

## BODY COMPOSITION HIGHLIGHTS ORIGINAL ARTICLE

# Preliminary validation and principal components analysis of the Control of Eating Questionnaire (CoEQ) for the experience of food craving

M Dalton<sup>1</sup>, G Finlayson<sup>1</sup>, A Hill<sup>2</sup> and J Blundell<sup>1</sup>

**BACKGROUND/OBJECTIVES:** The Control of Eating Questionnaire (CoEQ) comprises 21-items that are designed to assess the severity and type of food cravings an individual experiences over the previous 7 days. The CoEQ has been used in clinical trials as a multi-dimensional measure of appetite, craving and mood regulation however its underlying component structure has yet to be determined. The current paper has two aims; (1) to examine the psychometric properties, and internal consistency of the CoEQ; and (2) to provide a preliminary examination of the underlying components by exploring their construct and predictive validity.

**SUBJECTS/METHODS:** Data were pooled from four studies in which a total 215 adults (80% women; Age = 29.7 ± 10.3; BMI = 26.5 ± 5.2) had completed the CoEQ alongside measures of psychometric eating behaviour traits, ad libitum food intake, and body composition. A principal components analysis (PCA) and parallel analysis was conducted to examine the underlying structure of the questionnaire. The resulting subscales were tested for internal consistency (Cronbach's  $\alpha$  = 0.66–0.88).

**RESULTS:** PCA revealed four components that explained 54.5% of the variance. The components were identified as: Craving Control, Positive Mood, Craving for Sweet, and Craving for Savoury. Associations between the underlying CoEQ subscales and measures of body composition and eating behaviour traits confirmed construct validity of the subscales. The associations between the subscales and snack food selection and intake of palatable snack foods supported the CoEQ's predictive validity.

**CONCLUSIONS:** The CoEQ has good psychometric properties with a clear component structure and acceptable internal consistency. This preliminary validation supports the CoEQ as a measure of the experience of food cravings.

*European Journal of Clinical Nutrition* (2015) 69, 1313–1317; doi:10.1038/ejcn.2015.57; published online 8 April 2015

## INTRODUCTION

Food craving is defined as an intense desire to eat a specific food and has been associated with a loss of control over eating and poor weight management. For example, research has shown that greater levels of food craving are related to higher BMI<sup>1–3</sup> and increased binge, emotional and external eating tendencies.<sup>4–7</sup> However, food-craving experiences are common and not all craving for food is associated with disturbed eating behaviour. Therefore, food craving can be seen as existing on a continuum of experience, ranging from mild to extreme,<sup>8</sup> in normal and disordered eating, and may be elicited under a number of conditions. For example, Pelchat and Schaefer<sup>9</sup> demonstrated that young adults who consumed a monotonous, nutritionally-complete, sweet liquid diet over five days reported an increase in craving for foods that were savoury and meal based. In addition, research has shown that mood has an important role in food craving, with greater food cravings being reported when individuals are bored or anxious.<sup>6,10</sup>

The Control of Eating Questionnaire (CoEQ) has its origins in the Food Craving Record.<sup>6</sup> It comprises 21-items designed to assess the intensity and type of food cravings an individual experiences, as well as subjective sensations of appetite and mood. The CoEQ has previously been used on an item-by-item basis in a number of pharmaceutical clinical weight loss trials<sup>11–14</sup> and is sensitive to the effects of anti-obesity agents. For example, in a large scale,

phase 3 clinical trial examining the effect of treatment with a sustained-release combination of naltrexone plus bupropion on weight loss in obese adults, Greenway *et al.*,<sup>12</sup> found that those assigned to naltrexone plus bupropion reported an increased ability to resist food cravings (item 7) and control of eating (item 19), and reductions in the frequency of cravings (item 4), and incidences in which craving led to eating (item 21). Furthermore, items on the CoEQ which pertain to positive mood (items 8–11), craving for palatable sweet foods (item 12), and craving intensity (item 3) have been demonstrated to distinguish between overweight and obese females with and without binge eating tendencies,<sup>5</sup> and between those with binge eating tendencies who do or do not meet the Yale Food Addiction Scale<sup>15</sup> criteria for 'food addiction'.<sup>16</sup>

While the CoEQ has been used successfully in clinical weight loss trials as a multi-item measure of craving, appetite and mood regulation, its psychometric properties and underlying component structure has yet to be examined. Therefore, the current paper has two aims. The first was to examine the psychometric properties, and internal consistency of the CoEQ. The second aim was to provide a preliminary examination of the underlying components and their construct validity by exploring firstly their associations with body composition measures, and psychometric measures of eating behaviour traits; and secondly their predictive validity with regards to intake and selection of palatable snack foods.

