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Title: Self-reported eating traits: underlying components of food responsiveness and dietary restriction are positively related to BMI

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Abstract

Background: Self-report measures of dietary restraint, disinhibited eating, food reward sensitivity and 'food addiction' have been related to overeating, overweight and obesity. Impulsivity has emerged as a potential moderator in this relationship. However, the exact relationship between these measures and obesity is poorly defined.

Design and Method: Self-report data was collected from a representative sample (N=496) of males (N=104) and females, with a wide age (18-73yrs; M=27.41) and BMI (15.3-43.6; M=24.2) range. Principle component analysis was used to explore the underlying structure of the sub-scales from a variety of eating behaviour questionnaires. An emergent model for BMI was tested using PROCESS.

Results: Two emergent components relating to 'dietary restriction' and 'food reward responsivity' were supported in the analysis. Food reward responsivity component scores positively predicted food addiction and BMI, but this relationship was moderated by impulsivity scores. Dietary restriction component scores positively predicted BMI.

Conclusions: Frequently used eating behaviour measures can be reduced to two underlying components: a tendency to eat in response to environmental or emotional stimuli, and; a tendency to restrict food intake to control weight. A model is proposed in which high food reward sensitivity predicts overweight through increasing food addiction scores, particularly when individuals are also high in (motor) impulsivity. Dietary restriction is an independent, positive predictor of BMI and is likely to be reflecting unsuccessful attempts at dietary control.

Keywords: impulsivity, obesity, disinhibition, restraint, addiction, PROCESS

Introduction:

A variety of self-report measures of eating behaviour have been developed to quantify the extent to which an individual is ‘drawn’ to food in the environment and finds consumption of food rewarding. Several dimensions of eating motivation have been identified across the most commonly used self-report questionnaires (The Dutch Eating Behaviour Questionnaire (DEBQ; van Strein, Frijter, Bergers and Defares, 1986); the Three Factor Eating Questionnaire (TFEQ: Short version, Karlsson, Persson, Sjostrom, and Sullivan, 2000); The Power of Food Scale (PFS; Lowe, Butryn, Didie, Annunziato, Thomas, Crerand et al., 2009); and, the Emotional Eating Scale (EES; Arnow, Kenardy and Agras, 1995) such as: disinhibited eating, emotional eating, external eating, hunger, dietary restraint and food reward. However, the exact nature of these dimensions is unclear and there is overlap between the concepts (Vainik, Dagher, Dube and Fellows, 2013; Vainik, Neseliler, Konstabel, Fellows and Dagher, 2015). In addition, there is a lack of consistency in the literature on the association between these measures and obesity and overweight (e.g. Westenhoefer, Broeckmann, Munch, & Pudel, 1994;   Haynes, Lee & Yeomans, 2003; Ouwens, van Strein and van der Staak, 2003; Burton, Smit and Lightowler, 2007; Forman, Hoffman, McGrath, Herbert, Brandsma and Lowe, 2007; Yeomans & Coughlan, 2009; Burger and Stice, 2011; Fay and Finlayson, 2011; French, Epstein, Jeffery, Blundell and Wardle, 2012; Snoek, Engels, van Strien and Otten, 2013; Vainik et al., 2013).

