Hyper-palatable Food Consumption during Binge Eating Episodes: A Comparison of Intake during Binge Eating and Restricting

By

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Abstract

Background: Binge eating is considered a maladaptive behavior associated with reduced quality of health and functioning. Affect-based models of binge eating propose that binge eating may serve to reduce negative affect. These processes may be facilitated by the consumption of hyper-palatable foods (HPF) during binge eating. However, intake from HPF during binge eating has not been empirically investigated using a standardized definition for HPF. The aim of the proposed study was to elucidate the degree to which HPF are consumed during binge episodes, and to test the difference in percentage of caloric intake from HPF between binge episodes and restricting episodes.

Methods: The sample included adults (N=147, 83% women) diagnosed with sub-threshold (41%) or full-threshold (59%) bulimia nervosa (BN) who participated in a larger longitudinal study on eating disorders. At baseline, participants provided descriptions of foods consumed during binge and restricting episodes via the Eating Pathology Symptoms Inventory – Clinician Rated Version. Criteria from a quantitative definition of HPF were applied to foods consumed during binge and restricting episodes. A Wilcoxon matched-pairs signed-rank test was used to test the difference between percentage of energy intake from HPF during binge episodes relative to restricting episodes.

Results: There was a significant difference between the median percentage of energy intake from HPF during binge episodes compared to restricting episodes (95% vs 61%; Z= -7.35, $p<.0001$), where binge episodes involved a greater percentage of energy intake from HPF.

Conclusion: Results from the current study support the assumption of theoretical models of binge eating, indicating that HPF may be primarily consumed during binge episodes. Percentage of energy intake from HPF may be greater during binge episodes relative to restricting episodes among individuals with BN. Overall, the study suggests that HPF may be specifically targeted for consumption during binge episodes.

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Introduction

Binge eating is defined as the consumption of an abnormally large amount of food in a discrete period of time accompanied by a sense of loss of control over eating. Binge eating is an impairing behavior present in several eating disorders, including bulimia nervosa (BN), binge eating disorder (BED), and anorexia nervosa binge eating/purging subtype (American Psychiatric Association, 2013). Importantly, binge eating has been associated with a range of medical and psychological problems (Mond et al., 2006; Smink et al., 2012). For example, binge eating has been associated with health concerns including obesity and type 2 diabetes (Johnson et al., 2001; Udo & Grilo, 2019; Vainik et al., 2019). Binge eating has also been associated with general and eating-related psychopathology (Hay, 2003), impairments in social functioning, and reduced general well-being (Brownstone et al., 2013).

Leading models of binge eating assume that highly palatable and rewarding food is primarily consumed during binge episodes; however, this assumption lacks strong empirical support. Specifically, prominent models of binge eating are affect-regulation focused and suggest that binge eating provides a temporary distraction from aversive emotions (Haedt-Matt & Keel, 2011; Heatherton & Baumeister, 1991; Polivy & Herman, 1993). An underlying assumption of affect-based models is that highly rewarding foods are primarily consumed during binge episodes, and may serve to temporarily enhance positive affect and/or distract from negative affect (Small et al., 2003; van Strien et al., 2019; Wonderlich et al., 2018). Research generally supports the premise that certain foods may be particularly rewarding to consume because they have characteristics of enhanced palatability. For example, although most naturally occurring foods are considered palatable, or pleasant to taste, eat, and ingest (Cox et al., 2018; Erlanson-Albertsson, 2005; Yeomans, 1998), highly palatable foods are considered potent rewards capable of excessively stimulating brain reward systems (Berridge, 2007; Macedo et al., 2016). Thus, it is possible that highly palatable foods may be the primary target of binge episodes. However, although a considerable body of literature has examined food intake during binge episodes, there has been a lack of specificity in conceptualization and measurement of highly palatable foods. The lack of specificity

hinders conclusions regarding whether food with enhanced palatability or food in general is targeted during binge episodes. The distinction is important to ascertain because certain foods with artificially enhanced palatability may be difficult to stop eating. Consumption of foods that are difficult to stop eating during binge episodes may contribute to disinhibited eating and perceived loss of control over eating.

