



Research report

The Power of Food Scale. A new measure of the psychological influence of the food environment

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ABSTRACT

This paper describes the psychometric evaluation of a new measure called the Power of Food Scale (PFS). The PFS assesses the psychological impact of living in food-abundant environments. It measures appetite for, rather than consumption of, palatable foods, at three levels of food proximity (food available, food present, and food tasted). Participants were 466 healthy college students. A confirmatory factor analysis replicated the three-factor solution found previously by Capelleri et al. [Capelleri, J. C., Bushmakin, A. G., Gerber, R. A., Leidy, N. K., Sexton, C., Karlsson, J., et al. (in press). Discovering the structure of the Power of Food Scale (PFS) in obese patients. *International Journal of Obesity*, 11, A165]. The PFS was found to have adequate internal consistency and test–retest reliability. The PFS and the Restraint Scale were regressed on four self-report measures of overeating. The PFS was independently related to all four whereas the Restraint Scale was independently related to two. Expert ratings of items suggested that the items are an acceptable reflection of the construct that the PFS is designed to capture. The PFS may be useful as a measure of the hedonic impact of food environments replete with highly palatable foods.

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1. Introduction

The obesity epidemic is a result of individuals consuming more energy than they are expending. Substantial evidence now exists that the great difficulty many people have avoiding a positive energy balance and weight gain stems from appetitive motives that not only protect against energy deficits but, even in the absence of a caloric deficit, respond to the widespread availability of highly palatable foods with a powerful drive to consume them (Lowe & Butryn, 2007). The ability to obtain and eat palatable food any time one wants may barely affect some individuals but constitute an almost constant temptation to others. Such individual differences may be reflected in part by the reinforcing value of food. For instance, when given a choice of food or a variety of pleasurable sedentary activities, obese people work harder for access to food than the non-obese (Saelens & Epstein, 1996). Epstein and Leddy (2006) have also suggested that the dopamine release caused by ingestion of palatable foods may, through

conditioning, begin to occur in response to cues that predict food availability or ingestion. Thus the general availability of palatable food and frequent exposure to food-related cues may begin to influence psychological processes (e.g., thoughts, feelings, motivations) even when food intake is not imminent or underway. Given that there are individual differences in the degree to which the food environment affects people's thoughts, feelings and behavior, a measure capable of assessing such individual differences could be both theoretically and clinically useful.

The purpose of this paper is to test the psychometric properties of a new measure of appetitive drive to consume highly palatable food. The measure is called the Power of Food Scale (PFS). The measure is based on the assumption that the respondent is living in an environment such as a developed country where a variety of highly palatable foods are readily available. Thus the PFS is not a measure of the food environment, but a measure of individual differences in appetite-related thoughts, feelings and motivations in environments where plentiful palatable foods are constantly available. This approach is based on a two-factor model of appetite (Lowe & Butryn, 2007; Lowe & Levine, 2005) that suggests that individual differences in motivation to eat beyond physiological need will be magnified in environments where highly palatable foods are omnipresent.

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Table 1

PFS sample demographics and assessment measures used.

Data set	Participants			Age		BMI		Measures
	<i>n</i>	Male	Female	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
England I	164	33	131	19.5	3.8	22.6	3.7	DEBQ-External Eating Scale DEBQ-Emotional Eating Scale Restraint Scale
England II	149		–	21	1.1	21.8	2.9	Restraint Scale
Drexel I	81	0	81	19.8	1.6	23.1	4.3	DEBQ-External Eating Scale Restraint Scale TFEQ MCSDS
Drexel II	72	0	72	18	0.5	21.9	2.4	DEBQ-Emotional Eating Scale Restraint Scale TFEQ

Note: Gender information not collected from England II sample.