Inconsistencies in the literature may be the result of a failure to consider the role of more general personality traits, in particular impulsivity (Gerlach, Herpetz and Loeber, 2015; van der Laan and Smeets, 2015). Indeed, research has found that the relationship between self-reported eating behaviour measures and overweight is often moderated by personality traits such as impulsivity (Jansen, Nederkoorn, van Baak, Kierse, Guerrieri and Havermans, 2009). Food reward responsive individuals, as measured by the Power of Food scale (PFS; Lowe, Butryn, Didie, Annunziato, Thomas, Crerand et al., 2009) are reported to overeat only when they are also score highly on impulsivity assessed by a delay discounting task (e.g. Appelhans, Woolfe, Pagoto, Schneider, Whited and Leiberman, 2011). Emery, King, Fischer and Davis (2013) found that high levels of dietary restraint predicted higher binge eating tendencies in college students, but that impulsivity moderated the effect of restraint, such that high levels of 'urgency' impulsivity (acting without thinking when in a negative mood: UPPS; Whiteside and Lynam, 2001) predicted high binge eating tendencies across all levels of restraint. Furthermore, Nasser, Gluck & Geliebter (2004) reported that scores on the motor impulsivity ('acting without thinking') sub-scale of the Barratt Impulsiveness Scale (BIS 11; Patton, Stanford and Barratt, 1995) were significantly higher in patients with binge-eating disorder compared to controls. Therefore, impulsivity may play a crucial role in moderating the relationship between restraint, disinhibited eating, food reward sensitivity and over eating tendencies, but also be an independent contributor. French and colleagues (2012) reviewed much of the literature concerned with eating behaviour and impulsivity and conclude that it is essential to clarify whether impulsivity confers its own risk for obesity or whether this risk is limited to those who are highly motivated by food.

Murphy, Stojek and Mackillop (2014) have recently shown that certain sub-types of impulsivity (in particular 'acting without thinking') predict BMI through the mediating influence of scores on the Yale Food Addiction Scale (YFAS; Gearhardt, Corbin and Brownell, 2009). The YFAS includes items adapted from the DSM-IV criteria (APA, 2000) for substance dependence and can return a continuous variable score for food addiction tendencies, or a diagnostic dichotomous outcome that defines an individual as a 'food addict' or not. Davis, Curtis, Levitan, Carter, Kaplan and Kennedy (2011) found that those participants who met the diagnostic criteria for 'food addition' were more impulsive, experienced greater food cravings, and were more inclined to 'self-soothe' with food in response to negative moods than did controls. Burton and colleagues (2007) found that food craving mediated the relationship between external eating and BMI. YFAS scores have also been found to predict a variety of body composition measures directly (including BMI) in a large sample of men and women (Pedram, Wadden, Amini, Gulliver, Randell, Cahill et al., 2013).This suggests that the YFAS is a useful tool for identifying a distinct group of people with tendencies to experience cravings and 'lose control' around food and become overweight. Combined, these studies suggest that the YFAS may be measuring psychological tendencies important in determining overweight and obesity and may act as a *mediating* mechanism between food reward responsivity and BMI.

A better understanding of the relationship between psychological variables and obesity is vital if more effective behavioural interventions are to be developed. As yet, there has been no examination of eating behaviour, food addiction and impulsivity measures in a single model leaving a significant gap in current knowledge. Therefore the aim of the current study was to collect self-report data from a student and community based sample of men and women across a wide age and BMI range. The most commonly used eating behaviour measures (EES, TFEQ, DEBQ, PFS) were included, as well as a measure of impulsivity (BIS 11) and the YFAS, to clarify the relationship between these measures and BMI. Given that eating behaviour measures are often highly correlated (e.g. Elfhag and Morey, 2008), we suggest that they may be tapping into the same underlying trait behaviours. Therefore, our first aim was to conduct a principal components analysis to examine the underlying component structure of the eating behaviour questionnaires. Our second aim was to examine the moderating and mediating influences of impulsivity and YFAS scores in the relationship between these eating behaviour factors and BMI within one model. It was predicted that food reward responsivity and dietary restriction measures would predict food addiction and BMI, but that this relationship would be moderated by impulsivity.

Method

Participants and procedures

Participants were recruited from the student populations at Swansea University, and the University of Birmingham, as well as from the wider community (N=496). This study was granted departmental ethical approval by the Swansea University, Department of Psychology Research Ethics Committee. The demographic and questionnaire items were presented to participants online using SurveyMonkey (Palo Alto, California, USA) Participants either attended the lab to fill in the questionnaires (if they were students receiving course credit) or accessed the questionnaires remotely (in response to a call for community volunteers). Demographic information including gender, age, height and weight were recorded in the lab where relevant, but was otherwise self-reported. BMI for each participant was calculated using the standard formula (kg/m^2). BMI data was not available for 24 participants, therefore any analysis including BMI, N=471. See Table 1 for sample characteristics.

