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Assessment of the Motivation to Use Artificial Sweetener Among Individuals with an Eating Disorder

Janet Schebendach, Ph.D, R.D.^{a,†}, Diane A. Klein, M.D.^{b,†}, Laurel E.S. Mayer, M.D.^a, Evelyn Attia, M.D.^a, Michael J. Devlin, M.D.^a, Richard W. Foltin, Ph.D.^c, and B. Timothy Walsh, M.D.^a

New York State Psychiatric Institute, 1051 Riverside Drive, Unit 98, New York, NY 10032, USA

Columbia University Medical Center, New York, NY 10032, USA

^aEating Disorders Research Unit, New York State Psychiatric Institute USA

^bNew York University, Langone Medical Center, Department of Psychiatry, USA

^cDivision on Substance Abuse, New York State Psychiatric Institute, USA

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 to 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.

Corresponding author: J. Schebendach, PhD, New York State Psychiatric Institute, 1051 Riverside Drive, Unit 98, New York, NY 10032, USA, js2202@cumc.columbia.edu. Tele: 646-774-8014, Fax: 646-774-5854.

[†]These authors contributed equally to this work.

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Keywords

anorexia nervosa; bulimia nervosa; eating disorders; reward; ingestive behavior; motivation; progressive ratio task; hedonics; artificial sweetener

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 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 (Schebendach, Klein, Foltin, Devlin, & Walsh, 2007); (Saelens & Epstein, 1999), 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.

METHODS

Participants

Patients meeting the *Diagnostic and Statistical Manual of Mental Disorders, 4th edition* (American Psychiatric Association, 1994) criteria for AN, amenorrhea excepted (Mitchell, Cook-Myers, & Wonderlich, 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 (Metropolitan 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/m² 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.

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 degrees Fahrenheit.

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.

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 keyboard presses to earn one packet of Equal artificial sweetener. An additional 200 keyboard presses were required to complete each subsequent trial and earn an additional packet of Equal. Thus, the first completed trial required 50 keyboard presses and the remaining trials required 250 presses, then 450, 650, 850, 1050, 1250, 1450, 1650, and 1850 responses. To earn the maximum amount of 10 Equal packets, the participant had to complete 10 trials and perform 9,500 keyboard presses within a 60-

min period. The breakpoint, defined as the largest ratio completed before a participant stopped working, was the primary measure of motivation.

Both the taste test and the progressive ratio task were conducted on the Biological Studies Unit at the NYSPI. NC participants and BN outpatients (n=13) were discharged after study completion. Hospitalized AN (n=25) and BN (n=7) patients were escorted back to the inpatient unit and were not permitted to take any unconsumed beverage or Equal packets with them.

Outcome Measures

Hedonic Assessment—Participants were asked to select the Kool-Aid solution that contained their preferred number of Equal packets (1 to 10) and VAS ratings (0 to 100 mm scale) for liking, wanting, and sweetness intensity of the preferred solution were determined.

Assessment of Motivation—Results of the PR computer task included the PR breakpoint, total work performed (i.e., the total number of key board presses), and the number of Equal packets earned.

Statistical Analysis

One-way between-groups analysis of variance (ANOVA) was conducted to assess differences in clinical characteristics and hedonic outcome measures among participant groups. The Kruskal-Wallis test was conducted to assess between-group differences in PR task outcome measures. Post-hoc analyses were performed using Bonferroni-Hochberg criteria (Rom, 2013). An independent samples t-test was used to examine differences in admission BMI and length of hospitalization between the AN-R and AN-BP subtypes.

Spearman rank correlations were used to describe relationships between hedonic and motivational outcome measures. Pearson correlations between BMI (time of study) and the number of packets preferred (taste test) were determined for each participant group.

For each participant group, a simple linear regression model was constructed with the PR breakpoint as the dependent variable and the preferred number of Equal packets (taste test) as the independent variable.

Values are expressed as means $\pm$ the standard deviation (SD) for parametric data, and the median and interquartile range (IQR) for non-parametric data. Statistical significance was set at the $p < 0.05$ level; all tests are two-tailed. Statistical analyses were performed by IBM SPSS® Statistics for Windows, Version 23.0 (Armonk, N.Y., 2012).

RESULTS

Ninety-three individuals completed the study: 25 AN-restricting type (AN-R), 23 AN-binge/purge type (AN-B/P), 20 BN, and 25 normal controls (NC). Four additional participants were recruited and consented but did not complete the study. Of these, one BN participant voluntarily withdrew consent, two hospitalized AN patients were withdrawn at the

recommendation of the inpatient clinical team, and one NC was withdrawn due to concerns that the participant had restrained/restrictive eating behaviors.

