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FOOD ADDICTION (A MEULE, SECTION EDITOR)

The Role of Reward Sensitivity and Impulsivity in Overeating and Food Addiction

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Abstract

Purpose of Review This paper reviews the contribution of individual differences in two personality traits linked to addiction and over-consumption—impulsivity and reward sensitivity—in the context of overeating and food addiction.

Recent Findings There has been a rapid increase in the number of studies into overeating with a specific focus of late on food addiction. This review found trait impulsivity to be consistently associated with overeating and food addiction, while reward sensitivity has met with mixed results. While associated with overeating and food-cued cravings, reward sensitivity is less frequently associated with food addiction.

Summary The inclusion of impulsivity-related traits has gathered momentum in recent years adding additional understanding of individual factors that play roles in overeating that may lead to more severe overeating and obesity. Greater research is now required to determine the processes by which trait impulsivity and reward sensitivity lead to overeating behaviours.

Keywords Reward · Impulsivity · Personality · Eating · Food addiction

Introduction

The rapid increase in obesity rates across industrialised countries since the 1970s has been attributed in part to the unprecedented access to readily available, affordable, and highly palatable food [1]. This increase in obesity has been of concern in terms of the costs to the individual and to society [2]. In the Australian context, almost two-thirds of the population are overweight or obese: a 10% increase in the past 20 years [3]. Similar rates are found in the USA and other developed countries [4, 5]. While a wealth of research has investigated a range of contributing factors including changes in access to high calorie foods, in the nutritional content of food, portion size, and a general reduction in exercise [6], there is growing interest in the 'addictive' qualities of high caloric foods [6, 7] and the role that impulsivity traits play in the attraction towards, and lack of ability to inhibit, over-consumption of such food [8]. In this review, the focus is on the role of two related personality traits—impulsivity and reward sensitivity—in overeating, with a particular focus on food addiction.

This article is part of the Topical Collection on *Food Addiction*

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Overeating and Food Addiction

Researchers have argued that overeating in today's 'obesogenic environment' falls along a spectrum of eating behaviour that ranges from 'passive overeating' to binge eating, and at the most extreme level, to food addiction [6]. With a focus on overeating (rather than restrictive eating), this spectrum approach proposes a 'downward escalating dimension' that reflects an increase in severity and compulsiveness, from non-clinical occasional overeating (such as during festive occasions) through frequent overeating (snacking and grazing) to more serious binge episodes and clinically significant binge eating disorder (BED) and, at the extreme, food addiction [6].

Food addiction is characterised by the excessive overeating of high calorie food accompanied by loss of control and intense food cravings [9]. There has been a rapidly growing program of research supporting the links between food addiction and more traditional substance addictions [10, 11]. The impact of the concept is supported by a ninefold increase in the number of journal articles referring to food addiction from 2006 to 2010 [12]. More recent findings show an even greater increase in the publication of studies that explicitly use the term 'food addiction', with almost 90 papers in 2015 alone [13]. While many studies have included trait measures in the study of overeating and food addiction, few have taken an explicit personality perspective in exploring the role of such traits in the predisposition and maintenance of compulsive overeating [14•].

Facets of Impulsivity

Impulsivity is typically defined as 'a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individual or to others' [15]. While general 'impulsivity' plays a role in the development and maintenance of a range of excessive behaviours, including alcohol and drug abuse, problematic gambling, and overeating, there is consensus that this broad construct of impulsivity is multi-faceted [16]. In 2004, we proposed a two-factor model of impulsivity in relation to addiction with an emphasis on typical substances of abuse (e.g. alcohol and other drugs) and disordered eating [17, 18]. The first paper [17] reviewed factor analytic studies of impulsivity traits, while the second paper [18] reviewed the neuropsychological commonalities between impulsivity facets and addiction. The two facets in this model include (1) rash impulsivity and (2) reward sensitivity (also referred to as reward drive).

Rash Impulsivity

According to this model, rash impulsivity refers to an individual's inability to stop an initiated approach response, i.e. a failure to 'brake' once a goal-directed approach response has started. Neurologically, this trait reflects individual differences in the functioning of the prefrontal cortex [18]. Research investigating this facet has found this specific trait to be associated with risky behaviours related to substance use (e.g. unsafe sexual practices, poly-substance use), and binge eating [8, 19, 20]. Rash impulsivity is frequently measured using self-report questionnaires such as the Barratt Impulsiveness Scale [21].