Measures

The Power of Food Scale (PFS: Short version: Lowe et al., 2009)

The PFS is a widely used questionnaire with 15 items pertaining to a participants' appetite for palatable food. Each item is rated on a scale of 1-5, ranging from 'don't agree' at all to 'strongly agree'. This questionnaire was distributed to participants in order to measure appetite at three levels; where food is 1) available; 2) present; or, 3) tasted.

The Emotional Eating Scale (EES; Arnow et al., 1995)

The EES is used to measure overeating in response to emotional stimuli. It is a 25 item adjective checklist that asks participants to rate, on a 5 point scale, the degree to which each mood state generates a desire to overeat, has no effect, or a desire to under eat. It has three sub-scales; anger/frustration, anxiety and depression.

Table 1: *Sample Characteristics*

Characteristic/Measure	Mean (SD); Range
Gender	M:F 105:366
Age (Yrs)	27.41 (10.16); 18-73
BMI[a]	24.19 (4.77); 15.3-43.6
DEBQ[b] Dietary Restraint	2.82 (.98); 1-5
DEBQ[b] External Eating	3.11 (.68); 1-5
DEBQ[b] Emotional Eating	2.49 (.84); 1-5
TFEQ[c] Cognitive Restraint	2.55 (.76); 1-4.5
TFEQ[c] Uncontrolled Eating	2.31 (.59); 1-4
TFEQ[c] Emotional Eating	2.32 (.74); 1-4
PFS[d] Available	2.48 (1.08); 1-5
PFS[d] Present	3.14 (1.04); 1-5
PFS[d] Tasted	2.88 (.89); 1-5
EES[e] Anger/frustration	21.19 (7.88); 11-50
EES[e] Anxiety	17.85 (6.07); 9-40
EES[e] Depression	14.80 (4.47); 5-25
YFAS[f] Symptom Count	1.96 (1.46); 0-7
BIS[g] Motor	15.82 (4.0); 7-28
BIS[g] Attention	10.88 (2.68); 5-19
BIS[g] Cognitive Complexity	11.64 (2.62); 5-20
BIS[g] Self-control	13.32 (3.40); 6-23
BIS[g] Perseverance	7.72 (1.91); 4-15
BIS[g] Cognitive Instability	6.68 (1.88); 3-12

[a]BMI (body Mass Index); [b]DEBQ (Dutch Eating Behaviour Questionnaire); [c]TFEQ (Three Factor Eating Questionnaire – Short form); [d]PFS (Power of Food Scale); [e]EES (Emotional Eating Scale); [f]YFAS (Yale Food Addiction Scale); [g]BIS (Barratt Impulsiveness Scale – First order Sub-scales).

The Three Factor Eating questionnaire (TFEQ short version; Karlsson, Persson, Sjostrom, and Sullivan, 2000) and the Dutch Eating Behaviour Questionnaire (DEBQ; Van Strein et al., 1986)

The TFEQ and the DEBQ are self-report measures used to assess disinhibited eating behaviours (emotional and external) and the level of restraint in participants. The short version of the TFEQ was employed and sub-scale scores were recorded for cognitive restraint, uncontrolled eating, and emotional eating. The DEBQ also has three sub-scales matching those of the TFEQ, labelled dietary restraint, external eating and emotional eating.

The Barrett Impulsiveness Scale (BIS 11; Patton et al., 1995)

The BIS11 is a 30 item questionnaire that is widely used to measure impulsivity and is structured to assess long-term patterns of behaviour. It is used as a measure of trait impulsivity and is comprised of six first order (attention, cognitive complexity, motor, perseverance, self-control and cognitive instability) or three second order (attention, motor and non-planning impulsivity) sub-scales to measure different facets of impulsiveness. Stanford, Mathias, Dougherty, Lake, Anderson and Patton (2009) advocate the use of the first order sub-scales to discern the exact sub-types of impulsivity which relate to a variety of behaviours related to impulse control and Meule (2013) argued that the analysis of sub-scales is advocated in larger samples to detect the exact types of impulsivity related to over eating behaviour and obesity.

