

## REVIEW

# A narrative review of the construct of hedonic hunger and its measurement by the Power of Food Scale

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## Summary

### Introduction

The term 'hedonic hunger' refers to one's preoccupation with and desire to consume foods for the purposes of pleasure and in the absence of physical hunger. The Power of Food Scale (PFS) was developed as a quantitative measure of this construct in 2009. Since then, over 50 published studies have used the PFS to predict appetite-related outcomes including neural, cognitive, behavioural, anthropometric and clinical measures.

### Objective

This narrative review evaluates how closely the PFS captures the construct it was originally presumed to assess and to more clearly define hedonic hunger itself.

### Methods

The measure's relationship to four domains is reviewed and summarized: motivation to consume palatable foods; level of actual consumption of such foods; body mass; and subjective loss-of-control over one's eating behaviour. Findings are synthesized to generate a more accurate understanding of what the PFS measures and how it may relate to the broader definition of hedonic hunger.

### Results

Results suggest that the PFS is closely related to motivation to consume palatable foods and, in extreme cases, occurrence of loss-of-control eating episodes. PFS scores are not consistently predictive of amount of food consumed or body mass.

### Conclusions

Implications of these findings are discussed in the context of behavioural health, and avenues for further inquiry are identified.

**Keywords:** Food reward, hedonic hunger, loss-of-control eating, Power of Food.

## Introduction

Some degree of pleasure is involved in nearly all voluntary food intake (1). Further, hunger intensifies the pleasure derived from eating food (1). However, eating – particularly in modern cultures where delicious foods are omnipresent – also frequently occurs in the absence of acute need for calories. The weight gain that is linked to superfluous consumption of highly rewarding, calorie-dense foods is also closely linked to development

of diet-related medical conditions, including type II diabetes, cardiovascular disease and hypertension (2,3). Although many factors may stimulate such eating (e.g. food advertisements, smelling food, negative moods, seeing others eat), the pleasure food provides – via positive or negative reinforcement – underlies much of the influence of these diverse inducements.

The term hedonic hunger was originally proposed to refer to one's desire or drive to consume food for pleasure, in the absence of caloric need (4,5). People

who experience significant food deprivation and are in an acute state of caloric need are considered to be in a state of homeostatic or physiological hunger. Similarly, those who think a lot about eating in the absence of a need for calories could be said to be in a state of hedonic (or pleasure-based) hunger. Given the modern obesogenic food environment, in which palatable, energy-dense foods are widely available and acute hunger is relatively rare, it was thought that implicit or explicit awareness of palatable foods might induce some individuals to frequently think about or desire such foods at any time (4). The Power of Food Scale (PFS) (6) was developed with the intent of measuring the construct of hedonic hunger, or what its developers initially described as “the psychological impact of living in food-abundant environments” (6) (p. 114).

Because the construct was initially conceptualized, neurobiological research has established one possible mechanism for the development of intense hedonic hunger. Studies in both animals (7) and humans (8) implicate dopaminergic pathways in the development of progressively stronger appetitive responses to food stimuli. More specifically, dopamine release in reward-related brain areas, after repeated conditioning trials, tends to migrate from the receipt of palatable foods towards cues that predict its delivery (9). This is usually referred to as incentive salience theory. Considering this theory, repeated consumption of highly palatable foods in heterogeneous environments might impart motivational salience to diverse situations. In other words, the modern food environment itself becomes an appetitive context spurring eating-related thoughts and desires. These processes may be at work in the development of elevated hedonic hunger, although to date no others have evaluated converging evidence from multiple studies to support this claim. The goal of this paper is to review research on the PFS to better define the underlying construct it measures and to determine the predictive value of hedonic hunger in relation to other eating-related and weight-related constructs of interest. In short, this paper seeks to examine whether preoccupation with palatable foods translates to adverse psychological and behavioural outcomes.

### The Power of Food Scale

The current PFS consists of 15 items, rated on a 5-point Likert scale, assessing preoccupation with palatable foods across three distinct but related domains (contributing to three separate subscales of the measure).<sup>1</sup> The first is the Food Available scale, which assesses general

thoughts about food with items such as, “I find myself thinking about food even when I’m not physically hungry”. Second, the Food Present subscale assesses attraction to food that is directly available to the individual (sample item: “If I see or smell a food I like, I get a powerful urge to have some”). The final Food Tasted subscale evaluates desire for/pleasure derived from food when first tasted (e.g. “When I eat a delicious food I focus a lot on how good it tastes”). PFS total and subscale scores are derived from summing the item scores and dividing by the number of items. Unless otherwise indicated, any reference to PFS scores in the present manuscript refers to the total scale score. The PFS has demonstrated adequate psychometric properties, including internal consistency (10) and test–retest reliability (10,11). Of note, PFS total scores are not significantly affected by respondents’ hunger state when completing the measure (12), suggesting that the hedonic hunger construct remains stable in the short term, regardless of one’s physiological need for food. The PFS intentionally contains no items reflecting quantity or frequency of actual palatable food consumed, which was hoped to allow researchers to distinguish between motivation to consume and actual consumption.