Prior studies that examined food intake during binge episodes have focused on 1) intake of specific macronutrients (e.g., fat; sugar), or 2) consumption of foods from specific categories (e.g., sweets), under the assumption that specific macronutrients alone, or certain categories of foods, are measures of foods with enhanced palatability (Alpers & Tuschen-Caffier, 2004; Dalton et al., 2013b; Hadigan et al., 1989; Yanovski et al., 1992). Although the prior studies may inform on typical dietary intake during binge eating (e.g., macronutrient and caloric intake), or intake of groups of foods, they cannot directly inform whether foods consumed during binge episodes have enhanced palatability. Foods with enhanced palatability, termed hyper-palatable foods (HPF), contain combinations of palatability-inducing ingredients, namely fat, sugar, salt, and/or carbohydrates, at moderate to high levels that synergistically create an artificially enhanced eating experience (Bolhuis et al., 2015, 2016; Drewnowski, 1993; Drewnowski et al., 1989; Drewnowski & Greenwood, 1983; Small et al., 2003). When consumed, HPF may activate brain reward neurocircuitry and bypass physiological satiety mechanisms, leading to overconsumption despite satiety (Casperson et al., 2019; Erlanson-Albertsson, 2005; Yeomans, 1998; Yeomans et al., 2004). A central aspect of HPF is that the combination of palatability-inducing ingredients, rather than elevated levels of one ingredient alone, produce hyper-palatability (Abdallah et al., 1998; Bolhuis et al., 2015, 2016; Drewnowski, 1993; Drewnowski et al., 1989; Drewnowski & Greenwood, 1983; Méjean et al., 2014; Warwick & Schiffman, 1990). For example, a tablespoon of oil (a fat) ingested alone would not be palatable or pleasant to ingest. However, oil combined with sodium at moderate to high levels, in foods such as pizza, would be considered hyper-palatable. Thus, because hyper-palatability is created through the combination of ingredients, measures of individual

macronutrients (e.g., fat) that were used in the prior literature are not measures of hyper-palatability (Bolhuis et al., 2016; Drewnowski et al., 1989; Macedo, Freitas, & Silva Torres, 2016). In addition to research on specific macronutrients, research has also used food categories to quantify intake during binge episodes, such as snack foods or sweets. These general food categories lack specificity and may simultaneously miss identifying foods that *are* hyper-palatable but not contained in a category, and erroneously include foods that are *not* hyper-palatable but align with a category. For example, using a category of snack foods as a measure of palatable foods may lead researchers to miss identifying many meal-based items that are HPF, such as pizza and pasta. Furthermore, using a category of snack foods as a measure of palatable foods may lead to the inclusion of foods that are not hyper-palatable, such as a raw banana and unsalted nuts. Thus, using food categories may lead to a lack of specificity in identifying foods consumed during binge episodes that may be hyper-palatable. Taken together, quantifying individual macronutrient intake does not directly address palatability, and using general food categories lacks specificity and scope in identifying HPF, which may result in under or over estimation of HPF intake during binge episodes. Below, we describe the prior research conducted on food consumed during binge episodes, followed by the current study, which was designed to address limitations in prior work by characterizing hyper-palatable food intake using a standardized, quantitative definition.

Prior Research on Food Intake During Binge Eating

Research on food intake during binge episodes has used two main methodologies: laboratory test-meals and dietary self-report methods**.** During laboratory test-meals, individuals with BN or BED are instructed to binge eat and healthy controls are instructed to overeat during a provided meal. Most studies have examined between-subject differences in binge eating among individuals with BN or BED compared to overeating behavior of healthy non-eating disorder controls. However, some studies also tested within-subjects differences in eating behavior, which was measured by multiple test-meal conditions on non-consecutive days in which individuals were instructed to 1) binge or overeat, or 2) eat as they normally would (considered a non-binge episode). Laboratory test-meals consist of large quantities of a single item

(e.g., macaroni and cheese) or a buffet-style meal provided to participants. Food is weighed before and after the test-meal to determine an individual's total intake. One advantage of laboratory test-meal designs is that it allows researchers to create a controlled environment where intake can be measured directly. However, the artificial environment of laboratory test-meals limits the ecological validity of results. Dietary self-report methods, on the other hand, are useful for gathering information on intake in free-living conditions. Self-report methods such as food diaries and 24-hour dietary recalls require participants to report all foods and beverages they consumed during a specified timeframe (e.g., 7 days or the previous 24-hour period). Results from laboratory test-meals and dietary self-report methods typically describe intake from 1) individual macronutrients, and/or 2) specific food categories, as delineated below.