The Yale Food Addiction Scale (YFAS; Gearhardt et al. (2009))

The YFAS is a 25 item self-report measure of food addiction. It attempts to distinguish between those who simply indulge in unhealthy food and those who have *truly lost control* over their eating behaviour. Participants receive a continuous score relative to the number of addiction criteria that have been met, with a maximum score of 7.

Data Analysis

Principle component analysis (PCA) was performed in order to identify underlying eating behaviour components. Oblique (Promax) rotation was employed, as previous research suggests that the components were likely to be related. The number of components was left undefined, with identification of components by scree plot observation and set to eigenvalues $\geq$1 (Kaiser, 1960). Component scores were produced based on regression method, and used in subsequent analysis.

First order sub-scales of the BIS 11 were checked for internal reliability (Cronbach's alpha) and then entered simultaneously in to a regression model to identify any sub-scale significantly predicting BMI to be subsequently be tested in the model.

Modelling the mediating and moderating factors that may explain the relationship between predictor and outcome variables is becoming a prominent analytical approach used in psychological research. A useful statistical tool for incorporating many factors into a single model of both moderating and mediating variables has been provided by Hayes (2012) PROCESS macro for SPSS. Given the complexity of the behavioural variables outlined here, that are likely to contribute to overweight and obesity, the macro was chosen to test the current predictors of BMI. The macro allows for the variables of interest to be placed in the relevant model that best represents the expected relationships, and these are then tested for significance using robust bootstrapping techniques. The PROCESS pathway mediating and moderating macro (Hayes, 2012) was employed to test a model (driven by data and theory) of the inter-relationships between the predictor variables, with BMI as the dependent variable.

All calculations were performed in SPSS 20.0 and effect sizes were calculated using G*Power software (Faul, Erdfelder, Lang and Buchner, 2007).

Results

Principle Component Analysis

Principle components analysis (PCA) for the eating behaviour measures supported both a two and three-component outcome: When eigenvalues above 1 were considered then three components emerged (reflecting emotional eating, external eating and restraint). However, the scree-plot inflection point favoured two components (Stevens, 2002). Consequently fixing the number of components as two resulted in the sub-scales loading convincingly either on to: 1) food reward sensitivity, and over eating in response to external food cues and internal emotional states (‘*Food Reward Responsivity’ (FRR)*); or 2) the tendency to restrain eating (‘*Dietary Restriction ’(DR)*) (see Table 2). Given that previous research suggests that emotional and external eating are highly related, the two component outcome was considered parsimonious and subsequently used to test the model (to be thorough, the model was also run with separate emotional and external component scores in place of the single FRR component, but the outcome did not vary significantly, supporting the use of the single component score).

Note: The PCA was also conducted with YFAS in the analysis and it had the lowest factor loading onto the ‘food motivation’ component and reduced the communality average to below the cut-off threshold of .6 recommended for samples of more than N=250 (Field, 2009), therefore justifying the independent status of YFAS.

Reliability

Internal reliability was calculated for all sub-scales of the eating behaviour questionnaires, and were all deemed satisfactory (Cronbach's alpha ranged between .734-.933). Given that this is the first study to investigate the first order sub-scales of the BIS11 in relation to obesity, the Cronbach alpha values are reported in Table 3, showing that satisfactory reliability was attained for the motor and self-control sub-scales only.

Table 2: *Component Matrix*

Sub-scale	Component 1: Food Reward Responsivity	Component 2: Dietary Restriction
EES anger/frustration	.776	
EES anxiety	.730	
EES depression	.801	
PFS available	.802	
PFS present	.779	
PFS tasted	.660	
TFEQ cognitive restraint		.941
TFEQ uncontrolled eating	.626	
TFEQ emotional eating	.623	
DEBQ dietary restraint		.929
DEBQ external eating	.755	
DEBQ emotional eating	.844	

Component matrix for eating behaviour questionnaire sub-scales. Extraction method used was Principle Component Analysis with 2 components extracted.