Reward Sensitivity

A component of Reinforcement Sensitivity Theory [22, 23], reward sensitivity, is a biologically based predisposition to seek out and respond positively to reward. Individuals high in this trait notice and seek out appetitive and rewarding substances and experiences. Reward sensitivity is proposed as the expression of an underlying Behavioural Approach System (BAS), which Corr [24] refers to as the 'Let's go for it!' system. The mesolimbic dopamine 'reward' pathways in the midbrain have been proposed as the key biological basis of this trait [23]. The proposal that these neurological pathways underpin this motivational approach system (and by extension trait reward sensitivity) has been supported by numerous neuroimaging studies in which self-reported reward sensitivity has been related to increased activity in the ventral and dorsal striatum, ventral prefrontal cortex, and other midbrain regions [25]. Reward sensitivity is typically measured using self-report instruments such as the Carver and White Behavioural Inhibition System (BIS)/BAS scales [26] and Sensitivity to Punishment and Sensitivity to Reward Questionnaire [27], although both scales were developed for an earlier iteration of the theory see [28•, 29•] for detailed reviews.

Rash Impulsivity and Reward Sensitivity

While there is an association between rash impulsivity and reward sensitivity—ranging from $r = .16$ [30] to $r = .46$ [31]—factor analyses support two distinct factors [17]. Furthermore, although both traits appear similar in behavioural outputs (i.e. approach behaviour), they differ in terms of the hypothesised underlying brain regions, and each is proposed to have independent mechanisms by which they contribute to the development of addictive behaviours [17, 18, 32, 33]. Given common neural pathways underlying reward sensitivity and neural response to substances of abuse and palatable foods, a core theme of recent research has been the proposal that highly reward-sensitive individuals are more susceptible to the rewarding properties of drugs of abuse and high fat/high sugary 'tasty' food [17, 34, 35]. Reward sensitivity has been found to be associated with the early experimentation with drugs [19] and alcohol [36], and greater learning of appetitive cue associations and expectancies of reward [37]. Rash impulsivity, on the other hand, appears to pose additional risk for dysfunctional approach behaviours and more severe problems with addictive behaviour [38]. Thus, while reward drive may set an approach response in action (e.g. food cravings and desire to eat in response to food images), the inability to brake (i.e. high rash impulsivity) may influence the outcome of the behaviour (recurrent binge episodes, loss of control, and an inability to cut down).

Rash Impulsivity, Reward Sensitivity, and Eating—Recent Findings

This theoretical model of impulsivity in addiction and, by extension, overeating (see [17] for the proposed application to eating behaviour) has been supported across a range of behavioural outcomes including binge eating [8, 32, 39••]. Schag and colleagues have provided two recent systematic reviews covering experimental studies investigating reward sensitivity and rash impulsivity in relation to binge eating and obesity [8, 39••]. They found individuals who are obese (with or without co-existing BED) to be higher in reward sensitivity relative to normal weight individuals without a co-existing BED, while those with BED were higher in rash impulsivity than obese individuals without BED. Given these recent, and comprehensive, reviews of experimental studies in the context of binge eating and obesity, this review will focus on recent studies that have used self-report measures of rash impulsivity and reward drive in the context of overeating and food addiction.

Rash Impulsivity and Overeating/Food Addiction

The relationship between high rash impulsivity and overconsumption of food is well established in individuals with both bulimia nervosa (BN), BED, and food addiction see [40] for an earlier review of impulsivity and disordered eating. Table 1 shows recent studies that have used established measures of rash impulsivity [17]. Given that this is a topic of recent interest, a particular focus is on food addiction as measured by the Yale Food Addiction Scale (YFAS) [9]. Of the studies reviewed in Table 1, the majority have used the Barratt Impulsiveness Scale (BIS-11; this is a 30-item scale but referred to as the BIS-11 due to being the 11th version of the scale) [21] or the short 15-item version (BIS-15) [61]. Both the BIS-11 and the BIS-15 scale can be scored as a total score and/or three subscale scores: (1) attentional impulsivity (difficulties in maintaining attention or concentration), (2) motor impulsivity (acting without thinking), and (3) lack of planning (acting without forethought of future consequences). Other studies have used another measure of impulsivity—the UPPS-P, a five-factor scale based on the Big 5 theory of personality [62]—this measure has two subscales that assess the tendency to 'act rashly' in order to alleviate negative affect (negative *U*rgency), or enhance positive affect (*P*ositive urgency)—these two subscales explicitly include an emotional aspect as well as impulsiveness. The remaining three subscales are as follows: (lack of) *P*erseverance/persistence (an inability to remain on task), (lack of) *P*lanning/premeditation (a tendency to act without forethought of consequences), and *S*ensation seeking (the tendency to seek out novelty and, often risky, activities; see [32] for a discussion of differing models of impulsivity).