Previous papers have described what the PFS was *intended* to measure (4,10). However, what PFS scores *actually* assess may or may not align well with the original conceptualization of the hedonic hunger construct. Sufficient research employing the PFS has been published to begin answering these questions. To determine what dimensions or concepts hedonic hunger does (and does not) reflect, four key questions were identified to organize the present review and summary of findings.

The studies relevant to this review are highly diverse in terms of demographic characteristics of participants, the nature of the research questions related to hedonic hunger, the methodology employed (ranging from self-report to neuroimaging measures), the clinical versus non-clinical status of participants and whether the PFS was used as a predictor or as an outcome variable. Heterogeneity of methodology therefore precluded the use of systematic review methods, and thus, a narrative review approach is taken here. In most cases, there appeared to be one or more ‘signals’ emerging about the nature of hedonic hunger, despite the ‘noise’ produced by study heterogeneity.

### Aims of the present paper

The present paper aims to answer four key questions:

- 1 *Is hedonic hunger related to motivation to consume highly palatable foods in the absence of physiological hunger?*

<sup>1</sup>For interested readers, the full version of the PFS can be obtained through contact with author MRL at lowe@drexel.edu

- 2 Does hedonic hunger predict consumption of palatable food in the absence of physiological hunger?
- 3 Is hedonic hunger related to BMI or to proneness towards excessive weight gain?
- 4 Is hedonic hunger related to loss-of-control eating?

A total of 198 papers were screened (published before December 2016) which cited the PFS or used the measure as a predictor of outcomes related to weight, eating behaviour or biological substrates involved in eating. Of screened papers, only studies utilizing the PFS as a primary predictor or outcome variable were selected for further review. In certain isolated cases, the PFS was included in studies that did not have relevance to our review questions and were therefore excluded (e.g. a study investigating predictors of regular consumption of spicy foods) (13). The narrative review is organized thematically to address each question separately.

### **Question 1: Is hedonic hunger related to motivation to consume highly palatable foods in the absence of physiological hunger?**

The PFS was originally designed to assess preoccupation with and enhanced motivation to obtain and consume highly palatable foods. Results from laboratory studies provide support for the idea that the construct of hedonic hunger indeed involves cognitive preoccupation with such foods. For example, when not distracted by demanding cognitive tasks, male and female participants high in hedonic hunger were found to be more likely to direct their visual attention towards highly palatable foods and subsequently choose unhealthy snack foods from a menu of food choices (14,15). The researchers hypothesized that heightened attention to the hedonic properties of food stimuli may influence subsequent motivation to consume highly palatable foods. In another study utilizing functional magnetic resonance imaging, male and female individuals with greater hedonic hunger were found to exhibit heightened activation in visual processing areas of the brain in response to images and words depicting palatable foods (16,17). Hence, not only do individuals high in hedonic hunger attend more readily to palatable food stimuli, but they also appear to exhibit enhanced neural response upon seeing such cues. Together, these results provide behavioural evidence for a connection between the preoccupation the PFS is hypothesized to measure and the consequent behavioural and biological responses that might reflect such preoccupation.

In the original conception of the PFS, individuals high in hedonic hunger were hypothesized to have stronger motivation to consume palatable foods, particularly in the absence of caloric deficit (10). Results from research examining neural activation in food-seeking-related and reward-related areas of the brain suggest that hedonic hunger is associated with elevated drives to consume regardless of hunger state. For example, in their 2012 paper, Rejeski and colleagues (17) found that neural response to images of palatable food differs between individuals high and low in hedonic hunger in both fasted and fed states. When viewing palatable food cues in a fasted state, male and female individuals higher in hedonic hunger showed increased connectivity, or strength of associations, between regions associated with hunger, craving and food-seeking behaviour, including the cerebellum, basal ganglia and thalamus (17). In the fed state, those with higher PFS scores exhibited increased connectivity in areas associated with response to sensory stimuli (e.g. palatable food), as well as connectivity between regions associated with food reward and responsivity, including the medial prefrontal cortex, orbitofrontal cortex and the insula. This pattern of connectivity suggests that hedonic hunger is positively associated with increased attention towards the sensory properties of food and increased desire for food consumption. Therefore, although the connectivity patterns differed under physiologically deprived versus energy-replete states, hedonic hunger was associated with enhanced connectivity in both states. This suggests that the PFS may differentiate between those with higher versus lower drives to consume whether the hunger is homeostatic or hedonic in nature and indicates that the original theory that PFS would only predict preoccupation with palatable food in an absence of acute caloric need may be incorrect.