Table 3: *Cronbachs Alpha*

BIS11 sub-scale	Attention	Motor	Cognitive Complexity	Self-control	Perseverance	Cognitive Instability
Cronbach's alpha	.637	.778	.470	.737	.279	.582

Cronbach's alpha values for the Barratt Impulsiveness Scale version 11 (BIS11). First order sub-scales.

All six first order sub-scales of the BIS 11 were entered simultaneously into a linear regression model of BMI. The 'motor impulsivity' sub-scale was the only significant predictor of BMI (β=.207; t=3.931; p<0.0001), and was therefore selected for the proposed model.

Regression analysis:

To investigate whether the two component scores predicted BMI, they were entered into a hierarchical regression analysis. Motor impulsivity and YFAS scores were entered in the latter two stages of the model to assess any potential mediating effects. Gender and age were entered into the model as potential covariates (see Table 4). The mediating role of YFAS scores is immediately apparent in the regression output - FRR becomes insignificant when YFAS is added to the model. Motor impulsivity, however, makes an independent contribution and does not appear to mediate or be mediated by any other variable (i.e. it remains significant when YFAS is added to the model, and other variables remain significant when motor impulsivity is added to the model).

Model testing:

Based on the results of the PCA and the regression analysis it was predicted that FRR component scores would predict BMI, but would be mediated by YFAS symptom count.

Previous research (Appelhans et al., 2011; Emery et al., 2013; Nasser et al., 2004) suggests that impulsivity plays a moderating role and so it was entered as a potential moderator for each of the variables of interest (FRR, YFAS and DR), as well as a direct predictor, in order to identify the exact role motor impulsivity plays in predicting BMI.

The proposed model was tested using PROCESS pathway modelling for moderated mediations (Model 71). Cases were excluded case wise for any missing data with N=453 for the final model including all relevant variables. Given that age and gender significantly predicted BMI, where older participants and males were more likely to have a higher BMI ($p>.05$), they were included in the model as covariates. Bootstrap sampling was set to 5000 and confidence intervals to 95 per cent. Moderating variables were mean centred prior to analysis as recommended by Howell (2013). The overall model was a significant predictor of BMI ($F(13, 439)=8.42$; $p<0.0001$; Adj $R^2=.20$; $f^2=.087$). Figure 1 shows the significant pathways and interactions.

	Model 1			Model 2			Model 3			Model 4	
	B	SEB	β	B	SEB	β	B	SEB	β	B	SEB
Age	.136	.021	.289***	.145	.021	.309***	.140	.020	.297***	.135	.020
Gender	-1.263	.504	-.110*	-1.470	.501	-.128**	-1.807	.504	-.158***	-1.895	.501
FRR				.738	.210	.155***	.706	.208	.148**	.549	.214
DR							.753	.208	.158***	.697	.208
MotorImp										.148	.053
YFAS											
R^2	.097			.119			.141			.153	
F	26.31***			22.08***			20.25***			17.97***	
Δ F for change in R^2				12.337***			13.07***			7.688**	

Table 4: Hierarchical regression model output for predictors of BMI. FRR (Food Reward Responsivity); DR

(BIS 11 Motor Impulsivity); YFAS (Yale Food Addiction Scale). Gender and age include in the model as co

*p<0.05 **p<0.001 ***p<0.0001

YFAS scores significantly mediated the relationship between FRR scores and BMI (lower and upper confidence intervals: .23-1.23). The only pathway to be significantly moderated by motor impulsivity was between FRR scores and YFAS scores. The Johnson-Neyman technique (Johnson and Fay, 1950) was used to probe the nature of the interaction and showed that BIS11 motor impulsivity scores significantly moderated the relationship between FRR and YFAS, but only at high levels of FRR (at the 75th and 90th percentile ($f(1,452)=4.35; p<0.0001$ and $f(1,452)=5.02$; $p<0.0001$; $f^2=.062$ respectively). This was in a positive direction, where high motor impulsivity resulted in significantly higher YFAS scores than low impulsivity (see Figure 2). In real terms, high FRR in combination with high motor impulsivity predicted the occurrence of one more symptom on the YFAS, than high food motivation and low motor impulsivity (2.3 symptoms versus 3.3 symptoms). Motor impulsivity and DR showed significant direct pathways in predicting BMI.