As shown in Table 1, across a range of samples including overweight/obese adults and adolescents, undergraduates, adults from the community, and those seeking treatment for weight-loss, high scores on the BIS-11 are consistently associated with meeting criteria for a food addiction diagnosis or with a greater number of food addiction symptoms [34, 41–45, 47, 48, 50, 53–55, 57, 58], although in some cases, the association is weak or more complex [51, 59]. This association appears to exist regardless of the use of the full or short measure of the BIS-11 or the use of the original or revised version of the YFAS. The BIS-11 was also associated with less eating restraint, greater hunger [43], greater externally driven eating (eating triggered by external cues such as the sight and smell of appetitive food), and greater emotional eating (the tendency to eat to alleviate negative moods) [47]. Surprisingly, disinhibited eating was not associated [47]. When examining studies that investigated the subscales of the BIS-11, attentional impulsivity appears to be most specifically associated with food addiction, although in a sample of mostly overweight/obese individuals with type II diabetes, all three subscales are strongly associated with YFAS symptom scores [53]. All three subscales were also associated with YFAS symptom scores in a sample of overweight/obese adolescents [50] and in a female general hospital outpatient sample [55]. In a sample of overweight/obese treatment-seeking patients, non-planning impulsivity was higher in those meeting criteria for food addiction [48], although this subscale has not been associated with food addiction in other studies [51]. In studies using the UPPS-P, the (negative) emotionally laden impulsivity scale was consistently associated with a food addiction diagnosis or greater number of symptoms [46, 52, 56, 60].

Across the studies, the association between the BIS/UPPS-P and food addiction is mostly between .20 and .30 in generally normal weight samples. One study investigating food addiction in overweight/obese participants with type II diabetes found associations as high as .80 for attentional impulsivity [53] and in another study of food addiction in treatment-seeking overweight/obese adolescents as high as .61, also for attentional impulsivity [50]. Meule [70] has recently advocated testing interactions between the three subscales with recent studies finding motor impulsivity to moderate the effect of attentional impulsivity and overeating and weight. University women high in both attentional impulsivity and motor impulsivity have been found to have greater body fat and report more overeating and binge eating symptoms and ate more sweet foods during a food taste test [49, 51]. In a bariatric surgery sample, those high in both attentional impulsivity and motor impulsivity were more likely to meet criteria for food addiction [59].

Overall, these studies support the role of an impulsive temperament in food addiction and other related overeating behaviours. The association appears stronger in those individuals seeking weight-reduction treatment or with additional health issues. The combination of attentional impulsivity and motor impulsivity may convey particularly high risk for overeating and food addiction [71]. While trait impulsivity as measured by the BIS-11 and UPPS-P is frequently assessed in studies of food addiction, reward sensitivity has tended to be only explicitly tested in more recent years.

Table 1 Summary of recent studies investigating overeating that included a measure of rash impulsivity