Anticipation of future reward is an important component of motivation. If the construct of hedonic hunger corresponds to increased motivation to consume palatable foods, it should also be associated with greater reward response in anticipation of food consumption. Three studies have examined whether hedonic hunger is associated with differential neural activation in reward regions of the brain after exposure to food-related stimuli. Burger and colleagues (2016) examined whether hedonic hunger was related to anticipatory and consummatory response to food cues in women (11). During presentation of an anticipatory cue preceding actual food intake, higher PFS scores were associated with increased activity in regions of the postcentral gyrus known to be associated with both somatosensory processing of food stimuli and obesity; conversely, no significant associations between the PFS and *receipt* of palatable

food were found (11). Neuroimaging research employing magnetoencephalography (MEG) yielded similar findings among male participants. When presented with images of palatable foods in a fasting state, individuals with higher PFS total, Food Available and Food Present subscale scores exhibited more pronounced activation in the insular cortex, a region of activation associated with appetitive motives and reward-driven behaviour (18). In the same paradigm, when male participants were scanned just after eating to the point of subjective satiation, those with higher PFS total, Food Available and Food Present subscale scores exhibited greater insular cortex activation (19). Food Tasted scores were not predictive of neural activation in either study. Along with the Rejeski *et al.* findings reviewed above, these results support the idea that hedonic hunger predicts responses to food cues independently of acute hunger state. These findings also suggest that hedonic hunger is associated not only with heightened response to visual food cues but also with anticipation of reward received from consumption of palatable foods.

Overall, findings summarized thus far suggest that individuals high in hedonic hunger exhibit heightened responsivity to food cues, and this responsivity may be in part reflected in increased attention towards the potentially rewarding properties of food. In addition, this relationship appears to persist independently of hunger state. Future research should investigate whether the PFS does in fact differentiate people's appetitive responses independently of acute hunger level and, if so, why. Because elevated eating motivation might not always translate into greater food intake (especially in weight conscious individuals), a review of the relationship between PFS scores and actual food consumption is warranted and is described next.

## Question 2: Does hedonic hunger predict consumption of palatable food?

It appears that hedonic hunger involves preoccupation with and motivation to consume food. However, given the numerous other influences that affect eating behaviour (e.g. weight concerns, restrained eating, cultural customs, allergies, etc.), this motivation may not translate to systematically increased food intake. A review of several studies examining the relationship between hedonic hunger and palatable food consumption provides insight into this question. In a study involving healthy adult male and female participants, PFS scores were not significantly related to the amount of *ad libitum* milkshake consumed in a laboratory setting (20). In this study, participants were asked to arrive at the laboratory 'neither hungry nor full', and therefore, results may suggest that PFS is not related

to consumption in the absence of caloric need. Similar results have been observed in a study employing a more naturalistic design. In an ecological momentary assessment study among healthy weight male and female college students, hedonic hunger was not significantly associated with the number of self-reported overeating behaviours occurring over a 1-week period (21).

Other studies have yielded mixed findings. For example, in a representative community-based sample of men and women, hedonic hunger was related to self-reported frequency of unhealthy snack intake, but this relationship was no longer significant when controlling for habit strength (measured via a self-report measure of the degree to which snacking was automatic or habitual) (22). Further, in a study of college females, PFS did not predict food intake during a meal, but did predict amount of post-meal dessert consumption (23). In another study, undergraduate male and female students were asked to carry chocolates with them and refrain from eating the candies for a full 48 h. In this study, individuals higher in hedonic hunger were more likely to eat the chocolate (5). Interestingly, however, the same pattern did not emerge in a replication of this trial using a sample of overweight and obese women (24). Thus, it appears that hedonic hunger is only weakly or inconsistently associated with food intake.

Some studies have also examined whether hedonic hunger is associated with differential neural response when tasting food. Although not equivalent to *ad lib* consumption, neural response reflects the reward value associated with the taste of food, which has been associated with caloric intake (25). Neuroimaging research has yielded similar findings to those from studies examining actual food intake. A recently published study compared neural activation patterns when female participants anticipated and received palatable food tastes versus tasteless solution while undergoing functional magnetic resonance imaging scanning (11). As described in the review of question 1, increased hedonic hunger was associated with greater bilateral activity in brain regions associated with oral somatosensory processing during the anticipation of palatable food intake. However, PFS scores were not significantly associated with neural activation in any reward-related or oral somatosensory regions of interest during receipt of palatable food taste (11).

Variability in methodology and inconsistent findings preclude any firm conclusions about the relationship between hedonic hunger and food intake. Indeed, the absence of evidence does not necessarily confer evidence of a null relationship. Nonetheless, studies examining motivation to consume foods found consistent and significant relationships with hedonic hunger, and studies examining actual

food intake more often failed to demonstrate a reliable association. This might indicate – in line with the original conceptualization – that the PFS reflects strength of appetitive drive to consume palatable food more than the tendency to consume greater amounts of food.