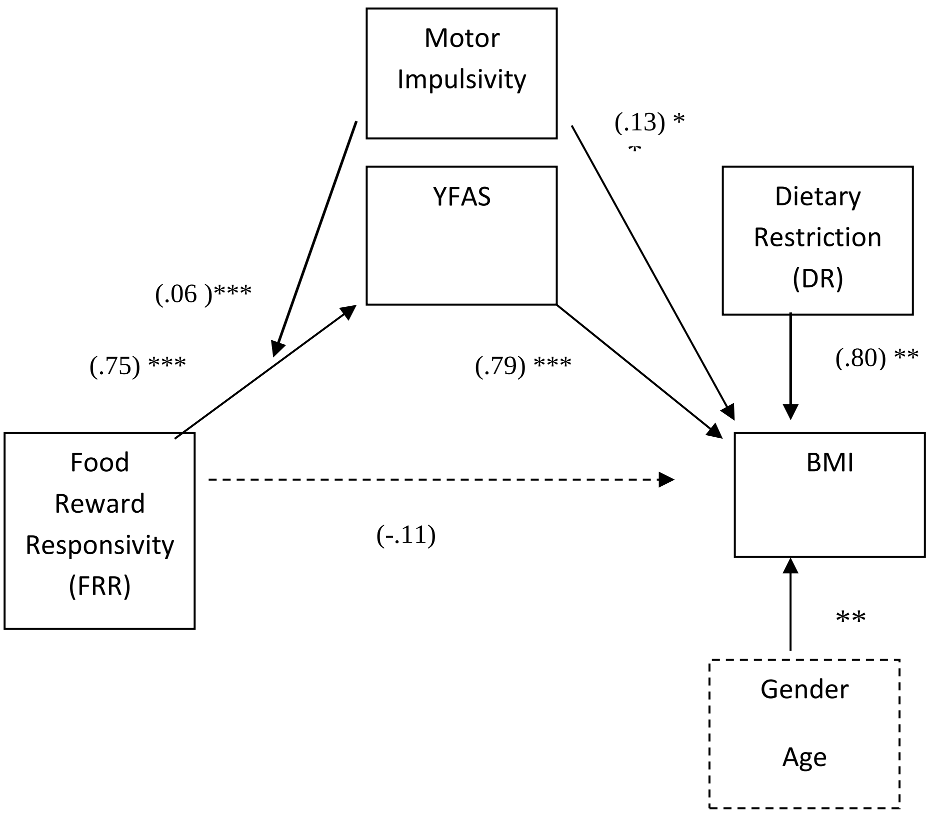

Figure 1: PROCESS moderated mediation model (Hayes, 2012; model 71). Solid arrows indicate significant positive pathways and interactions (coefficient (β) output in parentheses). The dotted arrow indicates a loss of significance for the pathway after mediation analysis. Absence of arrows indicates non-significant pathways. Gender (coded Male=1 Female=2) and age were included as covariates. FRR is a component score including DEBQ external eating; emotional eating; TFEQ uncontrolled eating; emotional eating; PFS available; present; tasted. DR is a component score including DEBQ dietary restraint; TFEQ cognitive restraint. Motor impulsivity is a first order sub-scale of the BIS11 (‘acting without thinking’). YFAS is the number of addiction criteria met (symptom count). BMI (Body Mass Index: kg/m^2).