<sup>1</sup>Appetite Control and Energy Balance Research, School of Psychology, Faculty of Medicine and Health, University of Leeds, Leeds, UK and <sup>2</sup>Academic Unit of Psychiatry and Behavioural Sciences, Leeds Institute of Health Sciences, School of Medicine, University of Leeds, Leeds, UK. Correspondence: Dr M Dalton, School of Psychology, Faculty of Medicine and Health, University of Leeds, Lifton Place, Leeds, LS2 9JT, UK.

E-mail: m.dalton@leeds.ac.uk

Received 10 December 2014; revised 9 February 2015; accepted 2 March 2015; published online 8 April 2015

## MATERIALS AND METHODS

Data reported in this paper were pooled from four separate studies conducted at the University of Leeds in samples consisting of staff, students and local residents of the surrounding Leeds area. A summary of sample demographic information and details of measures administered in each study is presented in Table 1. Each study protocol was reviewed and approved by the University of Leeds, School of Psychology ethical committee in accordance with the Helsinki declaration.

### Measures

**Control of eating questionnaire.** All participants completed the Control of Eating Questionnaire (CoEQ) at the end of each study protocol. The CoEQ is comprised of 21 items presented in six sections. Participants are required to respond according to their experience over the previous seven days. The first two sections contain questions relating to general levels appetite and overall mood (independent of food craving). The third and fourth sections contain questions that assess the frequency and intensity of food cravings in general, while the fifth section concerns craving for specific foods (e.g. dairy, starchy, sweet or non-sweet foods). Finally the sixth section (items 20 and 21) assesses an individual's perceived level of control over resisting a nominated, craved food item. Twenty items are assessed using 100-mm visual analogue scales (VAS) and one item (item 20) allows participants to enter their own nominated food.

**Binge eating scale.** All participants completed the Binge Eating Scale (BES).<sup>17</sup> The BES is comprised of sixteen items, eight describing the behavioural manifestations and eight describing the feelings and cognitions associated with binge eating. Each item consists of 3–4 descriptive statements that increase in severity (e.g. "I don't have any difficulty eating slowly in the proper manner" to "I have the habit of bolting down my food without really chewing it. When this happens I usually feel uncomfortably stuffed because I've eaten too much."). Participants select the statement from each of the sixteen items that is most descriptive of them, and the scores are summed to produce a total score ranging from 0–46. The BES has been shown to have good internal validity, with a Cronbach's alpha of 0.89<sup>18</sup> and good test retest reliability.<sup>19</sup>

**Three factor eating questionnaire.** Participants in Study 1, 2 and 3 completed the Three Factor Eating Questionnaire (TFEQ)<sup>20</sup> which assesses three aspects of eating behaviour; cognitive control of restraint (21 items), disinhibition of eating (16 items) and susceptibility to hunger (14 items). The disinhibition of eating subscale assesses the tendency to eat opportunistically, often in response to environmental cues.<sup>21</sup> Greater levels of Disinhibition have been consistently associated with increased energy intake<sup>22,23</sup> and greater propensity for weight gain.<sup>24,25</sup> Previous research has shown that the TFEQ has good internal validity.<sup>20</sup>

### Anthropometrics and body composition

Participants in each study underwent anthropometric measurements. Specifically, standing height without shoes was measured to the nearest 0.5cm using a stadiometer. Body weight was measured using an electronic balance and recorded to the nearest 0.1 kg. Waist circumference was measured 1cm above the top of the participants' naval after expiration. In Study 1, Study 3 and Study 4, air plethysmography (Bodpod, Concord, CA, USA) was used in order to obtain an estimate of fat mass, fat free mass, and percentage body fat. All anthropometric and body composition measures were taken following an overnight fast with the participants wearing non-underwired swimwear.