Hedonic hunger alone may be insufficient to predict intake, but could promote overconsumption when it exists in combination with other individual characteristics, such as impulsivity (5,26–29). For example, among overweight and obese adult females, individuals with greater hedonic hunger consumed more palatable food in a sham taste test following a standardized pre-load meal, but only for those also high in impulsivity (as measured by delay discounting) (29). Hedonic hunger was not significantly associated with bland food intake in the same taste test. Findings were partially replicated in a study employing a similar paradigm with normal weight females, wherein those with high PFS and low inhibitory control consumed the greatest amount of both palatable and non-palatable food (28). In addition, researchers examining unhealthy snack intake among male and female European adolescents found that the positive association between greater PFS scores and unhealthy snacking was attenuated by greater ‘self-regulatory competence’ or the ability to inhibit one’s urges to consume palatable foods (26). This study found a similar pattern of results in both males and females, suggesting that this relationship is not moderated by gender.

Additional research using more diverse samples and more rigorous methods (including behavioural measures of impulsivity and/or additional dimensions of self-control) are needed to draw firm conclusions. However, the available evidence tentatively suggests that the PFS assesses a latent predisposition to desire palatable foods and that this predisposition is most likely to result in increased eating when it co-exists with a weaker ability to inhibit impulsive motivations.

### Question 3: Is hedonic hunger related to body mass and change in body mass?

#### Hedonic hunger and current body mass

At the item level, the face validity of the PFS reflects cognitive preoccupation with and motivation to consume highly palatable foods. Because thinking about, obtaining and consuming such foods is presumably part of the process of acquiring excess adiposity, one would logically expect higher scores on the scale to be related to BMI. Several studies to date have reported on this relationship. However, as summarized in Table 1, although some small to moderate and statistically

significant associations have been identified (e.g. (30)), the majority of results reviewed here have found non-significant relationships between BMI and hedonic hunger in both men and women (10,11,31–33) with  $r$  values ranging from 0.02 to 0.35. These low correlations are likely not attributable to restricted range of BMI among study samples, as the studies reviewed included samples with BMIs ranging from the low normal range to overweight and obese. In sum, it appears that there is little evidence for a linear relationship between the PFS and body mass. This conclusion is perhaps unsurprising given the findings summarized for question 2 and the inconsistent relationship between hedonic hunger and food intake. There are a number of plausible explanations for this pattern of findings across studies. One possibility is that the omnipresence of food and food cues in modern environments is so powerful that it spurs frequent thoughts about and desires for delicious foods independently of BMI. Another is that, as discussed in the previous section, hedonic hunger acts in combination with other psychological factors to predict food intake beyond one’s caloric needs and subsequent accumulation of excess body mass.

#### Hedonic hunger and future change in body mass

Numerous studies to date have also investigated whether PFS predicts future weight gain in both normal weight samples and among those with overweight or obesity. In a longitudinal analysis of weight change over time among male and female college students, researchers found that baseline hedonic hunger failed to prospectively predict BMI change or change in fat mass over a period of 2 years (34). Another study replicated these null findings regarding hedonic hunger and future weight change in two separate longitudinal studies involving approximately 50 and 400 college women respectively (11). In contrast, one study, which classified normal-weight individuals as ‘obese-resistant’ or ‘obese-prone’, found that male and female obese-prone adults had significantly greater hedonic hunger, suggesting some association between PFS and risk for weight gain (35). However, this study was cross-sectional and assessed only *risk* for future weight gain, rather than actual weight change over time.

Even more clinically relevant than the relationship between hedonic hunger and BMI change among healthy-weight populations (the majority of whom are likely to remain in the normal weight range for at least several years) is that between hedonic hunger and weight change among those actively seeking to lose weight. For male and female patients undergoing behavioural weight loss treatment, findings are mixed: One study found that higher pretreatment scores on the Food Present and