In line with the goal of measuring appetite for – rather than consumption of – palatable foods, no items describing actual food consumption (or over-consumption) were included in the PFS. At the same time, there is evidence that the proximity of food to people impacts their appetitive reactions to it (Painter, Wansink, & Hieggelke, 2002). Therefore we designed PFS items that described three levels of food proximity. The first level assumes the widespread availability of palatable food in the environment. Thus these items are the most abstract because they describe reactions to an “implicit” food environment in which food is always available but is not physically present. The second level involves reactions to palatable foods when they are physically present but have not yet been tasted. The third level involves reactions to palatable foods when they are first tasted but are not yet consumed. To the extent that a factor analysis of the PFS supports the existence of these factors, then the availability of these subscales may be informative for addressing certain research questions. These distinctions also comprise our definition of the “food environment” in this paper. That is, by this term we are referring to the widespread availability of palatable food – especially in developed countries – ranging from its more distal availability (e.g., implicitly knowing that there is always food available in the refrigerator or at the corner store) to its most proximal availability (when first tasting a food), but excluding the actual consumption of food.

The initial pool of PFS items was generated by obese women participating in a weight loss trial. The process of developing and refining potential PFS items to create an initial pool of 21 items has been described in another paper (Cappelleri et al., in press). That paper also describes exploratory and confirmatory factor analyses conducted with the initial 21-item pool. The exploratory factor analysis, which was conducted among 1741 obese participants in a randomized clinical trial of a weight loss medication, indicated that the scale was best represented by a 3-factor, 2nd-order model with 3 domains and an aggregate domain (average of 3 domains). This solution was then confirmed among 1275 normal weight, overweight and obese individuals in a web-based survey. The Comparative Fit Index for the two samples was high (0.95 and 0.94, respectively) and Cronbach's alpha from the two data sets were acceptable, ranging from 0.81 to 0.91.

Examples of PFS items include: *If I see or smell a food I like, I get a powerful urge to have some; It seems like I have food on my mind a lot; and I think I enjoy eating a lot more than most other people.* Respondents are instructed to indicate the extent to which each statement describes them. Response options are on a 5-point Likert scale ranging from (1) *don't agree at all* to (5) *strongly agree*.¹

Capelleri et al. report that content validity of the PFS items (assessed by expert raters) was acceptable.

This study was designed with two key aims. First, it was designed to determine if the factor structure found by Cappelleri et al. (in press) could be replicated. Replication of the factor structure with a different sample would provide compelling evidence that the structure is not sample-specific. Second, this study was designed to evaluate the internal consistency, test–retest reliability, and convergent, incremental, and discriminant validity of the PFS. A preponderance of eating-focused research is conducted with college students. Thus, replicating the PFS factor structure and documenting its psychometric properties with college students should lend confidence to the use of this scale with that population.

Methods

Data reported in this paper were collected from four separate samples. A summary of sample demographic information and additional measures administered to each sample is presented in Table 1. The study protocol at each institution where data were collected was approved by the institutional review board at that university. Participants in the *England I* study were 164 students at the University of Liverpool, Liverpool, United Kingdom. Participants in the *England II* study were 149 students at Keele University, Staffordshire, England. Ethnicity data were not collected in either sample. Participants in the *Drexel I* study were 81 undergraduate students at Drexel University, Philadelphia, PA. The sample was 67% Caucasian, 17% Asian, 10% African American, 2% Hispanic, and 4% other. Participants in the *Drexel II* study were 72 students at Drexel University. The sample was 76% Caucasian, 7% African American, 14% Asian American, and 3% Hispanic American. Test–retest reliability was determined by re-administering the PFS to this sample after 4 months.

Several additional measures were administered to one or more samples of participants. The Restraint Scale (RS; Herman & Polivy, 1980) is a self-report measure of chronic dieting for the purpose of weight control. The RS predicts lab-based overeating and has acceptable test–retest reliability and internal consistency (Lowe & Thomas, 2009). The Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985) consists of subscales measuring three aspects of eating behavior: cognitive restraint (cognitive and behavioral aspects of controlling food intake), disinhibition (susceptibility to emotional and social cues), and hunger (eating when hungry). All three subscales have adequate internal consistency (Stunkard & Messick, 1985). The Dutch Eating Behavior Questionnaire (DEBQ) includes subscales called Emotional Eating (eating in response to emotional distress) and External Eating (eating in response to external food cues; van Strien, Rookus, Bergers, Frijters, & Defares, 1986). The DEBQ has

¹ Copies of the PFS can be obtained by contacting the first author.

adequate test–retest reliability, internal consistency, and discriminative and concurrent validity (van Strien et al., 1986). The Marlowe–Crowne Social Desirability Scale (MCSDS; Crowne & Marlowe, 1960) is a self-report measure designed to assess an individual's tendency to respond to questions in a socially desirable way, which could undermine the validity of a self-report measure (Crino, Svoboda, Rubenfeld, & White, 1983).