Prior research has not consistently supported the premise that certain macronutrients (e.g., fat, sugar) are targeted for consumption during binge episodes. For example, several studies across self-report and laboratory studies showed that individuals with BN or BED consumed greater total amounts of carbohydrates or fats (measured in grams or calories) during binge episodes compared to a) their typical dietary intake (in self-report studies), or b) compared to overeating episodes among healthy controls (in laboratory studies; Bartholome et al., 2013; Latner et al., 2009; Raymond et al., 2003, 2007). However, several of the studies noted that when comparing the percentage of total intake (in grams or calories) from carbohydrates or fats, there were no significant differences between binge and non-binge episodes, or between participants with BN/BED and controls (Bartholome et al., 2013; Raymond 2003, 2007). The findings therefore suggest that differences in macronutrient intake observed previously were likely a result of greater total intake (in grams or calories) during binge episodes, which yielded nominally higher intake of carbohydrates or fats, rather than substantive differences in food choices during binge episodes. However, some self-report and laboratory studies have demonstrated significant differences in percentage of macronutrients during binge episodes compared to a) participants' typical dietary intake (in self-report studies), or b) compared to overeating episodes among healthy controls (in laboratory studies). One self-report study found that individuals with BN consumed a significantly greater percentage of calories from

fat during binge relative to non-binge episodes (Alpers et al., 2004). Another self-report study found that individuals with BN consumed a significantly greater percentage of calories from fat and less from protein during binge episodes compared to non-binge episodes (Gendall et al., 1997). Similarly, one laboratory study reported that individuals with BED consumed a greater percentage of calories from fat and less from protein during binge episodes compared to healthy controls (Yanovski et al., 1992). However, three other laboratory studies found no significant differences in percentage of any individual macronutrient intake between individuals with BN/BED and healthy controls (Goldfein et al. 1993; Guss et al., 2002; Sysko et al., 2017). Thus, given the variation in findings, it remains unclear whether fat and carbohydrates are targeted for consumption during binge episodes. Overall, there appears to be no robust evidence that binge eating is distinctly characterized by high intake of any individual macronutrient, including those implicated in palatability (e.g., fat).

In contrast to the mixed evidence for macronutrient intake during binge episodes, studies that measured intake from categories of food during binge episodes have indicated that snacks or sweets may be consumed in large quantities during binge episodes. Two laboratory test-meal studies found that individuals with BN or BED ate significantly more snack/dessert type foods (e.g., potato chips, cake, ice cream) when instructed to binge eat compared to overeating behavior of healthy controls (Hadigan et al., 1989; Yanovski et al., 1992). Other laboratory or self-report studies found individuals with BN or BED had greater intake of dairy products or meat (in number of items or grams) compared to healthy controls (Cooke et al., 1997; Raymond et al., 2007). More recently, several studies examining binge eating behavior, comparing individuals scoring high vs. low on the Binge Eating Scale (Duarte et al., 2015) found that women with high scores consumed significantly more calories from high-fat sweet foods compared to controls (Dalton et al., 2013a, 2013b; Finlayson et al., 2011). Together, initial evidence suggests that snacks or sweet-type foods may be consumed during binge episodes. Although the findings may inform on general categories of foods consumed during binge episodes, these food categories do not distinguish or identify foods based on hyper-palatability directly, leaving questions regarding whether HPF are targeted for consumption during binge episodes.

Summary and Current Study

Overall, prior research has measured food intake during binge episodes by focusing on individual macronutrients (e.g., fat) and food categories (e.g., sweets). However, the measures are insufficient proxy measures of hyper-palatability and may limit our understanding of whether foods consumed during binge episodes may have enhanced palatability. Thus, the aim of the current study was to quantify the percentage of calories (kcal) consumed from HPF during binge episodes among individuals with BN, to determine whether foods consumed during binge episodes are primarily those with enhanced palatability. As a within-subjects comparison, the percentage of kcal consumed from HPF during episodes of dietary restriction was conducted; when restricting or under-eating through purposefully limiting the types or amounts of foods to influence body shape/weight, it is generally assumed that individuals consume small, low kcal meals, and thus likely not HPF (Elran-Barak et al., 2015). I hypothesized that individuals with BN would consume a greater percentage of kcal from HPF during a binge episode relative to a restricting episode. HPF intake during binge and restricting episodes was determined using the quantitative definition of HPF from Fazzino et al. (2019). The HPF definition identifies combinations of palatability-inducing ingredients that comprise HPF (25% kcal from fat, ≥0.30% sodium by weight; >20% kcal from fat, >20% kcal from sugar; >40% kcal from carbohydrates, ≥0.20% sodium by weight); thus using the definition will be the most direct method for identifying HPF consumed during binge and restricting episodes among individuals with BN.