**Table 1** Summary of published associations between the Power of Food Scale scores and body mass index

First author and year published	Study type	Participants included	Sample characteristics				Strength of PFS and BMI relationship
			Age	BMI	N (% female)		
Appelhans (2011)	Observational study of food sensitivity, inhibitory control and food intake in medically healthy obese samples	Healthy overweight or obese women in USA	31.0 ± 7.7	31.5 ± 3.4 kg m <sup>-2</sup>	62 (100%)	$r = -0.17$	
Cappelleri (2009)	Psychometric analysis of the PFS in (1) clinical and (2) web-based samples	1. Obese non-diabetic in clinical trial for weight management in USA 2. Non-obese healthy and overweight/obese (non-diabetic and diabetic groups) in USA	46.3 ± 11.0	38.6 ± 6.7 kg m <sup>-2</sup>	1741 (82%)	$r = 0.02-0.24$ for total/subscales scores and BMI $b = 1.47$	
Burger (2016)	Investigation of neural correlates associated with anticipation for and receipt of palatable food	1. Recruited from college campus in USA 2. College freshmen in USA 3. Community-based sample in USA	20.8 ± 1.3 years	23.8 ± 2.9 kg m <sup>-2</sup>	44 (100%)	$r = -0.22$	
Carpenter (2013)	Cross-sectional investigation of BMI and genetic polymorphisms in clinical weight-loss treatment patients	Obese females and males in USA	18.4 ± 0.6 32.7 ± 11.3 53.3 ± 15.5	23.8 ± 4.3 kg m <sup>-2</sup> 25.9 ± 7.3 kg m <sup>-2</sup> 33.1 ± 12.5 kg m <sup>-2</sup>	398 (100%) 100 (58%) 80 (74%)	$r = 0.05$ $r = 0.13$ $r^2 = 0.12^*$	
Finlayson (2012)	Observational study of weight change in university students	First-year female and male university students in UK and Scotland	19.2 ± 2.6	21.9 ± 3.2 kg m <sup>-2</sup>	250 (65%)	$r = 0.05$	
Lipsky (2016)	Cross-sectional investigation of relationship between PFS and weight/dieting outcomes among US young adults	Female and male members of nationally representative study cohort in USA (NEXT Gen Health Study)	20.3 ± 0.02	25.7 ± 0.30 kg m <sup>-2</sup>	2201 (59.2%)	$\beta = 0.32$	
Lowe (2009)	Initial validation of PFS	Female and male university students in UK	20.1 <sup>a</sup>	22.4 kg m <sup>-2a</sup>	466 (86%)	$r = 0.03^*$	
Rejeski (2012)	Investigation of the neural correlates associated with PFS in fasted and fed states	Obese sedentary older adults (50–80 years of age) in USA	64.65 ± 6.84	33.97 ± 2.67 kg m <sup>-2</sup>	22 (55%)	$r = 0.29$	
Vainik (2015)	Analysis of relationship between eating-related questionnaires	1. Females from Estonia 2. First-year university students in Canada	30.5 ± 9.8 21.1 ± 4.5	22.5 ± 4.7 kg m <sup>-2</sup> 22.1 ± 3.8 kg m <sup>-2</sup>	740 (100%) 456 (100%)	$r = 0.19^{***}$ $r = 0.05$	
Thomas (2013)	Investigation of behavioural qualities in obese-prone and obese-resistant individuals	Healthy obese-prone adults in the USA Healthy obese-resistant adults in the USA	26.1 ± 2.8 30.7 ± 3.4	30.4 ± 3.9 kg m <sup>-2</sup> 20.9 ± 1.9 kg m <sup>-2</sup>	29 (52%) 29 (48%)	Reported as not significant; no statistic provided	

<sup>a</sup>No standard deviation provided.

\* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Food Tasted subscales predicted greater weight loss during treatment (36), while another found no significant association (37). Interestingly, significant reductions in hedonic hunger during treatment were observed in both studies, and magnitude of reduction was positively associated with amount of weight lost. Hedonic hunger thus appears to change over time among individuals undergoing marked and volitional changes in eating behaviour.

Additional research has also examined the relationship between hedonic hunger and weight loss after surgical treatment of obesity. In a cross-sectional study comparing male and females with obesity who were seeking bariatric surgery to those who had undergone the procedure several months earlier, researchers found that post-surgery patients scored significantly lower on PFS total and Food Tasted subscale scores than preoperative patients (38). Furthermore, total percent of excess body mass lost was inversely associated with hedonic hunger among postoperative patients (PFS scores were not measured prior to surgery in these patients, so causal conclusions cannot be drawn). Another study examined longitudinal changes in hedonic hunger and its association with weight outcomes. Similar to observations made among behavioural weight loss patients, this study found that male and female bariatric patients' PFS scores significantly declined approximately 1 year post-surgery (39). However, among these patients, neither baseline scores nor change in hedonic hunger over time were significantly associated with total weight lost. Surgery is associated with major changes in appetitive hormones, food intake and other behaviours; it is impossible to know which factors might explain the large decreases in PFS scores (40). In summary, for behavioural weight loss patients, baseline hedonic hunger predicted weight loss and weight change and hedonic hunger change were directly correlated. In contrast, for patients undergoing bariatric surgery, observed reductions in weight and hedonic hunger were not as closely linked. This may suggest that the processes underlying success in these two treatments differs markedly or that hedonic hunger in general is more closely associated with behavioural weight loss outcomes versus bariatric. Further research is needed to clarify this point.

