



# Examining the ecological validity of the Power of Food Scale

Lindsay M. Howard<sup>1</sup> · Kristin E. Heron<sup>1,2</sup> · Kathryn E. Smith<sup>3,4,5</sup> · Ross D. Crosby<sup>3,4</sup> · Scott G. Engel<sup>3,4</sup> · Stephen A. Wonderlich<sup>3,4</sup> · Tyler B. Mason<sup>6</sup>

Received: 25 October 2019 / Accepted: 11 February 2020 / Published online: 27 February 2020  
© Springer Nature Switzerland AG 2020

## Abstract

**Purpose** Appetite for palatable foods may impact eating-related behaviors in everyday life. The present study evaluated the real-world predictive validity of the Power of Food Scale (PFS) using ecological momentary assessment (EMA).

**Methods** 30 women who reported binge eating completed the PFS and related measures. Subsequently, during a 14-day assessment period, participants completed five daily EMA surveys of appetite and binge eating via text message and web.

**Results** Results of generalized estimating equations showed that higher PFS scores were associated with higher momentary levels of hunger, eagerness to eat, and urge to eat but were unrelated to fullness, preoccupation with thoughts of food, and binge eating.

**Conclusion** This study supported the ecological validity of the PFS by demonstrating its association with momentary measures of appetite in everyday life using EMA. Although the PFS may not be predictive of binge eating, future research should investigate PFS as a dispositional moderator, and explore associations between the PFS and overeating (i.e., binge eating without the loss of control component) and loss of control eating in non-clinical samples.

**Level of evidence** Level IV, multiple time series.

**Keywords** Appetite · Binge eating · Validity · Women's health · Obesity

---

Article is part of the Topical Collection on Food and Addiction.

✉ Lindsay M. Howard  
lhowa007@odu.edu

<sup>1</sup> The Virginia Consortium Program in Clinical Psychology, Norfolk, VA, USA

<sup>2</sup> Department of Psychology, Old Dominion University, Norfolk, VA, USA

<sup>3</sup> Center for Biobehavioral Research, Sanford Health, 900 Fargo, ND, USA

<sup>4</sup> Department of Psychiatry and Behavioral Science, University of North Dakota School of Medicine and Health Sciences, Fargo, ND, USA

<sup>5</sup> Department of Psychiatry and Behavioral Science, University of Southern California, 2250 Alcazar Street #2200, Los Angeles, CA 90033, USA

<sup>6</sup> Department of Preventive Medicine, University of Southern California, Los Angeles, CA, USA

## Introduction

Binge eating is defined as eating an objectively large amount of food in a short amount of time while experiencing a sense of loss of control over eating [1]. This tendency to eat beyond immediate homeostatic needs may be related to anticipated pleasure from consuming palatable foods, which is thought to reflect the psychological impact of appetitive experiences in everyday life [2]. Importantly, the contextual factors related to eating behaviors fluctuate from moment-to-moment in naturalistic environments [3]. It is, therefore, necessary to evaluate the extent to which trait-level measures of appetitive processes capture eating-related cognitions and behaviors occurring in daily life.

Although there are a variety of measures available to assess eating in response to food stimuli (e.g., eating disorder examination [EDE]; [1]), these measures assess consummatory as opposed to appetitive aspects of eating. Thus, the Power of Food Scale (PFS) [4] was developed to measure appetite for, rather than consumption of, palatable foods, at three levels of food proximity (food available, food present, and food tasted) also termed hedonic hunger. The PFS

has been linked to overeating, loss of control eating, dieting, global eating disorder psychopathology, and obesity in healthy college students, young adults, a general German population, and adults with obesity [2–6].

As with most other measures of eating behavior, the PFS has been validated by administering retrospective self-report questionnaires in a laboratory setting or via web-based survey [2–4]. However, retrospective data collection limits the ability to make inferences about how these processes play out in everyday life. A growing body of research suggests that people have limited ability to accurately recall past experiences (e.g., over the past month), but are able to accurately report on a wide range of recent or current experiences (e.g., over the last hour) [7], highlighting the fact that designs which minimize recall bias are in critical need.