Race and ethnicity of participants were as follows: 25 Caucasians in the AN-R group; one Hispanic and 22 Caucasians in the AN-B/P group; one Native American, one African American, one African American/Hispanic, and 17 Caucasians in the BN group; two African Americans and 23 Caucasians in the control group. Ninety-one participants were female and two (one with BN and one with AN-B/P) were male.

Participants ranged in age from 17 to 45 years, with a mean of 25.7 ± 6.6 years and no significant differences among the participant groups. The BMI of AN patients ranged from 11.8 to 18.7 kg/m^2 upon admission, and 12.5 to 22.4 kg/m^2 on the day of study; there was no significant difference in the mean BMIs of AN subtypes at either time point. As expected, the mean BMI of AN patients was significantly lower than that of BN and NC participants; however, the mean BMI of BN and NC participants did not differ significantly (Table 1).

At the taste test, participants indicated that, on average, 4.9 ± 3 Equal packets was the best number to add to unsweetened Kool-Aid (Table 2). No significant differences in number of sweetener packets preferred, or in VAS ratings of liking, wanting, or sweetness intensity of the preferred solution, were observed. No significant correlations between BMI (time of study) and the number of sweetener packets preferred were found within participant groups (data not shown).

Participants worked at the PR task to obtain Equal packets that they could add to their choice of an unsweetened beverage. Work ranged from 0 to 9500 key-board presses and there were significant differences in total work and the PR breakpoint among the groups. As indicated (Table 2), the AN-B/P group performed significantly more work, earned significantly more Equal packets, and had a significantly higher breakpoint compared to the BN and NC groups. These motivational outcome measures, however, did not differ significantly between the AN subtypes.

Linear regression results indicated that the number of Equal packets preferred at the taste test was a significant predictor of the PR breakpoint in the AN-R and AN-BP groups ($F(1,23) = 13.397, p = 0.001, R^2 = 0.368$; and $F(1,21) = 18.318, p = 0.000, R^2 = 0.466$, respectively). In contrast, the number of packets preferred failed to predict the breakpoint in BN and NC participants ($F(1,18) = 2.896, p = 0.106, R^2 = 0.139$; and $F(1,23) = 1.056, p = 0.315, R^2 = 0.044$, respectively).

Among participants with AN-B/P, the preferred number of Equal packets (taste test) was significantly correlated with the breakpoint ($r=0.701, p < 0.01$) and total work ($r=0.701, p < 0.01$). The VAS measure of wanting was significantly correlated with the breakpoint ($r=0.521, p < 0.05$) and total work ($r=0.521, p < 0.05$), and the VAS measure of liking was significantly correlated with the breakpoint ($r=0.491, p < 0.05$) and total work ($r=0.491, p < 0.05$); however, the VAS measure of sweetness failed to correlate with either the breakpoint ($r=0.324, p = 0.132$) or total work ($r=0.324, p = 0.132$). Among participants with AN-R, the preferred number of Equal packets was also significantly correlated with the breakpoint ($r=0.580, p < 0.01$) and total work ($r=0.537, p < 0.01$) but no significant correlations were

found between VASs and motivational measures (data not shown). Finally, among BN and NC participants, no significant correlations were found between any of the hedonic and motivational measures (data not shown).

DISCUSSION

Clinical impressions and self-report measures indicate that patients with eating disorders use more artificially sweetened products than do their healthy counterparts (Brown & Keel, 2013; Klein et al., 2006; Klein, Schebendach, Brown, Smith, & Walsh, 2009; Klein, Schebendach, Gershkovich, Smith, & Walsh, 2010; Marino et al., 2009). To our knowledge, this is the first study to assess motivation to use artificial sweetener among people with eating disorders. This is among the few studies showing avidity, rather than aversion, towards a food-related substance among people with AN.

Three main findings emerge: (1) patients with AN-B/P subtype show greater PR performance on all measures of motivation (packets earned, total work, and breakpoint) compared with BN and NC groups; (2) among AN groups, measures of motivation are associated with the preferred number of equal packets at the taste test (hedonic measure); (3) VAS hedonics failed to distinguish among AN, BN and NC populations.

Greater motivation for sweet reward among the AN-BP subtype compared with normal-weight BN and with NC participants suggests a role for low body weight and/or food deprivation in this phenomenon. Among humans, the Keys study (Franklin, Scheile, & et al., 1948) describes over-use of gum and condiments among food-restricted men reduced to about 75% of their prior body weights, suggestive of starvation-induced enhanced motivation for orosensory stimulation. While to our knowledge the current study is the first attempt to examine reinforcing value of non-nutritive orosensory stimulation in people, Epstein and Raynor have shown food deprivation to increase the relative reinforcing value of food in a computer choice paradigm similar to our own (Raynor & Epstein, 2003). Among laboratory animals, increased appetitive responding toward various drugs of abuse has repeatedly been demonstrated in chronically food-restricted animals (Cabeza de Vaca & Carr, 1998), as has been speculated to put food-restricted people at risk of binge eating episodes (Carr, 2016). In the animal model of sham feeding, reducing the duration of food deprivation limits the duration of intake, supporting a relationship at least between short-term food restriction and drive for sweet reward (Weingarten, Duong, & Elston, 1996).