### Ad libitum snack food intake

Participants in Study 1 and Study 2 completed an ad libitum eating task in which they were presented with six pre-weighed bowls of palatable high-fat ( $\geq 40\%$ ) snack foods chosen to be either sweet (milk chocolate, chocolate finger biscuits and cookies) or non-sweet (ready salted crisps, salted peanuts and flavoured tortilla chips). Participants' acceptance of these foods was determined during initial screening. All foods were presented at the same time, and participants were required to taste and rate each food item on a number of sensory qualities including blandness, saltiness and sweetness using 100-mm VAS. They were informed that they could consume as little or as much as they liked of each item, and that their preferences and how much they wanted to eat would be assessed at the start of the task. The food items were removed after 10 min, and each bowl was weighed so that energy intake (kilocalories) could be determined.

### Data analysis

The data were tested to ensure they met the requirements for Principal Components Analysis (PCA) using the *Kaiser-Meyer-Olkin measure of Sampling Adequacy* and *Bartlett's test of sphericity*. Items 20 and 21 were not included in the PCA as these two items are unique in that they ask participants to nominate their own 'problem' food item and rate their perceived level of control over resisting this nominated food item. For the PCA, an oblique rotation was chosen as we anticipated that the underlying components (from items targeting appetite, mood and cravings) would be related. The number of components was determined using the PCA and the number of components to retain was determined using scree plot with parallel analysis.<sup>26</sup> Item means, standard error, and item total correlations were calculated for item analysis. Cronbach's  $\alpha$  was calculated to evaluate internal consistency. Relationships between CoEQ subscales and psychometric eating behaviour trait variables, body composition and energy intake were tested using Pearson correlation coefficients. An  $\alpha$ -level of 0.05 was used to determine statistical significance.

**Table 1.** Study sample demographics and assessment measures used

	N	Gender (F:M)	Age	BMI	Measures
Study 1	80	54:26	26.5 (8.1) 18 - 54	24.2 (4.3) 18.5–37.7	Waist circumference Body composition Binge Eating Scale Three Factor Eating Questionnaire Ad libitum energy intake
Study 2	50	50:0	24.3 (5.9) 18–41	27.1 (5.4) 18.6–39.8	Waist circumference Binge Eating Scale Three Factor Eating Questionnaire Ad libitum energy intake
Study 3	30	30:0	27.8 (10.5) 20 - 54	23.2 (2.9) 18.8–29.1	Waist circumference Body composition Binge Eating Scale Three Factor Eating Questionnaire
Study 4	55	37:18	41.0 (8.7) 20 - 55	30.8 (3.8) 26.1–39.7	Waist circumference Body composition Binge Eating Scale

Note: Body composition was assessed using air plethysmography.

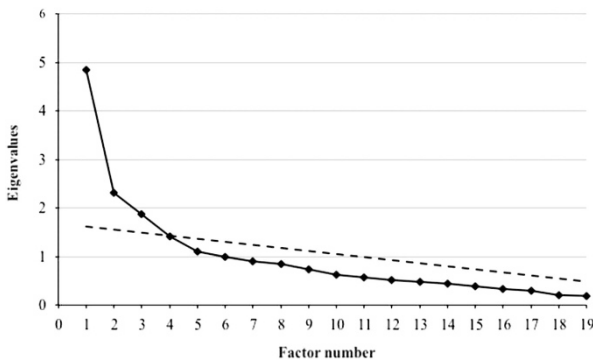
**RESULTS**

**Sample characteristics**

The sample was 215 participants (80.0% female) with a mean BMI of 26.4 kg/m<sup>2</sup>. Of participants, 42.8% had a BMI below 25.0 kg/m<sup>2</sup>; 33.5% had a BMI between 25.0–29.9 kg/m<sup>2</sup> and 23.7% had a BMI above 30.0 kg/m<sup>2</sup>. Participants' age ranged between 18–55 years (*M* = 29.6 years).