Methods

Participants

Participants in the current study were part of an ongoing parent study designed to measure eating disorder diagnosis and symptom course longitudinally (Forbush et al., 2018). Participants in the parent study were recruited from the community and from two midwestern universities via email, fliers, and community advertisement. Inclusion criteria for the current study were 1) diagnosis of full-threshold or sub-threshold BN, and 2) endorsement of both binge eating and restricting episodes as measured in the

Eating Pathology Symptoms Inventory- Clinician Rated Version (EPSI-CRV, Forbush et al., 2019). Individuals with either full or sub-threshold BN were included in the study because both diagnoses require episodes of binge eating, which was the primary variable of interest. The inclusion criterion requiring endorsement of both binge eating and restricting episodes was included to facilitate within-subject comparisons. Data from participants' baseline assessment was used in the current study.

Study Procedures

Study procedures were approved by the Institutional Review Board. After obtaining informed consent, participants completed a semi-structured interview of eating disorder pathology and provided height and weight measurements via digital scale and stadiometer (see Forbush et al., 2018 for detailed methods of study visit). The EPSI-CRV was used to determine BN diagnosis and presence of both binge and restricting episodes. In the objective binge eating and restricting modules of the EPSI-CRV, participants provided detailed information on food consumed during each respective episode. Food data from both modules were processed in preparation for analysis (detailed in the data processing section below).

Measures

The Eating Pathology Symptoms Inventory – Clinician Rated Version (EPSI-CRV)

The EPSI-CRV **(**Forbush et al., 2019) is a semi-structured interview based on the Eating Pathology Symptoms Inventory (EPSI) self-report measure, which was designed to assess eight dimensions of eating pathology (Forbush et al., 2013). The EPSI-CRV assesses eating-disorder psychopathology over the past three months via the following modules: body dissatisfaction, objective binge eating, cognitive restraint, excessive exercise, restricting, purging, muscle building, and negative attitudes towards obesity. In addition, the EPSI-CRV includes additional modules (low weight, overvaluation of weight and shape, and fear of weight gain) to determine eating disorder diagnosis based on the DSM-5 criteria. The interview takes approximately 40 minutes to complete. The EPSI-CRV has

demonstrated a high degree of interrater reliability for binge eating and restricting scales (intraclass correlation coefficients .97 and .99 respectively; Forbush et al., 2020). The EPSI self-report measure, on which the EPSI-CRV is based, has demonstrated excellent psychometric properties in community and clinical populations. Specifically, it has demonstrated strong evidence for discriminant, convergent, and criterion validity for distinguishing individuals with eating disorders from psychiatric, community, and college samples (Forbush et al., 2013). The binge eating scale of the EPSI self-report has also shown good two to four-week test-retest reliability, with significant convergent correlations in college students (.71), and high correlations with other eating pathology measures of BN and eating concerns (Forbush, Wildes, & Hunt, 2014; Forbush et al., 2013).

Intake Data for Binge and Restricting Episodes

The EPSI-CRV objective binge eating module and the restricting module were used to determine the presence of objective binge eating episodes (OBEs) and restricting episodes. Thus, detailed information regarding all foods consumed during the participants' most recent binge and restricting episode were collected. OBEs consist of the following criteria: consumption of an abnormally large amount of food in a discrete amount of time with a loss of control over eating. Restricting episodes consist of the following criteria: purposefully restricting or limiting the types or amounts of food consumed, resulting in intake that is less than what most individuals of similar age, sex, and weight would consume; and the restricting is done to influence body weight or shape, or to gain control over eating. During the OBE module, interviewers probe in specific ways intended to obtain maximal detail on food intake. Interviewers probe with "what else" and avoid questioning with "anything else" to avoid implying the interviewee has eaten too much. Additionally, to improve accuracy of reporting, the EPSI-CRV includes a handout with common guidelines for portions sizes of food for the interviewee to reference. Each OBE and restricting episode was confirmed as abnormally large/restrictive by a group of trained graduate students and a doctoral level clinical psychologist.