To address concerns that memories are often reconstructive [7], methodologies such as ecological momentary assessment (EMA) has emerged, which focus on collecting reports of momentary experiences in real time [5]. EMA data collection occurs in everyday life through the use of small electronic devices, such as smart phones [8]. The use of EMA has several advantages over traditional cross-sectional and longitudinal designs, including that it minimizes recall bias, maximizes ecological validity, and allows researchers to study the more immediate impact of thoughts, feelings, and behaviors in daily life [7]. Recent research has used EMA to study associations between retrospective survey measures and real-world eating behavior of adults [9, 10]. Consistently, the aim of the current study was to use EMA to examine the ecological validity of the PFS in women who engage in binge eating. We hypothesized that women that scored higher on the PFS at baseline would experience higher levels of momentary measures of appetite (i.e., fullness, hunger, eagerness to eat, urge to eat, and pre-occupation with thoughts of food) and binge eating in their everyday life using EMA.

## Methods

### Participants

30 women (93% White) who reported current binge eating completed 14 consecutive days of EMA surveys. Current binge eating was defined as reporting at least one objective binge-eating episode in the past month via clinical interview on a selected module from the EDE [1]. Women were excluded for the following reasons: (1) inability to read or speak English; (2) current psychosis; (3) current mania; (4) acutely suicidal; (5) current medical instability; (6) past year severe substance use disorder; (7) severe cognitive impairment or intellectual disability; (8) currently pregnant or breastfeeding; (9) current or past 4-week inpatient or partial

hospitalization; and (10) changes to eating disorder treatment in the past 4 weeks. The mean age of the sample was 34.13 years (SD 13.92, range 19–62), and the mean body mass index was 34.13 (SD 9.47, range 18.43–57.83). Most of the sample (> 75%) met criteria for an eating disorder using the EDE [1], with the most common diagnoses being bulimia nervosa ( $n = 14$ ) and binge eating disorder ( $n = 6$ ).

### Procedures

The study was reviewed and approved by the relevant institutional review board. Participants were recruited from an eating disorder and weight management clinic in the Midwest US as well as local community advertising. Potential participants were screened via phone or in-person at a clinic visit to evaluate initial study criteria. Those who met initial criteria and were interested completed an in-person study visit during which they completed the informed consent process as well as clinical interviews to assess eligibility criteria. Trained master's level assessors gave clinical interviews. Those who met all inclusion criteria completed self-report questionnaires and received training on the EMA protocol, which included completing an EMA survey in-person and receiving definitions of eating disorder behaviors (consistent with DSM-5).

The real time assessment in the natural environment (RETAIN; [retaine.org](http://retaine.org)) system was used to administer EMA surveys. Each day, participants received five semi-random text messages delivered to their mobile phones, which were administered within five pre-determined windows starting in the morning through the evening. In the text message, they were provided a link that allowed them to complete the EMA survey. Participants had an hour to complete the survey before they could no longer access it, which prevented backlogging of EMA reports. During the recordings, participants were asked about eating disorder behaviors, mood, and other momentary contextual factors. A research assistant called participants halfway through the EMA protocol to remind them about compliance and answer questions or address concerns. Participants received \$110 for completion of in-person clinical interviews and assessments, and \$2 per survey that they completed during the EMA protocol.

### Measures

#### Demographics

A demographics questionnaire was administered that included questions about age, gender, race, ethnicity, education, height, weight, current psychotherapy or counseling, and past psychotherapy or counseling.

## Power of Food Scale (PFS) [4]

The PFS is a 15-item self-report measure that assesses the psychological influence of appetitive experiences in everyday life, as indicated by appetite for, rather than consumption of, palatable foods. This is a multidimensional measure with three subscales: appetite for food available, food present, and food tasted. The three subscale scores are computed by taking the average of the items comprising the respective domains, while the total score is computed by taking the average of the three subscale scores. The PFS total score was used in analyses. Higher scores indicate a greater responsiveness to the food environment. Response options range from 1 (I do not agree) to 5 (I strongly agree). Past research shows PFS total scores significantly predict overeating and obesity in community samples, thus demonstrating criterion validity [2]. The PFS is a reliable measure in adults with average weight, overweight, and obesity (alphas range from 0.81 to 0.91) [2]. The PFS has demonstrated psychometric invariance across gender, ethnicity, and weight status in a diverse college sample [11]. Cronbach's alpha for the total score in the current sample was .89.