**Principal components analysis (PCA)**

The Kaiser-Meyer-Olkin measure of Sampling Adequacy (*KMO* = 0.772) and Bartlett's test of sphericity [ $X^2(171) = 998.2, P < 0.001$ ] indicated that the sample size and the data were adequate for conducting PCA. The PCA extracted five significant factors that explained 60.3% of the total variance. Eigenvalues before rotation were 4.85, 2.32, 1.88, 1.42 and 1.11. After oblique rotation, eigenvalues were 4.09, 2.61, 2.23, 2.71 and 1.15. Scree plot and parallel analysis indicated that of the five extracted factors, only the first four factors should be retained (see Figure 1). Component loadings and item statistics are presented in Table 2. The four factors were interpreted as: Craving Control; Positive Mood; Craving for Savoury, and Craving for Sweet. All other subscales were associated with the Craving Control subscale, and the



**Figure 1.** Scree plot and parallel analysis of eigenvalues for CoEQ factors.

Craving for Sweet subscale was weakly but positively associated with Craving for Savoury (see Table 3). The final component solution excluded two of the original appetite related scale items —“How hungry have you felt?” and “How full have you felt?”

Based on the outcome of the PCA, subscale (component) scores were calculated as follows; the sum of the items in each subscale was calculated, and divided by the number of items in the subscale in order to obtain a subscale score. For the Positive Mood subscale, scores from item 6 (“How anxious have you felt?”) were reversed. For the Craving Control subscale, the final subscale score was reversed so that a greater score represented a greater level of Craving Control.

**Reliability**

The corrected item-total correlations for each item are presented in Table 2. Regarding internal consistency, the Cronbach's alpha values for Craving Control, Positive Mood, Craving for Savoury and Craving for Sweet were .88, .74, .66 and .67, respectively.

**Criterion and construct validity**

*Association of CoEQ subscales with psychometric eating behaviour trait variables.* As shown in Table 4, the Craving Control subscale was negatively related with Disinhibition [ $P < 0.001$ ] and Hunger [ $P < 0.001$ ] from the TFEQ, and binge-eating tendency [ $P < 0.001$ ] as assessed by the BES, indicating that lower levels of Craving Control were associated with higher scores on these trait variables. Disinhibition, and binge eating tendency were also negatively related to Positive Mood [ $P < 0.001$ ]. Further, the Craving for Sweet and Craving for Savoury subscales were positively associated with Disinhibition [ $P < 0.001$ ;  $P < 0.01$ , respectively], Hunger [ $P < 0.001$ ] and binge eating tendency [ $P < 0.001$ ;  $P < 0.01$ , respectively]. These findings illustrate that the CoEQ subscales have convergent validity with existing psychometric trait measures.

*Association of COEQ subscales with anthropometric and body composition variables.* The Craving Control and Positive Mood subscales were negatively associated with body weight [ $P < 0.001$ ;  $P < 0.01$ , respectively], BMI [ $P < 0.001$ ;  $P < 0.01$ , respectively], waist circumference [ $P < 0.001$ ;  $P < 0.01$ , respectively] and fat mass

**Table 2.** Factor loadings and item statistics (mean, s.e.m. and corrected item total correlations) of the Control of Eating Questionnaire