Hyper-palatable Food Definition

The HPF definition developed by Fazzino, Rohde, & Sullivan (2019) was used to identify foods within binge/restricting episodes that were hyper-palatable (criteria defined in data processing section below). The HPF definition applies only to foods and not liquids (liquids have different optimum levels of palatability compared to solid foods). Initial evidence supports the HPF definition regarding convergent and discriminant validity. Specifically, evidence for convergent validity was tested in the source article by determining the definition's accuracy in identifying foods in the US food system generally considered palatable such as fast foods, sweets, and fried foods. Supporting the definition's convergent validity, the definition captured the majority of items identified as fast foods or fried foods (86%) and carbohydrate-dense sweets (e.g., cake, French toast; 88%). Discriminant validity was tested by determining the definition's accuracy in distinguishing HPF from raw and fresh foods or foods with only one palatability-inducing ingredient that would not be hypothesized to be hyper-palatable. Results indicated that the definition (appropriately) did not capture 97% of raw vegetables. In addition, it did not capture food items that contained only one palatability-inducing ingredient, such as heavy cream (no sugar or salt added) and unsalted nuts.

Data Processing

Data was processed using R statistical software (R Core Team, 2017). Food data from both binge and restricting modules in the EPIS-CRV was entered into the Automated Self-Administered 24-Hour Diet Recall tool (ASA24; Subar et al., 2012) to extract detailed nutrient data for foods consumed during binge and restricting episodes. The ASA24 is an online tool primarily used for self-reporting dietary intake over a 24-hour recall period; however, it has also been used as a data entry tool for researchers with the goal of obtaining detailed nutrient information on previously collected food data. The ASA24 uses an extensive food reference database to quantify food nutrients and provide nutrient data to researchers for analysis (Ahuja et al., 2013).

Food data were entered into ASA24 following standardized procedures for data entry. Portion sizes were entered based on food item descriptions and portion conversion charts were used to align reported metrics with those required by ASA24. For entry of binge episodes, if a range was reported for the quantity of a food item consumed (e.g., 2-3 slices of pizza), the highest reported value was entered into ASA24 (e.g., 3 slices of pizza). Some individuals had multiple binge and/or restricting episodes recorded, which were collected when interviewers were unsure whether the reported episode met criteria for an objective binge episode or restricting. In the case where multiple episodes were recorded, the episode with the highest total caloric value for binge episodes was used. For multiple restricting episodes, the episode with the lowest total caloric value was used.

The HPF criteria were applied to all food items that were consumed during binge and restricting episodes. Variables obtained from ASA24 that were needed to apply HPF criteria consisted of the following: food item description, serving size, total calories, total fat, total sugar, total carbohydrates, total sodium, and total fiber. Percentage of kcal (% kcal) from fat, sugar, and carbohydrates was calculated using values of 9 kcal/g for fat, and 4 kcal/g for sugar and carbohydrates (Helrich, 1990). Kcal from carbohydrates were calculated following the removal of fiber, as fiber can alter palatability, and the removal of simple sugar, to distinguish starchy carbohydrates from sugar-based carbohydrates. Percent sodium per food weight in grams was calculated as sodium by weight in grams divided by serving size in grams. Beverages were removed from the data before applying the HPF criteria. Foods were defined as HPF by satisfying criteria for one of three HPF groups: 1) fat and sodium (FSOD) food group (>25% kcal from fat and ≥ 0.30% sodium); 2) fat and sugar (FS) group (>20% kcal from fat and >20% kcal from sugar); and 3) carbohydrate and sodium (CSOD) group (>40% kcal from carbohydrates and ≥0.20% kcals from sodium by weight in grams). The percentage of kcal from HPF was calculated for each individual's binge and restricting episode by dividing the total kcal consumed from HPF by the total kcal consumed during the episode. Further, calculations were completed to report the percentage of kcal from each HPF group (FSOD, FS, and CSOD) by dividing the total kcal for foods from each respective group by total kcal consumed during the episode.

Statistical Analyses

Visualizations of the distribution of % kcal from HPF for binge and restricting episodes indicated unique non-normal distributions whereby one transformation would not result in similar distributions for both variables that would yield comparisons in analyses. Specifically, the % kcal from HPF for binge episodes was negatively skewed (-2.26). Conversely, % kcal from HPF for restricting episodes followed a U-shaped distribution where the highest frequencies were for 0% and 100% kcal from HPF. A Shapiro-Wilks test of normality was conducted for the differences between paired values of % kcal from HPF between binge and restricting episodes. The results of the normality test indicated the distribution of differences was not normally distributed ($W= 0.95$, $p<.001$). Since the data violated the assumption of normality, standard parametric tests of mean difference, such as the paired samples T-Test could not be used. However, non-parametric tests do not make assumptions about the distribution of data; thus, the non-parametric Wilcoxon matched-pairs signed-rank test compared the median % kcal from HPF during binge episodes relative to restricting episodes within individuals. In addition, some individuals denied consuming any food during their restricting episode, yielding a kcal intake of 0, which may inflate estimates of the difference in % kcal from HPF between participants' binge and restricting episodes. Therefore, an additional matched-pairs signed-rank test was used which included only individuals who consumed food and therefore had >0 kcal intake during the restricting episode. Descriptive statistics were calculated for total percentage of kcal from HPF and for each group, which resulted in four total HPF variables: 1) % kcal from HPF (total); 2) % kcal from FSOD group; 3) % kcal from FS group; and 4) % kcal from CSOD group.