Investigators and country	Year	Participants	Measure of impulsivity	Measure of eating behaviour	Results
Davis et al. [41] Canada	2011	72 overweight/obese	BIS-11	YFAS	Impulsivity (total score) higher in those meeting criteria for food addiction than those who do not
Meule et al. [42] Germany	2012	50 female undergraduates	BIS-15	YFAS	Attentional impulsivity higher in those meeting criteria for food addiction than those who do not, impulsivity (total score) and YFAS symptoms $r = .34$
Dietrich et al. [43] Germany	2014	110 men and 82 women	BIS-11	TFEQ	Impulsivity (total score) and restraint $r - .20$; disinhibited eating $r = .05$; hunger $r = .20$
Meule et al. [44] Germany	2014	50 normal weight women	BIS-15	YFAS	Impulsivity (total score) and YFAS symptoms $r = .26$
Meule et al. [45] Germany	2014	94 overweight/obese adults seeking bariatric surgery	BIS-15	YFAS	Food addiction group ($n = 38$) higher on attentional impulsivity than no food addiction group ($n = 56$). No difference between groups on other subscales or total score
Murphy et al. [46] USA	2014	233 undergraduates	UPPS-P	YFAS	Negative urgency and YFAS symptoms $b = .25$; lack of persistence and YFAS symptoms $b = .16$ (both controlling for other UPPS)
Stapleton and Whitehead [47] Australia	2014	56 men and 167 women	BIS-11	DEBQ	Impulsivity (total score) and external eating $r = .22$, emotional eating $r = .27$
Ceccarini et al. [48] Italy	2015	88 overweight/obese treatment patients	BIS-11	YFAS-16	Impulsivity (total score) and non-planning impulsivity higher in those meeting criteria for food addiction than those that did not. YFAS symptoms and impulsivity (total score) $r = .26$, attentional impulsivity $r = .30$. Other subscales not significant
Kakoschke et al. [49] Australia	2015	146 undergraduate students	BIS-11	DEBQ	External eating and attentional impulsivity $r = .15$, motor impulsivity $r = .17$, non-planning impulsivity $r = .13$. Motor impulsivity moderated attentional impulsivity in predicting amount of sweet food eaten during a taste test. External eating mediated the association between motor impulsivity and sweet food consumption
Meule et al. [50] Germany	2015	51 overweight/obese treatment adolescents	BIS-15	YFAS	Food addiction and attentional impulsivity $r = .61$, motor impulsivity $r = .42$, non-planning impulsivity $r = .30$
Meule and Platt [51] Germany	2015	133 undergraduate students	BIS-11	EDE-Q	Attentional impulsivity ranging between $r - .02$ (overeating) and .17 (EDE-Q total), motor impulsivity ranging between $r = .05$ (overeating) and .12 (EDE-Q total), non-planning impulsivity ranging from − .01 (overeating) to − .20 (EDE-Q total). Motor impulsivity moderated attentional impulsivity in predicting body fat percentage, loss of control over eating, and number of binge days
Pivarunas and Conner [52] USA	2015	878 undergraduate students	UPPS-P	YFAS	Food addiction and negative urgency $r = .24$, (lack of) premeditation $r = -.01$, (lack of) perseverance $r = .13$, sensation seeking $r = .02$, positive urgency $r = .21$
Raymond and Lovell [53] Australia	2015	334 men and women with type 2 diabetes (93% overweight or obese)	BIS-11	YFAS	Food addiction and attentional impulsivity $r = .80$, motor impulsivity $r = .70$, non-planning impulsivity $r = .68$
Ivezaj et al. [54] USA	2016	502 adults: 23 BED, 97 food addiction, 37 BED and food addiction, 345 overweight/obese controls	BIS-11	YFAS	Participants with BED or food addiction (but not BED + food addiction) higher in impulsivity (total score) than overweight/obese controls
Omar et al. [55] Egypt	2016	200 outpatient women	BIS-11	YFAS	Impulsivity (total and subscales) higher in those meeting criteria for food addiction than those that did not
Wolz et al. [56] Spain	2016	278 men and women seeking treatment for an eating disorder	UPPS-P	YFAS	Negative urgency and lack of perseverance higher in those meeting criteria for food addiction than those that did not
deVries and Meule [57]	2017	115 men and women with BN, 341 male and female controls	BIS-15	YFAS 2.0	

Table 1 (continued)

Investigators and country	Year	Participants	Measure of impulsivity	Measure of eating behaviour	Results
Austria					Impulsivity (total score) higher in those with BN than controls. Impulsivity significantly correlated with YFAS 2.0 symptoms
Meule et al. [58] Germany	2017	Study 1: 455 undergraduates Study 2: 133 bariatric surgery candidates	BIS-15	YFAS 2.0	S1: impulsivity (total score) higher in those meeting criteria for food addiction than those that did not. Impulsivity (total score) and YFAS symptoms $r = .17$. Attentional impulsivity and YFAS symptoms $r = .22$; motor impulsivity and YFAS symptoms $r = .12$ S2: attentional impulsivity higher in those meeting criteria for food addiction than those that did not. Attentional impulsivity and YFAS symptoms, $r = .22$
Meule et al. [59]	2017	133 obese bariatric surgery candidates	BIS-15	YFAS 2.0	Re-analysis of [55 study 2] data. Motor impulsivity moderated attentional impulsivity on likelihood of meeting diagnosis of food addiction
Loxton and Tipman [34] Australia	2017	374 women	BIS-11	YFAS	Impulsivity (total score) and YFAS symptoms $r = .21$
VanderBroek-Stice et al. [60] USA	2017	181 adults and undergraduates	UPPS-P	YFAS	Negative urgency and YFAS symptoms $r = .24$, sensation seeking, and YFAS symptoms $r = -.21$ Lack of perseverance and YFAS symptoms $r = .18$