*$p<0.05$ **$p<0.001$ ***$p<0.0001$

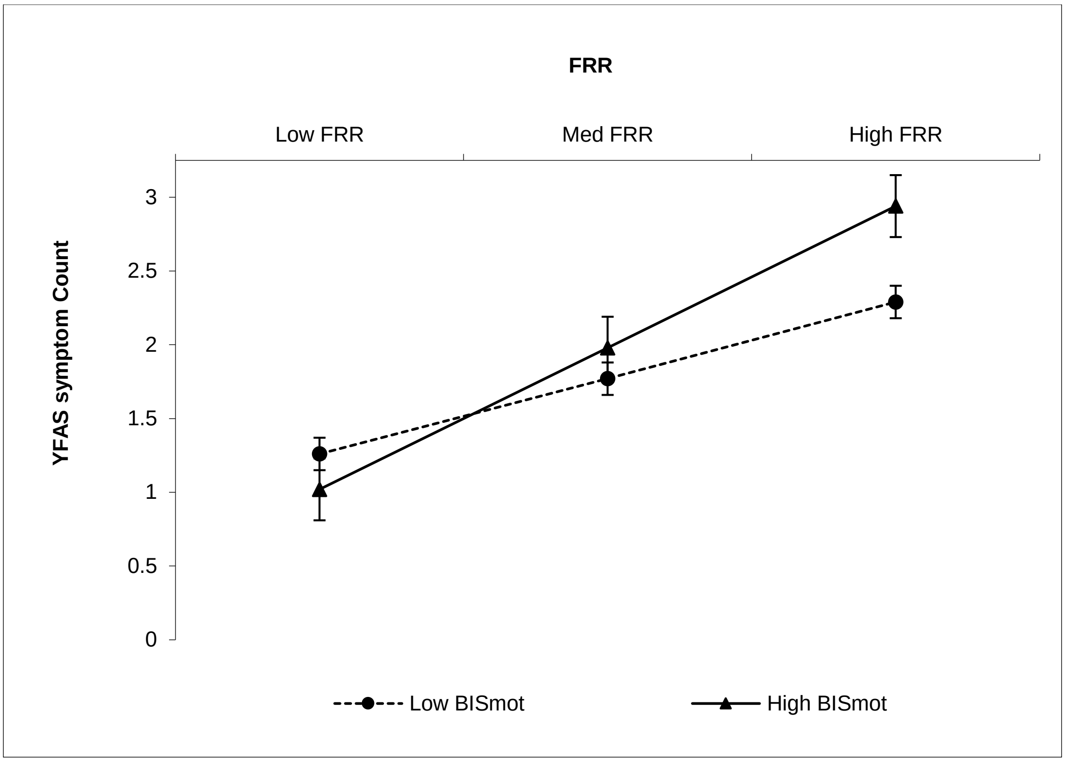

Figure 2: Mean (SE) YFAS Symptom Count for the interaction between BIS11 Motor Impulsivity (BISmot) and Food Reward Responsivity (FRR) component scores (+/- 1 SD).

Discussion

In an attempt to understand the complex relationship between self-reported eating behaviour and BMI, we conducted a study in which a student and community based sample of males and females with a wide age and BMI range, completed a broad selection of eating behaviour questionnaires. The scores were first entered into a dimension reduction procedure using Principle Components Analysis (PCA). Two underlying components of ‘food reward responsivity’ (FRR) and ‘dietary restriction’ (DR) emerged, demonstrating for the first time that an array of standard eating behaviour measures are tapping into similar constructs. Vainik and colleagues (2015) have very recently shown that a single underlying factor of ‘uncontrolled eating’, which varies in severity, underlies several self-report questionnaires of eating behaviour and predicted BMI in two female samples. However, the authors noted that the construct of food addiction was not included, and in addition, the study did not include measures of dietary restraint. We therefore confirm the previous finding that a single factor underlies many self-report measures of eating behaviour but extend them to a wider array of eating behaviour questionnaires with responses from both males and females with a broad age and BMI range. In addition, we add food addiction (YFAS), impulsiveness and dietary restraint measures to the analysis.