Results

Participant Characteristics

Participant characteristics are presented in Table 1. The sample included (N=147) adults diagnosed with sub-threshold (41%) or full-threshold (59%) BN. Most individuals were between 18 and

30 years old (86%). The majority of participants were female (83%) and White non-Hispanic/Latino (65%). Most individuals were employed (>60%) and had at least some college education (86%).

Summary Information for Binge and Restricting Episodes

Descriptive information for intake data from binge and restricting episodes is provided in Table 2. Individuals consumed a median of 2134.22 kcal (Q1= 1575.50 , Q3= 2742.40) during binge episodes and 558.53 kcal (Q1= 158.85, Q3= 817.92) during restricting episodes. Eighteen individuals (12%) denied consuming any food during their reported restricting episode, yielding a kcal intake of 0 for the restricting episode. The mean number of binge episodes was 6.33 (SD=5.75) days per month. The mean number of restricting episodes was 12.36 (SD= 8.26) days per month.

Characteristics of HPF Intake during Binge and Restricting Episodes

Characteristics of HPF intake during binge and restricting episodes are presented in Table 3. Notably, % kcal intake from HPF during binge episodes was very high (Median = 95.36%; Q1= 81.38% to Q3= 100%), indicating the vast majority of the sample consumed the majority of their kcal from HPF during their binge episode. Thirty eight percent of the sample (n=56) consumed 100% kcal from HPF. Three participants (2%) consumed 0 kcal from HPF during their binge episode. HPF intake during restricting episodes was much more variable (Median= 61.20, Q1= 8.60 to Q3= 90.20). Eighteen percent of participants (n=26) consumed 100% of total kcal from HPF. Among individuals who consumed food (>0 kcal) during the restricting episode, 12% (n=18) consumed 0 kcal from HPF. The percentage of kcal intake from each specific HPF group during binge and restricting episodes is reported in Table 3. Participants consumed the greatest median % kcal from FSOD foods in both binge and restricting episodes.

Model Results

Results of the Wilcoxon matched-pairs signed-rank test indicated that median % kcal intake from HPF was significantly higher during binge episodes (median = 95.36%) compared to restricting episodes (median= 61.20%, Z= -7.35, *p*= <.0001), suggesting that individuals consumed a significantly greater percentage of kcal from HPF during binge episodes relative to restricting episodes. An additional matched pairs test was conducted excluding individuals with 0 kcal intake during their restricting episode, and results indicated similar findings in that, the median % kcal intake from HPF was significantly higher during binge episodes (median= 95.45%) vs restricting episodes (median= 72.01%; Z= -5.98, *p*<.0001)

Discussion

The present study was the first to measure and compare percent kcal intake from hyper-palatable foods during binge eating and restricting episodes among individuals with BN using a quantitative definition of HPF. Results indicated that individuals with BN consumed a significantly greater percent kcal from HPF during binge episodes (median = 95%) compared to restricting episodes (median= 61%). Furthermore, findings suggested that HPF comprised the vast majority of kcal consumed during binge episodes (Q1=81%, Q3= 100%). Overall, findings suggest that HPF may be primarily targeted for consumption during binge episodes, supporting the assumption of affect-based models of binge eating (Haedt-Matt & Keel, 2011; Heatherton & Baumeister, 1991; Polivy & Herman, 1993).