## Momentary binge eating

Participants were asked to mark whether they had “binged (objective overeating with loss of control)” since the last recording, scored as 0 (no) or 1 (yes). Similar procedures have been used to define binge eating in other EMA studies [8].

## Momentary appetite

The EMA scale for appetite [12] was used to assess momentary levels of fullness, hunger, eagerness to eat, urge to eat, and preoccupation with thoughts of food on scales from 0 (none) to 100 (most intense). Associations between the PFS and the five appetite items were examined separately. Past findings have shown that appetite total scores are positively associated with energy intake in undergraduate and graduate students, thus demonstrating criterion validity [12].

**Table 1** Means, standard deviations, and general estimating equation results of PFS predicting EMA measures ( $N=30$ )

Outcome	$M$ (SD)	Estimate	SE	Wald-Chi square	$p$
Appetite hunger	38.81 (30.46)	6.31	2.95	4.57*	.032
Appetite eagerness to eat	37.71 (31.04)	9.01	2.81	10.23***	<.001
Appetite urge to eat	41.07 (31.67)	7.16	2.65	7.28**	.007
Appetite preoccupation	42.89 (32.84)	6.49	3.99	2.64	.104
Appetite fullness	41.67 (30.29)	3.37	4.12	0.69	.414
Binge eating	13.9%	0.22	0.22	0.94	.332

All variables were tested in separate models. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

## Statistical analyses

Descriptive statistics and EMA compliance were calculated. Separate general estimating equations (GEEs) using an AR1 serial autocorrelation with linear functions were used to assess associations between PFS total scores (grand-mean centered) and appetite facets, and GEEs with binary logistic functions were used to assess the association between PFS total scores and binge-eating episodes. PFS scores were entered in models as the independent variable and appetite facets and binge eating were the dependent variables. All available data were used in analyses.

## Results

There were 1,558 total EMA recordings. The mean number of recordings completed per participant was 51.93 (SD 13.49, range 16–70). The overall compliance rate was 78.3%. The number of EMA recordings completed was unrelated to demographic variables, PFS scores, or EMA appetite. Over the course of the EMA period, there were 213 binge-eating episodes across the sample. The mean number of binge episodes reported during the EMA protocol per participant was 7.10 (SD 4.40, range 1–16). The mean PFS score was 3.83 (SD 0.63, range 2.50–5.00). Table 1 presents the results showing higher PFS total scores were associated with higher momentary levels of hunger, eagerness to eat, and urge to eat. PFS total scores were unrelated to fullness, preoccupation with thoughts of food, and binge eating.

## Discussion

The present study evaluated the ecological validity of the PFS by exploring appetitive correlates in everyday life using EMA. Exploring the real-world predictive validity of the PFS is important for determining whether the PFS, a retrospective questionnaire, predicts appetite for palatable food in an individual's day-to-day life. Past research using retrospective designs have limited researcher's ability to make inferences about the correlates of PFS in real-world

settings, despite interest in how constructs measured by the PFS relate to appetite and eating behaviors in everyday life.

In the present study, we found that the PFS was associated with momentary levels of hunger, eagerness to eat, and urge to eat, establishing the ecological validity of the scale. Interestingly, the PFS was not significantly associated with momentary measures of fullness, preoccupation with thoughts of food, and binge eating, although all trends were in the expected direction. The non-significant association between the PFS and binge eating may reflect the fact that the PFS was intended to measure appetite for, as opposed to consumption of, palatable foods. Binge eating would be considered a consummatory behavior. Recent findings from the same sample show that momentary self-criticism and appearance concerns predict subsequent elevation on the preoccupation with thoughts of food item, potentially suggesting that this item taps more of a ruminative cognitive process as opposed to appetite or hedonic hunger [13]. Although speculative, the non-significant association between the PFS and momentary measures of fullness and preoccupation with thoughts of food could also indicate that “fullness” and “preoccupation with thoughts and food” are more distal measures of appetite, in comparison to the other appetite items that seem to assess the desire to eat more directly. Consistent with this possibility, Kikuchi and colleagues [12] found that the factor loading for fullness was less than 0.03 for the between-individual factor structure in their initial development study.

