of appetitive drive in people with AN. Sham feeding has been a useful method of assessing the motivational impact of the sweetness of a solution in animals (Davis, Smith, Singh, & McCann, 1999; Smith, 2000). In order to better assess appetitive drive, we developed a progressive ratio task.

The field of behavioral economics provides methods by which to measure the motivation to engage in behaviors like smoking (Epstein, Bulik, Perkins, Caggiula, & Rodefer, 1991), drug use (Comer et al., 1998), physical activity (Saelens & Epstein, 1999; Schebendach, Klein, Foltin, Devlin, & Walsh, 2007), and eating (Bodell & Keel, 2015; Epstein & Leddy, 2006; Epstein, Leddy, Temple, & Faith, 2007; Haynos, Hill, & Fruzzetti, 2016; Schebendach, Broft, Foltin, & Walsh, 2013) in a laboratory setting. In general, these laboratory paradigms quantify motivation in terms of the amount of "work" an individual is willing to expend to gain access to a specific a substance or behavior, often referred to as a reinforcer (Hodos, 1961). In humans, effort or "work" is often based on the number of taps on a computer keyboard. Specifically, the progressive ratio (PR) task measures motivation by requiring the participant to expend progressively increasing amounts of work to gain access to a reinforcer (Roane, 2008). The PR breakpoint is defined as the number of responses completed for a reward before the participant stops working; the more motivating a stimulus is, the greater the breakpoint (Hodos, 1961).

The current study aimed to quantify the hedonic and motivating effects of artificial sweetener among participants with AN and BN as compared with a healthy control population. To do so, we adapted the PR task to allow participants to work for access to artificial sweetener packets in a laboratory setting.

2. Methods

2.1. Participants

Patients meeting the *Diagnostic and Statistical Manual of Mental Disorders, 4th edition* (American Psychiatric Association, 1994) criteria for AN, amenorrhea excepted (Mitchell et al., 2005) and BN, and healthy normal controls (NC) participated in a laboratory study conducted by the Eating Disorders Research Unit at the NYSPI, Columbia University Medical Center from August 2008 to March 2013. Recruited participants were between the ages of 16 and 50 years. Exclusion criteria for AN and BN participants included significant medical illness, pregnancy or lactation, acute risk for suicide, current use of psychotropic medication or medication known to affect eating behavior, drug or alcohol abuse six months prior to study, and current or lifetime history of schizophrenia, bipolar disorder, or other psychotic disorder. Exclusion criteria for NC participants included a body weight less than 80% or greater than 120% of ideal body weight (Metropolital Life, 1959), significant medical illness, pregnancy or lactation, current or past psychiatric illness, lifetime history of an eating disorder, and current use of medication known to affect eating behavior. The New York State Psychiatric Institute (NYSPI)/Columbia University Department of Psychiatry Institutional Review Board approved this study. Written informed consent was obtained from participants prior to study.

Patients with AN were recruited from the Eating Disorders Research Unit (EDRU) of the New York State Psychiatric Institute, where they were concurrently receiving inpatient treatment for their disorder. The EDRU offers a behaviorally oriented treatment protocol aimed at weight restoration to a BMI of approximately 19.5 kg/m^2 and normalization of eating behavior. Hospitalized patients are not permitted to use artificial sweeteners or artificially sweetened products (e.g., diet beverages) on the inpatient unit but they are not prevented from doing so during off-unit activities. Inpatients participated in this study at varying time points during their hospital stay. Outpatients and controls were recruited through flyers posted on the medical campus and local and online media. Participants were told we were conducting a study of response of people with and without eating disorders to sweeteners without calories.

2.2. Taste test (hedonic assessment)

The first part of the study consisted of tasting and rating unsweetened Kool-Aid® (Kraft Foods, Kraft-Heinz Company, Northfield, IL) mixed with varying amounts of artificial sweetener. A series of eleven clear plastic cups was arranged horizontally along a table top. Each cup contained 16 fl. oz. of unsweetened cherry flavored Kool-Aid dissolved in distilled water, and a drinking straw. Cup "zero" was positioned on the far left and contained unsweetened Kool-Aid only. Cups numbered one through ten were positioned to the right of cup zero and had a corresponding number of Equal® packets (Merisant Company, Chicago, IL) placed directly in front of it, e.g., one packet in front of cup one, two packets in front of cup two, etc. To ensure that all packets were visible, the individual packets were lined up vertically in front of the corresponding cup. Participants were instructed to thoroughly empty the specified number of packets into the 16 fl. oz. cup of unsweetened Kool-Aid and stir well (with the straw). A pitcher containing a baking soda and water rinse (23.7 g per 1000 ml distilled water), a rinse cup, and a spit bucket were also situated on the table. Unsweetened Kool-Aid was prepared, refrigerated the evening prior to study, and removed from the refrigerator two hours prior to study in order to be served at approximately 50 °F.

For each beverage tasted, participants were asked to rate their perceived sweetness, liking, and wanting of the solution on visual analogue scales (VASs). These VASs consisted of pencil and paper assessments that contained the questions: "How much did you LIKE what you just tasted?", "How much do you WANT MORE of what you just tasted?", and "How SWEET did what you just tasted seem to you?" Beneath each question was a 100-mm horizontal line anchored by "not at all" on the left and "extremely" on the right. Participants were asked to indicate their answers to these questions by placing a vertical mark along the horizontal line to estimate their experience. VAS ratings for each solution were made on a separate piece of paper.

After tasting and rating a beverage, participants were asked to thoroughly rinse and spit before proceeding to the next beverage. Although participants could taste and rate all 11 beverages, they were instructed to taste and rate the beverage that was one past the beverage they considered to be too sweet. For example, if they considered beverage five (16 fl. oz. unsweetened Kool-Aid mixed with five packets of Equal) to be too sweet, they were asked to go on to taste and rate the 6th beverage.

After providing standardized instructions, the research assistant left the study room and continued to observe the subject via a closed circuit monitoring system. After completion of the task, the participant was instructed to ring a wireless doorbell.

2.3. Progressive ratio computer task (assessment of motivation)

The second part of the study consisted of a progressive ratio (PR) computer task in which participants could earn Equal packets to add to their choice of an unsweetened beverage (Kool-Aid, coffee, or tea) immediately upon completion of the task. The PR task consisted of 10 trials and "work" consisted of finger presses on a computer keyboard. The work required in the first trial was 50