BIS-11 Barratt Impulsiveness Scale 11 [21], *BIS-15* Barratt Impulsiveness Scale—short version [61], *YFAS* Yale Food Addiction Scale [9], *UPPS* UPPS-P Impulsive Behaviour Scale [62, 63], *YFAS 2.0* Yale Food Addiction Scale version 2.0 [64], *YFAS-16* Yale Food Addiction Scale—Italian version [65], *DEBQ* Dutch Eating Behaviour Questionnaire [66], *TFEQ* Three-Factor Eating Questionnaire [67], *POF* Power of Food Scale [68], *EDE-Q* Eating Disorder Examination—Questionnaire [69]

Reward Sensitivity and Overeating/Food Addiction

Heightened reward sensitivity has been consistently associated with binge eating, meeting diagnosis for BN, and for having preferences for foods high in fat and sugar, and for colourful and varied food [72]. Compared with studies that incorporate the BIS-11 or the UPPS-P, far fewer studies have explicitly used purpose-built measures of reward sensitivity in food addiction studies (i.e. this review located only four published studies at this date [9, 34, 73, 74]). Table 2 presents recent studies that have used established, psychometrically sound self-reported reward sensitivity scales investigating food addiction and other forms of overeating, such as externally driven eating and emotional eating. As shown, and similar to rash impulsivity, there is consistency in the association between high reward sensitivity and external eating, emotional eating, fat intake, and a behavioural task assessing the willingness to work for food across samples of adults and children [34, 35, 37, 43, 47, 75–79, 81–83, 90].

However, the association between reward sensitivity and food addiction has met with mixed results with only one study thus far to have found a significant positive association [34]. Others that have included measures of reward sensitivity have not found any association [9, 73, 74]. This may be due to differences in the measures used to assess reward sensitivity. Studies that have used the total BAS scale score from the Carver and White BIS/BAS [26] scales have repeatedly failed to find a relationship between reward sensitivity and food addiction diagnosis or symptom score, whereas in the study that used the Torrubia et al. [27] Sensitivity to Reward (SR) scale has found this association [34]. The use of different measures of BAS has been problematic quite generally [28•, 29•, 91]. The widely used BIS/BAS scales consist of a single Behavioural Inhibition System (BIS) scale (a measure of punishment sensitivity) and three BAS scales (fun-seeking, drive, reward responsiveness). However, many studies combine the three BAS subscales to form a total scale—this is problematic on a number of fronts. To start, confirmatory factor analyses consistently find a three-factor model to be a better fit than a single-factor model e.g. [92, 93]. More importantly, the BAS subscales also tend to correlate differentially with each other and with overeating [94, 95]. For example, Loxton and Dawe [94] found only the fun-seeking scale to be associated with dysfunctional eating in a sample of high school girls. Similar to Meule's [70] proposal that BIS subscales should also be used to disentangle impulsivity components, using the total BAS score may have also missed finding significant associations that may be evident with specific subscales. However, none of the studies to date have reported subscale associations of the BAS scales and food addiction to determine if this is driving the apparent lack of association.

Table 2 Summary of recent studies investigating overeating that included a measure of reward sensitivity