Results

The sample was comprised of 466 participants, who had a mean BMI of 22.4 kg/m². The majority of participants (79.5%) had a BMI below 25 kg/m²; 18.5% were overweight (i.e., BMI 25.0–29.9 kg/m²) and 2.0%, were obese (i.e., BMI > 30.0 kg/m²). Participants ranged from 18 to 42 years of age ($M = 20.1$ years). Females comprised 86.0% of the sample for which gender was known (for a subgroup of 149 participants, data on sex were not collected). No differences between women and men were found on PFS scores ($M = 2.28$, $SD = 0.76$ and $M = 2.14$, $SD = 0.63$, respectively; $t(229) = 1.02$, $p = .31$). Similarly, a one-way ANOVA indicated that there were no differences in mean PFS scores between participants who were Caucasian ($M = 2.22$, $SD = 0.69$), African American ($M = 2.12$, $SD = 0.73$), or Asian ($M = 2.51$, $SD = 0.78$; $p = .28$).

Factor analyses

Preliminary analysis of the data revealed that all assumptions of confirmatory factor analysis were met. There was no evidence of multicollinearity and outliers were detected and deleted using Mahalanobis distance [$\chi^2(15) = 37.70$]. This resulted in two cases being deleted from the analysis. Confirmatory factor analysis (CFA) was performed by Mplus 4.1 (Muthén & Muthén, 2006). A three-factor structure was assumed to exist, as in Cappelleri et al.'s (in press) study that yielded the 15-item version of the PFS: (1) food available, (2) food present, and (3) food tasted. Each item was specified to load on a single factor as specified in the Cappelleri et al. solution; error covariances were constrained to zero, and factors were allowed to correlate. Fit was measured by the chi-square test, the comparative fit index (CFI), and the root mean square error of approximation (RMSEA). A model with reasonably good fit can be characterized by values obtained from three criteria: a chi-square value that does not exceed a limited multiple of its degrees of freedom, a CFI greater than 0.90, and a RMSEA that is smaller than 0.08 (Hu & Bentler, 1999). CFA models are often evaluated with multiple fit indices to ensure the reliability of any conclusions regarding goodness of fit. The fit of the three-factor model was satisfactory ($\chi^2_{[87]} = 276$, $p < .001$; CFI = 0.94, RMSEA = 0.07). Each item loaded significantly on its respective factor (see Table 2). The correlations between the three factors were high (factors 1 and 2, $r = .78$; factors 2 and 3, $r = .84$; factors 1 and 3, $r = .84$), which supports the use of a total scale score. The three-factor model was compared to a one-factor model, which was clearly inferior ($\chi^2_{[90]} = 450$, $p < .001$; CFI = 0.88, RMSEA = 0.09).

Reliability

The corrected item–total correlations (i.e., the correlation of the item with the sum of all other items, with that item removed) ranged from .50 to .73. Chronbach's alpha was .91. Four-month test–retest reliability in the Drexel II sample was adequate ($r = .77$, $p < .001$).

Validity

As shown in Table 3, several measures were examined as correlates of both the PFS and the RS. The PFS was significantly

Table 2

Standardized factor loadings and factor correlations for the three-factor PFS model.

Item	Food available	Food present	Food tasted
PFS 1	0.66		
PFS 2	0.72		
PFS 3		0.65	
PFS 4		0.62	
PFS 5	0.74		
PFS 6		0.80	
PFS 7		0.66	
PFS 8			0.65
PFS 9			0.66
PFS 10	0.60		
PFS 11	0.77		
PFS 12			0.74
PFS 13	0.83		
PFS 14			0.57
PFS 15			0.61

Table 3

RS and PFS: comparison of correlations with self-report measures.

	RS	PFS	R ² change for PFS
RS	–	.30*	–
TFEQ-D	.50*	.61*	.22*
TFEQ-H	.13	.63*	.39*
DEBQ-Emot.	.64*	.54*	.07*
DEBQ-Ext.	.29*	.66*	.37*

* Significant at the 0.01 level (2-tailed).

related to scores on all measures (Table 3). No PFS/BMI correlation was found ($r = .03$) but this could result from a limited range of BMI values.