In summary, evidence points towards a limited relationship between baseline hedonic hunger and future weight change among non-clinical samples, presumably among individuals who were not engaging in volitional efforts to reduce weight through dieting and exercise. However, hedonic hunger may be associated with intentional changes in weight: Specifically, PFS scores appear to decline over time among patients undergoing behavioural weight loss or surgical treatment for overweight/obesity. This is particularly intriguing given that PFS does not

predict the amount of palatable foods consumed in daily life (see question 3). Rather than play a causal role in weight reductions through reduced consumption of palatable foods, it is possible that reductions in PFS and weight during weight loss treatment are only indirectly related. In general, individuals who undergo weight loss treatment are instructed to modify many aspects of their eating patterns and food environment; they likely encounter and consume fewer palatable foods as a result and hence have fewer occasions on which to experience a hedonic drive to consume them. Thus, hedonic hunger may be a malleable characteristic that fluctuates with time as one or more additional factors related to eating patterns (e.g. food intake, weight, the food environment) change.

#### Question 4: Is hedonic hunger related to loss-of-control eating?

The review thus far has examined the relationship between hedonic hunger and the quantitative aspects of palatable food consumption (i.e. neural response in reward regions of the brain, measured amount of food consumed and total body mass). Hedonic hunger may also be related to *qualitative* aspects of palatable food consumption. A key qualitative and diagnostic distinction for those with maladaptive eating patterns is the degree to which one experiences feelings of loss of control (LOC) over his/her eating. LOC eating is defined as a subjective sense of feeling driven or compelled to consume food during a distinct eating episode, and is a core feature of eating disorders involving binge eating (41). Importantly, LOC can be present even during consumption of food amounts that would not be considered objectively large to an outside observer. Theoretically, some have conceptualized LOC eating in the eating disorders as an extreme form of the motivation to consume palatable foods described in question 1 (42).

A recent longitudinal study conducted by our group examined the relationship between hedonic hunger and LOC eating behaviour among weight-gain-prone college women at baseline, 6 months, 12 months and 24 months (43). Findings indicated that hedonic hunger was associated with increased endorsement of LOC eating at baseline. Further, although LOC decreased over the 2-year period in the overall sample, those with greater hedonic hunger at baseline showed a smaller decline. Among those who did not endorse LOC eating at baseline, higher PFS scores predicted greater risk of LOC onset during the study period. These results suggest that hedonic hunger is associated with risk for the onset and maintenance of LOC eating in non-clinical populations. Results from other studies also suggest that elevations in hedonic hunger

may serve as a proxy for the presence of binge eating among those seeking treatment for obesity or eating disorders. One comparative study demonstrated that females with obesity and comorbid binge eating disorder (BED) exhibited higher PFS scores than their peers with obesity who denied the presence of LOC or any binge eating (44). Another study found that greater hedonic hunger was associated with increased risk for the presence of comorbid BED in a sample of 500 male and female patients undergoing evaluations for bariatric surgery (45). Therefore, among individuals who struggle with weight, hedonic hunger appears to be uniquely associated with greater risk for LOC eating.

Results from clinical eating disorder patient samples also suggest a connection between hedonic hunger and LOC. In a comparison of women with anorexia nervosa, bulimia nervosa, obesity and those with no eating or weight control problems, patients with bulimia were found to have the highest total PFS scores, followed by anorexia nervosa-binge/purge subtype patients, then individuals with obesity, the non-clinical group and finally anorexia nervosa-restricting subtype patients (46). Hedonic hunger was also positively associated with the frequency of binge eating among patients with bulimia. This study reported similar results for PFS subscale scores. Therefore, hedonic hunger not only differentiates groups with and without binge eating but also indicates the severity of binge eating among those exhibiting the symptom.

Research into the relationship between hedonic hunger and LOC is relatively new, and our current conclusions rely on four empirical studies; further research in this area is needed. Preliminarily, however, these results all point to a link between hedonic hunger and the presence and severity of LOC or binge eating, rather than a general pattern of overeating with no associated distress or sense of compulsion (i.e. as observed in those with non-BED obesity). Not only does hedonic hunger appear to be closely related to LOC and binge eating, but it also serves to distinguish among individuals with eating problems that include LOC eating (i.e. bulimia or BED) versus those which do not (non-BED obesity and anorexia-restricting type). Thus, the PFS appears to be sensitive to detecting the qualitative experience of LOC.

## **Integration of findings: What does the PFS measure, and what can be concluded about the construct of hedonic hunger?**

### **Construct validity**

Overall, the PFS appears to tap into motivation to consume palatable foods, rather than the amount of food

one is likely to consume on a given occasion. In extreme cases (e.g. bulimic-spectrum eating disorders), this motivation may confer a subjective sense of compulsion or LOC over one's eating. The results reviewed here suggest that such instances of LOC may be part of a more generalized, hypermotivational state that certain emotions and food cues unleash. Interestingly, the research reviewed here also suggests that this preoccupation and motivation do not translate to increased food consumption, nor do they reliably yield increased risk for obesity.