Our previous attempt to model sham feeding in a laboratory “sip and spit” paradigm using Kool Aid solutions sweetened with varying concentrations of aspartame (Klein, Schebendach, Gershkovich, Smith, et al., 2010) demonstrated feasibility of this novel paradigm, but there were no differences among AN and NC, and AN and BN participants (Klein et al., 2009). One notable difference between our modified sham feeding paradigm and the current study is that the latter allows patients to handle and administer their own Equal packets, versus presenting them with pre-prepared solutions. It is possible that use of discrete packets, which patients may find less anxiety provoking than pre-mixed solutions, promoted greater use among the underweight participants, though it is also likely that the paradigms measured two different parameters of intake.

The lack of difference between participants with AN-R and BN or NC with respect to breakpoint, total work performed, and sweetener packets earned suggests that low body weight alone is not sufficient to increase laboratory measures of motivated behavior. An area of great general interest in eating research is whether non-nutritive sweeteners, increasingly prevalent in our diet, could actually promote overeating and overweight by virtue of dissociation of sweet taste and calories and/or by stimulating appetite directly (Brown & Keel, 2013; Mattes & Popkin, 2009). If true, it is conceivable that high-level sweetener use serves a binge-promoting function in eating disorders patients (Brown & Keel, 2013), potentially to the extent of serving as a “gateway behavior” in the transition from a restricting to a binge-purge form of their eating disorder, a proposal that would require much further research to substantiate.

Hedonic Assessment

An additional aim of this study was to compare the hedonic effects of artificial sweetener across populations. Contrary to prediction, we did not find a difference in the number of Equal packets preferred during the taste test among the diagnostic groups, nor did we find a difference in self-reported liking, wanting or perceived sweetness per VAS measures for the solution of preference. The failure of VASs to differentiate among participant groups may be due to the incomplete understanding of the concepts of liking, wanting, and perceived sweetness, and/or difficulty providing accurate self-assessment of these subjective states. More sophisticated assessments including neuroimaging may provide useful insight into hedonic responsiveness in eating disorders (Frank, Shott, Hagman, & Mittal, 2013).

Study Limitations

The current study has several limitations. First, methodological differences in the design of operant tasks make it difficult to compare findings across studies. Our study used a PR ratio schedule where effort increased by 200 keyboard taps. Although this PR schedule is identical to that which was used to assess motivation for exercise in patients with AN (Klein, Schebendach, Gershkovich, Bodell, et al., 2010; Schebendach et al., 2007) and food in patients with BN (Schebendach et al., 2013), it is possible that the use of a different PR schedule, or use of a variable ratio schedule, may have yielded different findings. Second, the PR breakpoint task allowed participants to work exclusively for Equal packets. It is possible that other types (e.g., saccharin, sucralose, etc.) or brands of artificial sweeteners may have yielded different findings. Third, hospitalized patients had restricted access to artificial sweeteners. Given that out-patients and controls had free access to these products, it is possible that they were less willing to work for Equal packets in the laboratory setting. Fourth, because caffeinated beverages are restricted on the inpatient unit, it is possible that patients were willing to participate in the PR task for the purpose of gaining access to caffeine (in coffee and tea) as well as artificial sweetener. Fifth, all participants were asked to sip, taste, rate, and spit out samples of cherry flavored Kool-Aid sweetened with up to 10 packets of Equal immediately prior to the PR task. Although post-ingestive effects were minimized by the modified sham feeding design (i.e., sip and spit), it is possible that willingness to work for Equal packets was influenced by exposure to sweet taste immediately before the PR task. A study design that provided a time interval between the taste test and the PR task may have yielded more robust findings. Sixth, all participants with

AN were recruited from the same inpatient unit. The absence of a practical way to limit communication among inpatients may have allowed “contagion”, so the experience of one patient may have affected that of another. In contrast, participants with BN and controls were recruited from the community and cross-communication about the study was highly unlikely. Seventh, the VAS may not have been the most appropriate measure of sweet hedonics. The VAS is not well validated for comparison across different types of participants. It has been found to miss important differences between healthy weight and obese subjects (Bartoshuk, Duffy, Hayes, Moskowitz, & Snyder, 2006; Kalva, Sims, Puentes, Snyder, & Bartoshuk, 2014) and may do so in our clinical population. Finally, underweight AN patients were at varying stages of weight restoration. Motivation to work for sweetener may have differed if these individuals were studied prior to nutrition rehabilitation.