Incremental validity was examined, as it seemed important to determine if the PFS was capable of accounting for variance in the validity measures beyond that accounted for by the RS. Multiple linear regressions were conducted to assess the relative influence of the RS and PFS on the TFEQ and DEBQ subscales. (Statistical power for these regression equations was adequate: a minimum of 99 participants are needed to have a power of .80, with an effect size (f^2) of 0.10 (which is a small-to-moderate effect size) and alpha of 0.05). When the RS and PFS were entered as simultaneous predictors in the regression models, PFS remained a significant predictor of all four subscales (TFEQ-Disinhibition: $B = 2.48$, $SEB = 0.31$, $p < .001$; TFEQ-Hunger: $B = 2.99$, $SEB = 0.30$, $p < .001$; DEBQ-Emotional Eating: $B = 4.88$, $SEB = 0.86$, $p < .001$; DEBQ-External Eating: $B = 4.89$, $SEB = 0.39$, $p < .001$). The RS was a significant independent predictor of TFEQ-Disinhibition ($B = 0.22$, $SEB = .04$, $p < .001$) and DEBQ-Emotional Eating ($B = 0.77$, $SEB = 0.08$, $p < .001$) in these analyses, but not TFEQ-Hunger ($B = (0.05)$, $SEB = 0.04$, $p = .17$) or DEBQ-External Eating ($B = 0.07$, $SEB = 0.04$, $p = .055$). As shown in Table 3, when the RS was entered first as a predictor of each of those four variables, the PFS explained a significant amount of additional variance.

In the Drexel I sample, the correlation between the PFS and the MCSDS was small but significant ($r = -.23$, $p = .04$), suggesting that PFS responses may be influenced by a desire to appear in a socially desirable light.

Discussion

This study examined the psychometric properties of the PFS. Confirmatory factor analysis in mostly normal weight college students supported a three-factor solution, consistent with Cappelleri et al.'s (in press) results in mostly overweight adults. The three factors are (1) food available, (2) food present, and (3) food tasted. The three factors are highly correlated and the scale has high internal consistency, which supports the use of a total

scale score. The temporal stability of the PFS was quite high, particularly in light of the fact that four months elapsed between the two administrations of the PFS. The fact that a 15-item, three-factor solution was found in the derivation and confirmation samples in the Capelleri et al. study of mostly older, overweight individuals and in the current sample of mostly younger, normal weight individuals supports the robustness of 15-item full scale and of the three factors of which it is comprised. This study had adequate statistical power for factor analysis, according to the standard guideline that recommends a minimum of 10 participants per item in a measure (Pett, Lackey, & Sullivan, 2003).

Tests of the PFS' validity indicated that it was moderately correlated with the Disinhibition and Hunger subscales of the TFEQ and with the Emotional Eating and External Eating subscales of the DEBQ. When regressions controlling for RS scores were conducted, the PFS remained a significant predictor of all four subscales (Table 2). In addition, the amount of incremental variance accounted for by the PFS in three of these measures (Hunger, Emotional Eating and External Eating) was quite large, with the amount of additional variance explained (i.e., increment in R^2) by the PFS ranging between 22% and 39%. This is an important finding given that in past research the RS has itself been a robust predictor of anomalous appetitive responses to a wide variety of stimuli (Lowe, 1993). These analyses indicate that the PFS (1) may reflect appetitive responsiveness to a broader range of stimuli than the RS, and (2) accounts for variance in susceptibility to eating, beyond that accounted for by the RS, in response to social, emotional, food-related and hunger stimuli. Nonetheless, because these results are based solely on relationships with other self-report measures, it is critical to test these conclusions using measures of appetitive responsiveness not involving self-report.

Fairburn, Cooper, and O'Connor (2008) have previously distinguished between dimensions measuring the amount of food consumed and whether food intake was accompanied by feelings of loss of control. It is possible that self-perceived lack of eating control underlies these relationships more than a susceptibility toward overeating. Again, it will be important to test this hypothesis using measures not based on self-report.