	Mean	Component					<i>r</i> <sub>itc</sub>
		1	2	3	4	5	
Q11. How difficult has it been to resist any food cravings?	49.0 (1.8)	<b>0.86</b>	-0.03	0.01	-0.01	0.07	0.77
Q12. How often have you eaten in response to food cravings?	51.6 (1.6)	<b>0.80</b>	0.05	-0.08	0.02	0.19	0.64
Q10. How strong have any food cravings been?	49.3 (1.7)	<b>0.74</b>	-0.03	0.18	0.08	-0.12	0.73
Q19. Generally, how difficult has it been to control your eating?	43.2 (1.6)	<b>0.73</b>	-0.13	0.09	0.11	0.21	0.71
Q9. During the last 7 days how often have you had food cravings?	51.0 (1.6)	<b>0.67</b>	-0.04	0.14	0.16	-0.15	0.68
Q8. How contented have you felt?	61.2 (1.6)	-0.03	<b>0.88</b>	0.07	0.03	0.16	0.74
Q5. How happy have you felt?	62.2 (1.6)	-0.02	<b>0.86</b>	0.07	0.12	0.14	0.65
Q7. How alert have you felt?	58.4 (1.7)	-0.03	<b>0.64</b>	-0.06	0.04	-0.34	0.39
Q6. How anxious have you felt?	49.2 (2.2)	0.02	- <b>0.63</b>	0.11	0.22	-0.03	0.45
Q4. How strong was your desire to eat savoury foods?	61.5 (1.9)	0.17	0.16	<b>0.76</b>	-0.13	0.05	0.51
Q17. How often have you had cravings for starchy foods (bread, pasta)?	40.9 (2.3)	-0.01	-0.09	<b>0.76</b>	0.05	-0.08	0.53
Q16. How often have you had cravings for dairy foods (cheese, yoghurt)?	37.7 (2.2)	-0.14	-0.11	<b>0.56</b>	0.32	0.33	0.33
Q18. How often have you had cravings for savoury foods (fries, crisps, burgers etc)?	47.3 (2.1)	0.30	-0.14	<b>0.53</b>	-0.17	-0.22	0.40
Q3. How strong was your desire to eat sweet foods?	54.2 (2.3)	0.27	-0.04	-0.27	<b>0.72</b>	0.01	0.66
Q13. How often have you had cravings for chocolate and chocolate flavoured foods?	51.8 (2.1)	0.27	-0.06	-0.20	<b>0.61</b>	0.01	0.53
Q14. How often have you had cravings for other sweet foods (cakes, pastries, biscuits, etc)?	44.4 (2.0)	0.20	-0.08	-0.03	<b>0.60</b>	-0.26	0.48
Q15. How often have you had cravings for fruit or fruit juice?	46.5 (2.0)	-0.19	0.02	0.22	<b>0.56</b>	0.21	0.17
Q1. How hungry have you felt?	54.4 (1.4)	0.18	0.19	0.19	0.41	-0.24	-
Q2. How full have you felt?	65.0 (1.3)	0.24	0.10	-0.04	-0.03	<b>0.74</b>	-

**Table 3.** Correlations between CoEQ subscales

	<i>Craving Control</i>	<i>Positive Mood</i>	<i>Craving for Sweet</i>	<i>Craving for Savoury</i>
Craving Control	–			
Positive Mood	0.244**	–		
Craving for Sweet	–0.576***	–0.139	–	
Craving for Savoury	–0.365***	–0.185	0.173*	–

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ .**Table 4.** Correlations between CoEQ subscales and measured variables

	<i>Craving Control</i>	<i>Positive Mood</i>	<i>Craving for Sweet</i>	<i>Craving for Savoury</i>
<i>Demographic variables</i>				
Age	0.062	–0.047	–0.053	0.172
Gender (M:F)	–0.117	–0.013	0.058	–0.008
<i>Psychometric eating behaviour trait variables<sup>a</sup></i>				
Restraint	–0.005	–0.157	0.020	0.130
Disinhibition	–0.487***	–0.357***	0.338***	0.223**
Hunger	–0.458***	–0.095	0.396***	0.322***
Binge Eating Scale	–0.518***	–0.302***	0.408***	0.242**
<i>Anthropometric and body composition variables<sup>b</sup></i>				
Height (cm)	–0.048	0.042	0.103	0.015
Weight (kg)	–0.255***	–0.227**	0.255***	0.137
BMI	–0.310***	–0.230**	0.232**	0.103
Waist (cm)	–0.259***	–0.230**	0.221**	0.133
Fat mass (kg)	–0.314***	–0.308***	0.249**	0.265**
Fat free mass (kg)	–0.111	–0.023	0.148	0.094
<i>Ad libitum energy intake<sup>c</sup></i>				
Total energy intake	–0.203*	–0.208*	0.397***	0.041
Energy from sweet foods	–0.220**	–0.200*	0.413***	0.022
Energy from savoury foods	–0.063	–0.104	0.150	0.049

Note: \* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ . <sup>a</sup> $n = 160$ . <sup>b</sup>For height, weight, BMI and waist circumference measures  $n = 215$ ; for fat mass and fat free mass measures  $n = 165$ . <sup>c</sup> $n = 130$ .

[ $P < 0.001$ ]. The Craving for Sweet subscale was positively associated with body weight [ $P < 0.001$ ], BMI [ $P < 0.01$ ], waist circumference [ $P < 0.01$ ] and fat mass [ $P < 0.01$ ]. Finally, the Craving for Savoury subscale was positively associated with fat mass [ $P < 0.01$ ]. There were no associations between the CoEQ subscales and fat free mass, height, age or gender.