Although the pleasure obtained from consuming palatable foods may generally be viewed as desirable and adaptive (particularly if it does not confer increased risk for obesity), the strong connection between the PFS and LOC eating suggests that hedonic hunger reflects something beyond a normative desire to eat delicious foods. It appears to identify the minority of individuals for whom such foods are particularly compelling and have cognitive (in terms of food preoccupation), affective (in terms of powerful yearnings and cravings) and behavioural (in terms of the experience of LOC eating episodes) implications. This drive to consume highly palatable foods appears to be largely orthogonal to one's concurrent weight status or *ad libitum* food intake.

No studies to date have explored whether the LOC experienced by individuals during binge episodes is a cause or consequence of elevated hedonic hunger. Given that PFS scores change significantly in concert with changes weight and eating patterns over time—at least among clinically obese populations (36,37)—and that increasing PFS scores are observed with increased frequency of binge eating among eating disorder patients (46), is it probable that hedonic hunger becomes elevated as a consequence of repeated consumption of highly palatable foods. Theoretically, this repeated consumption may lead to progressively increased sensitization to the incentive salience of these foods well beyond normal ranges. Awareness of and attention to highly palatable foods in one's environment may consequently be enhanced, thereby increasing hedonic hunger. This conclusion also converges with established theory in the development of LOC as an extreme form of 'wanting' palatable foods which are of high incentive salience (42).

The construct of subjective 'LOC' described above is quite distinct from the term 'out of control' as a description of excessive caloric intake. Nearly all individuals with overweight or obesity gained weight because they consistently took in energy above their caloric needs. In this sense, their eating behaviour was out of control because few people intend to eat amounts of food that produce substantial weight gain. However, most overweight and obese individuals do not experience the kind of clinically significant LOC or preoccupation with



food that those with eating disorders experience regularly. Although not originally intended during development of the measure, the PFS appears to tap into LOC as a component of disordered eating. Because these feelings – as distinct from the amount of food eaten – occur at all levels of BMI, little correlation exists between BMI and PFS scores. In a few cases, obese samples demonstrated significantly higher hedonic hunger relative to normal weight groups. However, robust evidence also suggests that individuals with obesity have a higher prevalence of full-threshold or subthreshold binge eating (47–49). Thus, the role of binge eating in these group differences should be explored further.

The strong, consistent relationship between LOC and hedonic hunger (which primarily assesses eating motivation *outside* of the context of consumption) also suggests that the manifestation of LOC may go well beyond the act of eating itself. Rather, such individuals may experience obsessive thoughts and desires independently of the anticipation or act of eating. This ‘spread of effect’ may partly explain why LOC eating is associated with various adverse emotional and psychological states independently of amount of food consumed during LOC episodes (50,51).

In the context of clinical overweight and obesity, these findings highlight the importance of distinguishing between the quantitative (i.e. food consumption and weight status) and qualitative aspects (i.e. cognitive preoccupation and affective drives for eating) of behavioural health. This distinction applies not only to the PFS but also to other measures of the psychological aspects of food consumption. For example, evidence suggests that measures such as the restraint and disinhibition scales of the Three Factor Eating Questionnaire also demonstrate low correlation with naturalistic intake of palatable foods (21), and others have found that several measures of restrained and disinhibited eating have similarly low association with BMI (31). Despite this, the relation of the PFS to LOC eating may have important implications for the health of individuals across the weight spectrum. Evidence on the health consequences of LOC eating support its relevance to health outcomes in both obese and non-obese populations. For example, research among obese individuals with and without binge eating demonstrates that the former typically experience poorer health outcomes, including increased risk for glucose dysregulation and type II diabetes after controlling for BMI (52). Thus, measures like the PFS that assess hedonic drives to consume food may serve as useful indicators of eating patterns that may increase risk for adverse health outcomes, independent of body mass.

### Construct stability over time

When initially developed, the construct measured by the PFS was also thought to represent a trait-like individual characteristic that remains stable over time. Under conditions where food intake, body mass and the food environment remain stable, this assumption appears to be justified (see question 3 for details or references (10,11,34)). However, the evidence reviewed indicates that hedonic hunger decreases substantially with weight loss, whether the weight is lost through caloric restriction or surgical intervention. Both food restriction and weight loss are associated with sharp decreases in PFS scores, and those with restricting anorexia nervosa have shown the lowest mean scores of any group tested to date (46).