The validity of the PFS has been further tested in two recent studies. Forman et al. (2007) asked participants to keep a transparent box of chocolate kisses with them for two days while abstaining from all chocolate consumption. They tested two strategies for helping participants cope with chocolate cravings they might experience: a control-based strategy (e.g., thought-stopping) and an acceptance-based strategy (e.g., cognitive defusion). Participants who ate the kisses had significantly higher PFS scores than those who did not. The PFS significantly predicted the strength of chocolate cravings and the intensity of and distress associated with cravings. They also were significant or marginally significant interactions between response to the treatment conditions and PFS scores, which supports the validity of the PFS in clinically relevant domains. Levitsky and Shen (2008) conducted a laboratory study that also documented the ability of the PFS to predict food intake. After being served a large, restaurant-style meal, which caused significant reductions in hunger and increases in satiety, participants were offered dessert. Despite the feeling of satiety, almost all subjects consumed dessert and the PFS was a significant predictor of the amount of dessert consumed.

In studies where overeating in response to a wide range of contexts (hunger, emotions, highly palatable foods, etc.) is of interest, the PFS may be a good measure to use because it appears to reflect such a broad-based susceptibility and minimizes burden on respondents. The present results also suggest that, among predisposed individuals, food-abundant environments do not just

affect food intake (during the several daily bouts of eating most people engage in), but also influence food-related cognition, affect, and motivation even when food intake is not imminent or underway. This in turn raises the possibility that for some people the deleterious effects of the "toxic" food environment (Horgen & Brownell, 2002) extend well beyond weight gain and physical health. A recently completed study in line with this suggestion found that the PFS predicted whether overweight and obese individuals sought outside help for weight control, with those who had sought such help in the past scoring higher on the PFS than those who had not (Annunziato & Lowe, 2007).

It is likely that there are meaningful individual differences in the strength of hedonically based motivations to eat (Epstein & Leidy, 2006) and a measure that assessed these differences could be useful for both theoretical and clinical reasons. The PFS may help fulfill this need by measuring sensitivity to the hedonic aspects of the food environment. The assumption underlying the PFS' potential utility is that such responsiveness can manifest itself not only in overeating (i.e., energy intake beyond energy needs) but also in the activation of food-related thoughts, feelings and motivations at almost any time of the day (and, in night eaters, perhaps even in the middle of the night).

There are a number of ways in which the PFS might be useful clinically. For instance, we (Lowe, 2003; Lowe & Levine, 2005) have previously argued that individuals who are highly susceptible to the omnipresence of palatable food in the environment may need to gain control over their "personal eating environments" to achieve long-term weight control. Such individuals may need to systematically increase the structure of the foods they eat (e.g., through the use of pre-portioned frozen entrees) and reduce the energy density of foods in their homes. The PFS may be useful in identifying individuals for whom such modifications may be particularly advisable. The PFS might also be useful in furthering our understanding of abnormal eating behaviors. For instance, morbidly obese individuals obviously have a history of caloric consumption far in excess of their energy needs. However, as they gain weight their food intake might also be influenced by neurophysiological adaptations to excessive food intake and to the physiological changes caused by excess body fat. Use of the PFS before and after bariatric surgery in such individuals might shed light on how different aspects of food's psychological influence does (or does not) change after the massive loss of adipose tissue produced by the surgery.

The primary limitation of this study is that the number of overweight and obese participants, and the number of male participants, was small. The small number of men in the study may limit the ability to generalize our findings, although it should be noted that a substantial proportion of participants examined in the Cappelleri et al. (in press) analyses were men. In addition, because the first stage of the PFS' development was based on information provided by obese women, additional research with a larger male population will be necessary to test the validity of the PFS among men. Ethnicity data were not collected for many of the participants, so it is not known how ethnically diverse the sample was; this may limit the generalizability of the findings. The self-report of weight and height to calculate BMI is also a limitation, albeit a minor one, given that the correlation between self-report and measured height and weight is high (Nieto-Garcia, Bush, & Keyl, 1990). There may be some bias towards socially desirably responding on the PFS (given the significant correlation between PFS and the Marlow-Crowne social desirability scale) that future research should further examine. Finally, additional research must be conducted to objectively evaluate the PFS's validity, for example by measuring lab-based food intake in response to relevant cues and examining physiological indices of appetitive responsiveness. Additional research also should be conducted to determine how scores on

the PFS may change in individuals who are currently losing weight (i.e., those in negative energy balance).

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