The current study contributes to the existing literature by further elucidating the types of foods that may be consumed during binge episodes. For example, evidence in the literature has indicated that snacks and sweets, defined categorically, may be commonly consumed during binge episodes (Dalton et al., 2013a, 2013b; Hadigan et al., 1989; Yanovski et al., 1992). Our findings using the HPF definition indicate that FSOD HPF may comprise the greatest % kcal consumed during binge episodes, followed by % kcal from CSOD HPF. FSOD HPF commonly comprise meal-based foods, and CSOD HPF are commonly snack items (Fazzino et al., 2019). Thus, our findings are in contrast to the existing literature

and indicate that foods that are often rich, savory, meal-based items (FSOD) may be primarily consumed during binge episodes, followed by salty and starchy snacks (CSOD). Furthermore, our results indicate that % kcal from FS HPF comprised the lowest percentage of kcal during binge episodes (median 13% of kcal) compared to FSOD and CSOD HPF. These findings are in contrast to two prior studies that examined consumption of foods high in fat and sugar (Dalton et al., 2013a, 2013b; Finlayson et al., 2011) and found that individuals with high compared to low scores on the BES, consumed significantly more kcal from high-fat sweet snack foods. The conflicting findings may be due to comparisons between subjects (intake of participants high vs low in binge eating behavior), compared to within-subjects comparisons made in the current study (binge vs restricting intake behavior). However, the prior studies used specific food categories (snacks or sweets) as proxy measures for HPF and thus may have missed identifying foods, especially FSOD and other meal-based items that do not align with snack or sweets food categories. Research quantifying HPF intake moving forward may benefit from using a standardized definition of HPF in order to directly target foods with enhanced palatability.

Given that HPF may be particularly rewarding and challenging to stop eating, the artificially enhanced eating experience created by HPF may contribute to clinical features of binge eating such as perceived loss of control (LOC) over eating. It is possible that high motivation and frequent consumption of HPF over time may even increase one's risk for new or worsening LOC over eating. One longitudinal study found that among a sample of women at elevated risk for weight gain, high motivation to consume HPF at baseline predicted the onset of LOC within a two-year time period (Lowe et al., 2016). Another study found a significant positive association between motivation to consume HPF and binge eating frequency among individuals with BN (Witt & Lowe, 2014). The authors of these studies suggested that a high drive to consume HPF may contribute to increased feelings of powerlessness over consumption and risk for eating disorders over time. However, it is also possible that HPF intake directly contributed to worsening LOC over time. Future research is needed to elucidate potential mechanisms through which HPF may lead to LOC over eating and risk for eating disorders to inform preventative measures.

Another notable finding from the current study was that individuals consumed over half of their % kcal from HPF during restricting episodes. Restricting episodes have been characterized by behavioral components like fasting, skipping meals, and purposefully limiting types or amount of food consumed (Elran-Barak et al., 2015). The assumption in the field regarding food intake during restricting episodes is that individuals avoid consumption of certain foods, which are typically those high in fat and kcal (Gianini et al., 2019; Kales, 1990), in order to compensate for excess kcal intake during binge eating (Polivy & Herman, 1985; Ridgway & Jeffrey, 1998; Wallin et al., 1994). To my knowledge, this is the first study to characterize food intake during restricting episodes among individuals with BN. Previous research has reported on dietary intake outside of binge episodes among individuals with BN, however this has not been specific to restricting as defined in the current study (purposefully restricting or limiting the types/amounts of food consumed, resulting in intake that is less than normal to influence body weight/shape/eating behavior). Thus, the current results are not readily comparable to previous research. Additionally, some research suggests that restricting episodes often precede or predict binge episodes (Masheb et al., 2011; Zunker et al., 2011). Given that HPF may be difficult to stop eating, it is possible that HPF intake during restricting episodes may predict or promote transition into episodes of binge eating. Future research should test this potential mechanism directly.

The study also reported on total kcal and macronutrient intake to compare with previous research on dietary intake during binge episodes. On average, individuals consumed 2339 kcal during binge episodes. Previous studies on binge eating have yielded similar estimates (Bartholome et al., 2013; Dalton et al., 2013b; Latzer et al., 2018; Raymond et al., 2007), although several studies have reported average intake upwards of 4000 kcal (Alpers & Tuschen-Caffier, 2004; Sysko et al., 2017). Overall, total kcal during binge episodes in the present study appeared to be similar in magnitude to the findings of prior studies. Thus, the binge episodes measured in the current study appear to be comparable to the binge episodes measured by others in the existing literature.