**Ad libitum snack food intake.** Total energy intake and energy intake from sweet snack foods were negatively associated with Craving Control [ $P < 0.05$ ;  $P < 0.01$ , respectively] and Positive Mood [ $P < 0.05$ ], and positively associated with Craving for Sweet [ $P < 0.001$ ] (see Table 4). There were no associations between the Craving for Savoury subscale and snack food intake.

## DISCUSSION

The current paper examined the psychometric properties of the CoEQ. Principal component and parallel analysis in a varied sample revealed a four-component solution: Craving Control, Positive Mood, Craving for Sweet, and Craving for Savoury. The Craving Control component was correlated with the other three components, and Craving for Sweet was weakly correlated with the Craving for Savoury component. The individual component subscales had acceptable internal reliability, and showed construct and criterion validity, which provide support for their use in research. The final component structure excluded two of the appetite related items - "How hungry have you felt?" and "How full have you felt?" This outcome supports the suggestion that while

hunger and craving are closely related constructs, aspects of craving can be distinct from hunger, as they represent a more target-specific motivation to eat.<sup>8</sup>

Further to examining the psychometric properties of the CoEQ, the current paper provided a preliminary examination of the validity of the CoEQ components. These analyses indicated that lower scores on Craving Control over the previous seven days were associated with higher levels of binge eating tendency, disinhibition and susceptibility to hunger but not dietary restraint. This finding is in line with previous research<sup>8</sup> and intuitively suggests that lower control over cravings may be a characteristic of eating behaviour traits associated with overeating but not in response to energy restriction *per se*. However, it is important to note that the experience of food cravings is not restricted to those with greater levels of eating pathology. It was also demonstrated that lower scores on the Positive Mood subscale were associated with greater levels of binge eating tendency and Disinhibition. This finding is consistent with previous research that has demonstrated individuals with subclinical binge eating behaviour tend to report experiencing lower day-to-day levels of positive mood compared to those without binge eating.<sup>27–29</sup> These findings support the construct validity of these CoEQ subscales.

Associations between CoEQ subscales and body composition demonstrated that lower Craving Control and Positive Mood, and greater Craving for Sweet were associated with a higher BMI, waist circumference and greater levels of fat mass. The association between craving and BMI has previously been reported<sup>2,3</sup> but to our knowledge this is the first study explicitly showing a relationship between experience of food cravings and adiposity. Interestingly, there were no associations between any of the CoEQ subscales and fat free mass. These findings are in accordance with previous studies that have shown greater levels of adiposity (but not fat free mass) are associated with eating behaviour traits such as Disinhibition<sup>25</sup> and binge eating tendency.<sup>30</sup> Furthermore, they support the proposed distinction between fat mass and fat free mass signalling in appetite control<sup>31,32</sup> and demonstrates the capacity of the CoEQ subscales to converge with theoretically relevant subscales. Future research should explicitly examine whether body fat is specifically associated with hedonic aspects of appetite control such as experience of food cravings and loss of control over eating (see for example<sup>33</sup>).

The predictive validity of the CoEQ subscales was confirmed when the associations with snack food intake, and selection of sweet or savoury snack foods in an ad libitum eating task were assessed. Lower scores on the Craving Control and Positive Mood subscales were associated with increased total energy intake, and selection of sweet foods. Furthermore, greater Craving for Sweet was most strongly associated with selection and intake of sweet foods. There were no associations between Craving for Savoury and savoury snack food selection and intake. One possible explanation for this may be that the Craving for Savoury subscale captures more of a meal-based craving that was not captured in the present ad libitum snack intake task. Future research should examine whether specific craving subscales predict intake at meals under laboratory or free-living conditions.