It is possible that these reductions reflect changes in the way individuals who have reduced their food intake and body weight wish to view themselves, rather than actual changes in hedonic hunger. Alternatively, these observations may relate to a viewpoint previously described (4). This is that the relation between food exposure (or lack thereof) and hedonic hunger works in a *feedforward* manner: The more an individual consumes palatable food, the stronger their hedonic hunger becomes. As observed in those who lose substantial amounts of weight, the less someone is exposed to or consumes palatable food, the weaker hedonic hunger becomes. This is the opposite of the *feedback* manner in which homeostatic hunger functions, where the greater the food restriction the more intense the hunger. Therefore, if hedonic hunger is generated by repeated consumption of highly palatable foods, it may be that a sharp reduction in exposure to or intake of such foods rapidly reduces the food preoccupation that characterizes hedonic hunger. Mechanistically, this suggests a similar process to that illustrated above in the case of the development of LOC eating and hedonic hunger, but in the opposite direction.

### Relation to other measures of food-related reward and disinhibition

Results reviewed thus far suggest that hedonic hunger (as measured by the PFS) represents an underlying construct of anticipated reward derived from consuming palatable foods, that this construct is associated with problematic eating behaviour (i.e. LOC eating) and that it is malleable in response to behavioural or environmental changes. Hedonic hunger is also correlated with many other widely used measures of overt manifestations of problematic eating behaviour, including disinhibited eating, emotional eating and food addiction (31). Many of these other scales emphasize actual

consumption of highly palatable foods, rather than preoccupation with them (e.g. Emotional Eating Scale (53), Yale Food Addiction Scale (54), etc.). Despite their differences in face validity, all of these measures appear to tap into a similar construct, which some have described as 'uncontrolled eating' (31) and others 'food reward responsivity' (55).

Given the wide availability of highly palatable foods in the modern food environment, one might also expect individuals high in hedonic hunger to exercise dietary restraint or engage in attempts to moderate such responsivity to food cues. Two studies have examined the correspondence between the PFS and self-report measures of cognitive restraint, as measured by the TFEQ (56). These studies identified low to modest correlations between the PFS total and subscale scores and the cognitive restraint subscale of the TFEQ ( $r_s = -0.27$  to  $0.11$ , most with non-significant  $p$  values; 11) (57). These results suggest that hedonic hunger and restraint are distinct constructs and that not all individuals who experience high levels of hedonic hunger engage in overt attempts to avoid eating highly palatable (and typically energy-dense) foods. Similar to findings regarding the PFS and impulsivity, in which overconsumption only occurs when hedonic hunger exists in combination with low impulse control, it may be interesting to explore whether PFS (drive to consume palatable foods) and restraint (attempts to over-ride that drive) interact to predict actual intake in similar ways.

Further research is required to determine whether the PFS uniquely assesses anticipated reward from and hence drive to consume palatable foods, in a manner that is distinct from older, more well-established measures. Therefore, continued use of the PFS is warranted in *conjunction* with other measures of overt disinhibited eating behaviour. This may help delineate the distinction between these related concepts.

### Limitations and future directions

This review must be considered in the context of important limitations. First, given the heterogeneity in methodology, populations studied and outcomes assessed, a review of the literature required a non-systematic approach. Although sufficient evidence was available to answer several important questions, in certain cases, there were too few studies conducted within a given research domain or with a specific population of interest to draw confident conclusions. This was particularly true for investigations involving the PFS subscales. Further, many of the studies reviewed, particularly those involving eating disorder patient samples, included primarily female participants. Evidence suggests

differential influences on eating-related behaviour between sexes (58). Moreover, although a handful of studies excluded participants who were premenopausal, no studies controlled for menstrual status beyond this. For most cross-sectional studies, it is likely that participants were likely randomly distributed across various stages of the menstrual cycle. For longitudinal and neuroimaging studies, however, it is important for future studies to consider menstrual status as an additional factor influencing hedonic hunger and eating behaviour. Finally, only published results are included here; unpublished null results may also exist.

This review serves as a launching point for additional research examining the construct of hedonic hunger and investigating the complex interplay among anticipated reward received from palatable foods, stable individual characteristics such as impulsivity and behavioural health outcomes (e.g. overt eating behaviour, obesity and binge eating). Future studies should study hedonic hunger in relation to new manipulations (e.g. various levels of chronic food availability, the psychological availability of food that is physically available, etc.). Future work would also benefit from inclusion of more diverse samples and multimodal assessment of eating behaviour, including appetitive hormones and body composition, neuroimaging, executive functioning ability and behavioural outcomes. The extent to which PFS or its subscales capture food-specific appetitive drives or more general reward sensitivity should also be explored. More longitudinal studies with more frequent assessment are also needed to understand how hedonic hunger changes over time, especially in response to qualitative and quantitative changes in food availability, food intake and weight change. Finally, additional research should determine whether the PFS subscales, which are based on graded proximity of food to the respondent, actually correspond to individuals' reactions to food as it moves from implicitly available to actually tasted.

### Conflict of Interest Statement

Ms. Espel-Huynh and Ms. Muratore have nothing to disclose. Dr. Lowe receives fees from a licence for the Power of Food Scale that he holds in partnership with Drexel University and occasionally receives royalty payments from users.

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