The current study had several limitations. First, food intake data was self-reported rather than directly measured and thus, may be prone to biases in estimation. For example, individuals may be inclined to under-report their intake due to negative emotions often associated with binge eating and/or difficulty with retrospective recall (Bartholome et al., 2013; Walsh & Boudreau, 2003). However, self-reported data may be more ecologically valid than studies conducted in an artificial laboratory environment and thus are useful despite potential underestimations in reported food intake. Second, foods eaten together in one bite (e.g., chips and dip) were not combined in the data prior to applying the HPF definition for analysis. This may result in underestimation of HPF intake, given that in combination, certain items may meet HPF criteria, but may not when examined separately. Future research is needed to replicate findings when food items are combined. Third, the semi-structured interview used to gather food intake data was designed to measure eating disorder pathology and not precise estimates of food intake. Therefore, data from the current study may be less precise than data obtained from standardized dietary assessment protocols administered by registered dieticians. However, the assessment used in the study included a handout to aid in the estimation of portions sizes, consistent with dietary recall approaches. Additionally, interviewers were directed to probe in specific ways to encourage detailing large amounts of food (i.e., asking "what else" rather than "anything else") for a population in which detailing food intake may be distressing. Finally, the study sample included mostly white, non-Hispanic women between the ages of 18 and 30, therefore limiting the generalizability of findings to other populations. Future research is needed to determine whether the findings replicate in samples better represented by racial and ethnic minority participants, as well as samples comprised of adolescent and middle-aged adults.

Strengths of this study include the use of a quantitative definition of HPF that is a direct measure of enhanced palatability. Additionally, intake during binge episodes was compared within-subjects to restricting episodes. Within-subject comparisons minimizes the effect of random error related to individual-level variability which is a limitation of testing differences in intake between subjects (e.g., BN

vs. controls). Finally, the sample was comprised of a substantial number of individuals engaging in binge eating and restricting episodes that was confirmed by diagnostic interview.

Overall, the results from the current study support the assumption of affect-based models of binge eating that HPF is primarily consumed during binge episodes. Moving forward, it would be beneficial to understand whether HPF serve to distract from or reduce negative affect during binge episodes, thereby reinforcing binge eating over time. This knowledge may provide a more nuanced understanding of the process by which binge eating is reinforced as conceptualized by affect-based models of binge eating. Furthermore, research is needed to determine whether HPF intake during binge episodes may contribute to and exacerbate the LOC individuals experience during binge episodes over time.

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Appendix

Table 1

Participant Characteristics (N=147)

Variable	Mean (SD) or N (%)
Age	23.44 (6.46)
Gender	--
Female	122 (83%)
Male	21 (14%)
Transgender	1 (1%)
Not reported	3 (2%)
Race	--
White/Caucasian	96 (65%)
Black/African American	4 (3%)
Asian/Pacific Islander	20 (14%)
Native-American/American Indian	0 (0%)
More than one race/ethnicity	11 (7%)
Other	9 (6%)
Not reported	7 (5%)
Ethnicity	--
Hispanic/Latino	14 (9.5%)
Education	--
< High-school GED	0 (0%)
High-school GED or equivalent	14 (10%)
Some college, no degree	78 (53%)
Post-secondary degree	28 (19%)
Graduate/Professional degree	21 (14%)
Not reported	6 (4%)
Employment	--
Employed	91 (62%)
Unemployed	51 (35%)
Not reported	5 (3%)

Table 2

Summary Intake Information for Binge and Restricting Episodes

Variable	Median	IQR
Binge		
Total Kcal	2134.22	1166.90
Total Protein (g)	69.59	61.66
%	13.80	7.80
Total Fat (g)	92.25	66.67
%	40.27	12.36
Total Carb (g)	147	96.67
%	46.80	16.40
Total Sugar (g)	64.86	75.44
Total Fiber (g)	16.55	12.17
Total Sodium (g)	3.45	2.58
Restricting		
Total Kcal	558.53	659.07
Total Protein (g)	20.20	38.40
%	15.63	9.35
Total Fat (g)	16.46	31.87
%	29.75	21.36
Total Carb (g)	27.09	47.10
%	53.39	32.31
Total Sugar (g)	16.71	39.92
Total Fiber (g)	5.13	10.44
Total Sodium (g)	0.92	1.45

Note. Descriptive statistics are reported for intake variables in grams and in percentage of total calories.

IQR = interquartile range 25th percentile to 75th percentile

Table 3

Percentage of Caloric Intake from HPF Groups during Binge and Restricting Episodes

	Binge episode		Restricting episode	
	Median	**IQR**	**Median**	**IQR**
Total HPF	95.36	18.62	61.20	81.6
FSOD	60.51	56.39	24.34	62.22
FS	13.25	38.22	0	17.16
CSOD	19.21	38.63	8.72	28.39

Note. HPF = hyper-palatable foods; FSOD= fat and sodium group, FS = fat and simple sugars group, CSOD= carbohydrate and sodium group. IQR = interquartile range 25th percentile to 75th percentiles