The current findings suggest that the PFS is associated with three momentary measures of appetite, but not binge eating behavior itself in a largely clinical sample. Although previous research has linked the PFS to overeating, loss of control eating, dieting, and obesity in college and community samples using cross-sectional designs [2–6], the PFS may not be associated with binge episodes in daily life using a clinical sample. It is possible that binge eating may be more habit driven in a clinical sample. Moreover, the current study defined binge episodes as overeating accompanied by a feeling of loss of control. Future research should explore the ecological validity of the PFS with overeating alone (i.e., eating what others would consider an unusually large amount of food *not* accompanied by a loss of control) as well as a sense of loss of control eating alone, as the present study focused on binge eating (overeating with loss of control). The PFS may also interact with other trait- and state-level factors (e.g., poor executive functioning, food reward sensitivity, inhibitory control, and negative affect) to increase risk for binge eating [14]. For example, established relationships between negative affect and binge eating might be moderated by power of food, such that the relationship between negative affect and binge eating may be stronger for individuals who score higher on the PFS.

## Clinical implications

Investigating the ecological validity of the PFS has potential clinical utility for working with women with bulimia and binge eating disorder. The psychological influence of food may be an important target for reducing eating-related concerns, especially given its association with appetite in daily life. It is notable that the PFS is associated with hunger, eagerness to eat, and urge to eat because these are common targets of evidence-based treatments, such as dialectical behavior therapy (DBT) and mindfulness-based interventions, shown effective for reducing overeating and loss of control eating [15]. Tenets of DBT and other mindfulness-based interventions support urge surfing (i.e., riding the wave of an impulse) and contact with the present moment as a way to shift attention away from hunger or an eagerness to eat towards the here and now [13]. These same interventions might decrease scores on the PFS given that the psychological influence of food is impacted by thoughts typically unconcerned with the present moment (e.g., “I often think about what foods I might eat later in the day”). Future research should investigate whether these empirically based interventions reduce PFS scores, and whether the PFS might further inform specific interventions.

## Limitations

A limitation of this study is generalizability. The study used a primarily White clinical sample of all women, thus further validation in men, non-clinical populations, and racial and ethnic minorities is warranted. The sample size of the present study is also considered a limitation. In addition, EMA does not allow for determination of causal relationships between constructs; therefore, the PFS should be used in longitudinal studies to investigate its impact on appetite, overeating, binge eating, and other relevant health outcomes. Despite these limitations, the present study provides evidence of ecological validity, suggesting that the PFS indeed reflects appetitive experiences in everyday life.

## Conclusion

Taken together, the present study established preliminary evidence of the real-world predictive validity of the PFS by exploring appetitive correlates in everyday life using EMA. Results indicated that trait levels of hedonic hunger were associated with appetite for palatable food in naturalistic settings, as evidenced by relationships between PFS scores and momentary levels of hunger, eagerness to eat, and urge

to eat. Future research using longitudinal designs and diverse samples should explore the predictive utility of the PFS on relevant health outcomes (e.g., weight gain, eating disorder onset) and the potential influence of moderators such as poor executive control and negative affect, as the psychological influence of food may be an important target for reducing eating-related concerns.

### What is already known on this subject?

The PFS [4] is a 15-item self-report measure that was developed to measure hedonic hunger (i.e., appetite for palatable foods). The PFS has been validated using cross-sectional designs, and has been linked to overeating, loss of control eating, dieting, global eating disorder psychopathology, and obesity in healthy college students, young adults, a general German population, and adults with obesity [2–6].

### What does this study add?

The present study established the ecological validity of the PFS by exploring appetitive correlates in everyday life using EMA. The PFS was associated with momentary levels of hunger, eagerness to eat, and urge to eat. The psychological influence of food may be an important target for reducing eating-related concerns.