The primary limitation of the current study was that the sample was limited with regards to the number of male participants, and degree of social and ethnic diversity, which may restrict the generalisability of the findings. Further, as the CoEQ was only administered at one time point in each study, the test re-test reliability of the scale remains to be demonstrated in future research. However, the outcomes of this paper suggest that the CoEQ is a valid measure of the experience of food cravings, and offers a useful research contribution in that it samples experiences over a 7-day period, distinguishes specific, directional cravings from loss of control due to cravings, assesses mood, and converges with other validated psychometric eating behaviour traits and quantitative food intake in a theoretically meaningful way. Food cravings are clinically relevant experiences that militate against the maintenance of good eating habits. The experience of food craving is posited to be related to neurological and neurochemical processes, which in turn could form the target for certain anti-obesity agents. In future research, the CoEQ, and perhaps in particular the Craving Control component, will provide the means for a more psychometrically robust outcome measure in clinical trials on obesity and weight management, and for investigations of the controversial issue of food addiction. To this end, the CoEQ has importance for investigating a common form of dysregulated eating that has implications for the management of obesity. Food cravings have high face validity and are widely perceived to occur and to influence inappropriate and unhelpful food choices. The CoEQ can provide a useful instrument for clinicians and researchers to identify areas of difficulty reported by many people inside and outside the clinic. Further work is necessary to demonstrate the replicability of these findings in large diverse samples, and confirm the component structure of the CoEQ reported here. To summarise, CoEQ subscales were associated with eating behaviour traits that predict overeating, measures of adiposity, and selection and intake of snack foods. This preliminary examination suggests that the CoEQ is a reliable and valid measure of the experience of food cravings.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## ACKNOWLEDGEMENTS

This research was supported by Biotechnology and Biological Sciences Research Council grant: BB/G530141/1. The authors' responsibilities were as follows—MD, GF and JB designed the studies; MD collected the data; MD analysed the data and wrote the first draft of the manuscript; all authors interpreted the data and revised the manuscript.