Conclusion

This study supports increased appetitive motivation in patients with AN, distinguishing subtypes, and the novel application of a PR ratio operant task to quantify motivation to gain access to sweet taste in individuals with eating disorders. Patients with AN-B/P subtype worked the hardest to obtain Equal packets, and preference for sweet taste (hedonics) was correlated with motivated behavior (breakpoint and total work) in the AN groups. The increased amount of work for sweetener among individuals with AN suggests that the reward value of sweetener devoid of calories is enhanced, suggesting that the characteristic food avoidance in AN cannot be easily accounted for by decreased rewarding value of sweet taste-related stimuli. To the extent that work for sweetener within the PR task was also positively associated with self-reported history of sweetener use suggests that this novel laboratory paradigm captures an important motivational component for sweet tastes that varies among individuals with anorexia nervosa.

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Table 1

Clinical characteristics in anorexia nervosa restricting subtype (AN-R), anorexia nervosa binge/purge subtype (AN-B/P), bulimia nervosa (BN), and normal control (NC) participants.

Clinical Characteristics	AN-R (n=25)	AN-B/P (n=23)	BN (n=20)	NC (n=25)
Age (years) ^a	25.9 ± 8.1	26.7 ± 6.5	24.3 ± 4.6	25.6 ± 6.4
BMI (kg/m ²) at time of study ^b	17.2 ± 2.5 ^{w, x}	17.9 ± 1.5 ^{y, z}	21.4 ± 2.6 ^{w, y}	21.1 ± 1.8 ^{x, z}
BMI (kg/m ²) upon admission in AN patients ^c	15.3 ± 1.7	15.9 ± 1.5		
Days hospitalized immediately prior to study in AN patients ^d	33.1 ± 32.8	29.3 ± 33.4		
Duration of Illness (months) ^e	122.8 ± 102.1	134.1 ± 73.9	98.8 ± 58.3 ^f	

All values are means ± SD

^aANOVA for age: $F(3,89) = 0.510$, $p = 0.677$

^bANOVA for BMI at time of study: $F(3,89) = 24.241$, $p < 0.001$; means with the same superscripts (^w, ^x, ^y, ^z) are significantly different by post-hoc Bonferroni-Hochberg criteria

^cIndependent samples t -test: $t(46) = -1.435$, $p = 0.158$

^dIndependent samples t -test: $t(46) = 0.395$, $p = 0.695$

^eANOVA for duration of illness: $F(2,64) = 0.984$, $p = 0.379$

^fBN sample: n=19

Table 2

Progressive ratio (PR) computer task performance and hedonic (taste) assessment in anorexia nervosa restricting subtype (AN-R), anorexia nervosa binge/purge subtype (AN-B/P), bulimia nervosa (BN), and normal control (NC) participants.

	AN-R (n=25)	AN-B/P (n=23)	BN (n=20)	NC (n=25)	Significance ^c
Hedonic Assessment: Taste Test					
Number of Equal [®] packets preferred	4.9 ± 3.3	6.0 ± 3.4	4.8 ± 3.1	3.9 ± 2.2	$F(3,89) = 1.966, p = 0.125$
VAS rating: liking (100 mm) ^a	57.9 ± 24.9	61.6 ± 34.2	48.5 ± 27.7	57.2 ± 26.2	$F(3,89) = 0.801, p = 0.496$
VAS rating: wanting (100 mm) ^a	49.6 ± 30.0	53.7 ± 35.7	40.6 ± 28.5	50.3 ± 27.3	$F(3,89) = 0.703, p = 0.552$
VAS rating: sweetness (100 mm) ^a	62.2 ± 24.1	65.4 ± 23.2	61.5 ± 23.5	58.3 ± 24.0	$F(3,89) = 0.354, p = 0.786$
Motivational Assessment: PR Task					
Packets earned ^b	3 (5)	4 (3) ^{y,z}	2 (2) ^y	3 (3) ^z	$\chi^2(3) = 11.206, p = 0.011$
Total work (keyboard presses)	750 (1825)	1400 (2550) ^{y,z}	300 (700) ^y	750 (1225) ^z	$\chi^2(3) = 11.748, p = 0.008$
Breakpoint	450 (850)	650 (600) ^{y,z}	250 (400) ^y	450 (500) ^z	$\chi^2(3) = 10.956, p = 0.012$

^a VAS rating for Kool-Aid prepared with preferred number of Equal packets

^b 1 Equal packet earned per completed trial

^c Significance determined by ANOVA for hedonic variables and the Kruskal-Wallis test for motivational variables

Values are means ± SD for hedonic variables and the median and interquartile range (IQR) for motivational variables.

For each measure, values with the same superscripts (y, z) are significantly different by post-hoc Bonferroni-Hochberg criteria.