When the emergent eating components scores were entered into an hierarchical regression model along with motor impulsivity and YFAS scores, the FRR component score failed to remain significant when YFAS scores were added, suggesting a mediating role. Previous research indicates a moderating role for motor impulsivity (Appelhans et al., 2011; Emery et al., 2013; Nasser et al., 2004) and so a PROCESS modelling technique for assessing the mediating effects of YFAS scores and the moderating effects of motor impulsivity on the relationship between FRR, DR, YFAS and BMI within one model was employed. Analysis supported an indirect pathway between FRR and BMI through YFAS scores, particularly in those with high motor impulsivity scores. In other words, within the population tested, those who scored highly on a variety of eating behaviour questionnaires were more at risk of increased scores on the YFAS (and increased BMI), if they were also high in motor impulsivity. Interestingly, the interaction analysis confirmed that the number of symptoms met on the YFAS increases from two to three when high motor impulsivity accompanies high FRR scores. This increase is the difference between a diagnosis of food addiction or not (when accompanied by clinical distress). The findings support those from Murphy and colleagues (2014) who found that impulsivity was mediated by YFAS scores in predicting BMI, but in addition, suggest the contribution of FRR in this relationship. Motor impulsivity and FRR interact to predict YFAS scores as a mediator in predicting BMI.

The moderating role of impulsivity has also been shown previously to explain the relationship between dietary restraint and overweight (Emery et al., 2013). However, the significant relationship between BMI and dietary restriction (DR) was not moderated by motor impulsivity in our model. Previously, dietary restriction tendencies have been shown to be protective in low impulsive individuals, but unsuccessful in highly impulsive individuals (Jansen et al., 2009). In the present sample, the interaction between restraint and impulsivity did not reach significance and dietary restriction emerged as an independent predictor of BMI. Papies, Stroebe and Aarts (2008) have shown that individuals who are overweight and are high dietary restrainers, exhibit unsuccessful dieting behaviour, where goals of hedonic food enjoyment frequently override weight loss goals in the presence of tasty food cues. This may explain the pattern of our findings. In addition, this study tested men and women from student and community populations with a wide range of age and BMI, whereas previous studies have primarily reported findings from narrow samples of mainly female participants, adolescents or children. It would therefore be useful now to explore the role of dietary restraint in different populations to investigate whether the interaction between impulsivity and restraint is limited to certain age or gender groups.

Interestingly, motor impulsivity scores remained a significant direct predictor of BMI, in addition to moderating FRR. The use of the first order sub-scales for the first time, in a representative sample provides new evidence that motor impulsivity specifically is key in predicting BMI. Motor impulsivity not only makes individuals high in FRR vulnerable to overeating, but also represents a general risk for overweight. It is possible that motor impulsivity is associated with other behaviours related to an increase in BMI, such as greater alcohol consumption, and poorer lifestyle choices not measured here. As such, it is a viable measure for identifying individuals vulnerable for overweight and obesity and answers some of the questions posed by French and colleagues (2012) regarding the independent and moderating status of impulsivity.

A few limitations to the current study must be noted. First, the study is based on cross-sectional, self-report data and ideally the model would benefit from replication in experimentally controlled conditions of food intake and weight gain over time. However, self-report designs allow for larger samples and greater generalisation of findings and so were deemed appropriate for the aims of this study. Second, although the BMI range was relatively wide, it would be useful to include data from the more severe obesity classes to investigate how this pattern of behaviour applies to these groups. Third, although every effort was made to collect data from a representative group of male participants, the female to male ratio was still about 3:1 and any future research would benefit from applying this model to large male samples in order to test its generalizability to both men and women. Having said this, gender was controlled for in the analysis and the diverse age range of the sample allows for a model that may be applied to a larger section of the population than standard student based data. Last, the model was tested on the same sample on whom the PCA was conducted and so replication of the findings in a separate sample would confirm reliability.

Conclusions

This is the first model to assess the relationships between several measures of eating behaviour, impulsivity, food addiction and BMI in a representative sample. These data suggest that a variety of questionnaires tap into an underlying tendency to find food rewarding, but that motor impulsivity is important in translating this into a perceived loss of control over eating (food addiction) and increased BMI. Cross-comparison of previous studies using any of these eating behaviour measures is therefore supported and motor impulsivity is a viable candidate for profiling those at risk from weight gain and a promising target for intervention. Research now needs to look to finding ways of reducing impulsivity in those vulnerable to overweight. Indeed, interventions based on training of response inhibition (e.g. Houben and Jansen, 2011) and priming higher level construal thinking (Price, Higgs and Lee, under review) show promise in aiding reduced consumption and, as supported by this model, may be more effective than dietary restriction methods alone.

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