**Funding** This study was funded in part by T32MH082761 from the National Institute of Mental Health.

### Compliance with ethical standards

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the University of North Dakota and Sanford Health and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

### References

- Fairburn CG, Cooper Z, O'Connor M (2008) Eating disorder examination. In: Fairburn CG (ed) *Cognitive behavior therapy and eating disorders*. Guildford Press, New York. 10.1002/0471743984.vse9327
- Cappelleri JC, Bushmakina AG, Gerber RA, Leidy NK, Sexton CC, Karlsson J, Lowe MR (2009) Evaluating the power of food scale in obese subjects and a general sample of individuals: development and measurement properties. *Int J Obesity* 33:913–922. <https://doi.org/10.1038/ijo.2009.107>
- Goldschmidt AB, Crosby RD, Cao L, Engel SG, Durkin N, Beach HM et al (2014) Ecological momentary assessment of eating episodes in obese adults. *Psychosom Med* 76:747. <https://doi.org/10.1097/PSY.000000000000108>
- Lowe MR, Butryn ML, Didie ER, Annunziato RA, Thomas JG, Crerand CE et al (2009) The power of food scale. A new measure of the psychological influence of the food environment. *Appetite* 53:114–118. <https://doi.org/10.1016/j.appet.2009.05.016>
- Andreeva E, Neumann M, Nöhre M, Brähler E, Hilbert A, de Zwaan M (2019) Validation of the German version of the power of food scale in a general population sample. *Obes Facts* 12:416–426. <https://doi.org/10.1159/000500489>
- Lipsky LM, Nansel TR, Haynie DL, Liu D, Eisenberg Colman MH, Simons-Morton B (2019) Lack of prospective relationships of the power of food scale with body mass index and dieting over 2 years in U.S. emerging adults. *Eat Behav* 34:101302. <https://doi.org/10.1016/j.eatbeh.2019.101302>
- Smyth JM, Stone AA (2003) Ecological momentary assessment research in behavioral medicine. *J Happiness Stud* 4:35–52. <https://doi.org/10.1023/A:1023657221954>
- Smyth J, Wonderlich SA, Heron K, Sliwinski MJ et al (2007) Daily and momentary mood and stress predict binge eating and vomiting in bulimia nervosa patients in the natural environment. *J Consult Clin Psych* 75:629–638. <https://doi.org/10.1037/0022-006X.75.4.629>
- Jeffers AJ, Mason TB, Benotsch EG (2019) Psychological eating factors, affect, and ecological momentary assessed diet quality advance online publication. *Eat Weight Disord*. <https://doi.org/10.1007/s40519-019-00743-3>
- Mason TB, Smith KE, Crosby RD, Wonderlich SA, Crow SJ, Engel SG, Peterson CB (2018) Does the Eating Disorder Examination Questionnaire global subscale adequately predict eating disorder psychopathology in the daily life of obese adults? *Eat Weight Disord* 23:521–526. <https://doi.org/10.1007/s40519-017-0410-0>
- Serier KN, Belon KE, Smith JM, Smith JE (2019) Psychometric evaluation of the power of food scale in a diverse college sample: Measurement invariance across gender, ethnicity, and weight status. *Eat Behav* 35:101336. <https://doi.org/10.1016/j.eatbeh.2019.101336>
- Kikuchi H, Yoshiuchi K, Inada S, Ando T, Yamamoto Y (2015) Development of an ecological momentary assessment scale for appetite. *Biopsychosocial Med* 9:2. <https://doi.org/10.1186/s13030-014-0029-6>
- Mason TB, Smith KE, Crosby RD, Engel SG, Wonderlich SA (2019) Examination of momentary maintenance factors and eating disorder behaviors and cognitions using ecological momentary assessment. *Eating Disorders* 11:1–14. <https://doi.org/10.1080/10640266.2019>
- Manasse SM, Espel HM, Forman EM, Ruocco AC, Juarascio AS, Butryn ML et al (2015) The independent and interacting effects of hedonic hunger and executive function on binge eating. *Appetite* 89:16–21. <https://doi.org/10.1016/j.appet.2015.01.013>
- Telch CF, Agras WS, Linehan MM (2001) Dialectical behavior therapy for binge eating disorder. *J Consult Clin Psych* 69:1061–1065. <https://doi.org/10.1037/0022-006X.69.6.1061>

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.