## REFERENCES

- 1 Franken IH, Muris P. Individual differences in reward sensitivity are related to food craving and relative body weight in healthy women. *Appetite* 2005; **45**: 198–201.
- 2 Abilés V, Rodríguez-Ruiz S, Abilés J, Mellado C, García A, de la Cruz AP et al. Psychological characteristics of morbidly obese candidates for bariatric surgery. *Obesity surgery* 2010; **20**: 161–167.
- 3 Delahanty LM, Meigs JB, Hayden D, Williamson DA, Nathan DM. Psychological and behavioral correlates of baseline BMI in the diabetes prevention program (DPP). *Diabetes Care*. 2002; **25**: 1992–1998.
- 4 Weingarten HP, Elston D. The phenomenology of food cravings. *Appetite* 1990; **15**: 231–246.
- 5 Dalton M, Blundell J, Finlayson G. Examination of food reward and energy intake under laboratory and free-living conditions in a trait binge eating subtype of obesity. *Frontiers in Psychology* 2013; **4**: 757.
- 6 Hill AJ, Weaver CF, Blundell JE. Food craving, dietary restraint and mood. *Appetite* 1991; **17**: 187–197.
- 7 Meule A, Lutz A, Vögele C, Kübler A. Food cravings discriminate differentially between successful and unsuccessful dieters and non-dieters. Validation of the Food Cravings Questionnaires in German. *Appetite* 2012; **58**: 88–97.
- 8 Hill AJ. The psychology of food craving. *Proceedings of the Nutrition Society* 2007; **66**: 277–285.
- 9 Pelchat ML, Schaefer S. Dietary monotony and food cravings in young and elderly adults. *Physiology & behavior* 2000; **68**: 353–359.
- 10 Waters A, Hill A, Waller G. Bulimics' responses to food cravings: is binge-eating a product of hunger or emotional state? *Behaviour Research and Therapy* 2001; **39**: 877–886.
- 11 Wadden TA, Foreyt JP, Foster GD, Hill JO, Klein S, O'Neil PM et al. Weight Loss With Naltrexone SR/Bupropion SR Combination Therapy as an Adjunct to Behavior Modification: The COR-BMOD Trial. *Obesity* 2011; **19**: 110–120.
- 12 Greenway FL, Fujioka K, Plodkowski RA, Mudaliar S, Guttadauria M, Erickson J et al. Effect of naltrexone plus bupropion on weight loss in overweight and obese adults (COR-I): a multicentre, randomised, double-blind, placebo-controlled, phase 3 trial. *The Lancet* 2010; **376**: 595–605.
- 13 Apovian CM, Aronne L, Rubino D, Still C, Wyatt H, Burns C et al. A randomized, phase 3 trial of naltrexone SR/bupropion SR on weight and obesity-related risk factors (COR-II). *Obesity* 2013; **21**: 935–943.
- 14 Wilcox CS, Oskooilar N, Erickson JS, Billes SK, Katz BB, Tollefson G et al. An open-label study of naltrexone and bupropion combination therapy for smoking cessation in overweight and obese subjects. *Addictive Behaviors*. 2010; **35**: 229–234.
- 15 Gearhardt AN, Corbin WR, Brownell KD. Preliminary validation of the Yale food addiction scale. *Appetite* 2009; **52**: 430–436.
- 16 Dalton M, Biopsychological Investigation of Hedonic Processes in Individuals Susceptible to Overeating: Role of Liking and Wanting in Trait Binge Eating: University of Leeds; 2013.
- 17 Gormally J, Black S, Daston S, Rardin D. The assessment of binge eating severity among obese persons. *Addictive Behaviors*. 1982; **7**: 47–55.
- 18 Freitas SR, Lopes CS, Appolinario JC, Coutinho W. The assessment of binge eating disorder in obese women: a comparison of the binge eating scale with the structured clinical interview for the DSM-IV. *Eating Behaviors* 2006; **7**: 282–289.
- 19 Timmerman GM. Binge Eating Scale: Further Assessment of Validity and Reliability. *Journal of Applied Biobehavioral Research*. 1999; **4**: 1–12.
- 20 Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research* 1985; **29**: 71–83.
- 21 Bryant EJ, King NA, Blundell JE. Disinhibition: its effects on appetite and weight regulation. *Obesity Reviews*. 2008; **9**: 409–419.
- 22 Chambers L, Yeomans MR. Individual differences in satiety response to carbohydrate and fat. Predictions from the Three Factor Eating Questionnaire (TFEQ). *Appetite* 2011; **56**: 316–323.
- 23 Ouwens MA, van Strien T, van der Staak CPF. Tendency toward overeating and restraint as predictors of food consumption. *Appetite* 2003; **40**: 291–298.
- 24 Carr K, Lin H, Fletcher KD, Epstein LH. Food reinforcement, dietary disinhibition and weight gain in nonobese adults. *Obesity* 2013; **22**: 254–259.
- 25 Finlayson G, Cecil J, Higgs S, Hill AJ, Hetherington M. Susceptibility to weight gain. Eating behaviour traits and physical activity as predictors of weight gain during the first year of university. *Appetite* 2012; **58**: 1091–1098.
- 26 Hayton JC, Allen DG, Scarpello V. Factor retention decisions in exploratory factor analysis: A tutorial on parallel analysis. *Organizational research methods* 2004; **7**: 191–205.
- 27 Greeno CG, Wing RR, Shiffman S. Binge antecedents in obese women with and without binge eating disorder. *Journal of Consulting and Clinical Psychology* 2000; **68**: 95–102.
- 28 Wegner KE, Smyth JM, Crosby RD, Wittrock D, Wonderlich SA, Mitchell JE. An evaluation of the relationship between mood and binge eating in the natural environment using ecological momentary assessment. *International Journal of Eating Disorders*. 2002; **32**: 352–361.
- 29 Goldschmidt AB, Tanofsky-Kraff M, Wilfley DE. A laboratory-based study of mood and binge eating behavior in overweight children. *Eating Behaviors* 2011; **12**: 37–43.
- 30 Dalton M, Blundell J, Finlayson G. Effect of BMI and Binge Eating on Food Reward and Energy Intake: Further Evidence for a Binge Eating Subtype of Obesity. *Obesity Facts* 2013; **6**: 348–359.
- 31 Blundell JE, Caudwell P, Gibbons C, Hopkins M, Naslund E, King NA et al. Body composition and appetite: fat-free mass (but not fat mass or BMI) is positively associated with self-determined meal size and daily energy intake in humans. *British Journal of Nutrition*. 2012; **107**: 445–449.
- 32 Blundell JE, Caudwell P, Gibbons C, Hopkins M, Naslund E, King N et al. Role of resting metabolic rate and energy expenditure in hunger and appetite control: a new formulation. *Disease models & mechanisms* 2012; **5**: 608–613.
- 33 O'Neill BV, Bullmore ET, Miller S, McHugh S, Simons D, Dodds CM et al. The relationship between fat mass, eating behaviour and obesity-related psychological traits in overweight and obese individuals. *Appetite* 2012; **59**: 656–661.