Investigators and country	Year	Participants	Measure of reward sensitivity	Measure of eating behaviour	Results
Gearhardt et al. [9] USA	2009	353 undergraduates	BIS/BAS	YFAS	BAS total and YFAS $r = .12$
Clark and Saule [73] USA	2013	67 bariatric	BIS/BAS	YFAS	BAS total and food addiction symptoms $r = -.10$
Hennegan et al. [37] Australia	2013	243 female undergrads	SPSRQ, J5	DEBQ	SR scale and emotional eating $r = .25$ and external eating $r = .35$; J5 BAS scale and emotional eating $r = .08$ and external eating $r = .20$
Matton et al. [75] Belgium	2013	579 adolescents	SPSRQ, BIS/BAS	DEBQ	SR scale and emotional eating $r = .16$ and external eating $r = .36$; BAS total and emotional eating $r = .06$ and external eating $r = .28$
Dietrich et al. [43] Germany	2014	110 men and 82 women	BIS/BAS	TFEQ	BAS total and restraint $r = .18$; disinhibited eating $r = .14$; hunger $r = -.05$ hunger; BAS total associated with greater BMI for women, negatively associated w BMI for men (independent of eating behaviour)
Rollins et al. [76] USA	2014	33 children 3–5 years	BIS/BAS-C	RRV of Food	Children with higher BMI ($r = .41–.42$) and higher BAS total $r = (.36–.48)$ worked faster on the RRV task. Those who worked harder ate more calories
Stapleton and Whitehead [47] Australia	2014	56 men and 167 women	BIS/BAS	DEBQ	BAS total and external eating $r = .31$; emotional eating $r = .23$; in regression after controlling for gender, emotion regulation, and impulsivity, BAS significantly associated with external, $B = .19$, but not for emotional eating, $B = .09$
Tapper et al. [77] UK	2015	84 men and 100 women	BIS/BAS	FFQ	BAS total and fat intake $r = .25$; reward drive and fat intake $r = .24$; fun-seeking and fat intake $r = .14$. No associations with sugar intake ($rs = .01–.13$)
Chen et al. [74] China	2015	950 students	BIS/BAS	YFAS-R-C	BAS total and food addiction symptoms $r = .08$; food addiction diagnosis $r = .06$
Li et al. [78] China	2015	95 undergraduates	BIS/BAS	Attentional bias towards ice cream, food cravings	BAS total and food craving $r = .25$; attentional bias towards ice cream: BAS fun-seeking $r = .61$, BAS Reward Responsiveness $r = .62$ (RR), BAS Drive $r = .54$ (D). BAS total and food craving mediated by attentional bias towards ice cream
De Decker et al. [79] Belgium	2016	443 children 5.5–12 years	BAS_Drive—parent report	Food consumed, screen time, etc.	BAS Drive and weekly consumption of fast food, $B = .10$, sweet drinks $B = .10$
Vandeweghe et al. [80] Belgium	2016	98 preschool children	BIS/BAS-C SPSRQ-C Parent report	DEBQ—parent report	BAS total and external eating $r = .29$, emotional eating $r = .00$, POS $r = .36$, BAS Drive and external eating $r = .31$, emotional eating $r = .05$, POS $r = .34$, BAS Reward Responsiveness and external eating $r = .25$, emotional eating $r = .00$, POS $r = .35$, SR and external eating $r = .46$, emotional eating $r = .20$, POS $r = .40$
De Decker et al. [81] Belgium	2017	446 children 5.5–12	BAS_Drive—parent report	Fat and Lean Mass Index	Girls: BAS Drive positively associated with baseline fat mass and lean mass; BAS Drive explained 15% change in fat mass and 12% in lean mass over 4 years, (increased FMI and decreased LMI)
Loxton and Tipman [34] Australia	2017	374 women	SPSRQ	YFAS, POF, DEBQ	SR and food addiction symptoms $r = .31$ SR and Power of Food subscales $r = .33$ to .37 SR and emotional eating $r = .27$, external eating $r = .41$
Matton et al. [82] Belgium	2017	252 adolescents	SPSRQ	DEBQ	Girls: SR and restraint $r = -.06$; emotional $r = .25$; external $r = .38$ Boys: SR and restraint $r = .17$; emotional $r = .22$; external $r = .34$
Vandeweghe et al. [83] Belgium	2017	211 children 2.5–9 years	BIS/BAS-C scales	CEBQ, DEBQ—parent report	BAS total and food approach $r = .30$, external eating $r = .36$; BAS total and BMI mediated by food approach and external eating

BIS/BAS Behavioural Inhibition System and Behavioural Approach System Scales [26], *SPSRQ* Sensitivity to Punishment and Sensitivity to Reward Questionnaire [27], *J5* Jackson 5 scales [84], *YFAS* Yale Food Addiction Scale [9], *DEBQ* Dutch Eating Behaviour Questionnaire [66], *TFEQ* Three-Factor Eating Questionnaire [67], *FFQ* Food Frequency Questionnaire [85], *YFAS-R-C* Yale Food Addiction Scale Revised—Chinese [74], *POF* Power of Food Scale [68], *CEBQ* Children's Eating Behaviour Questionnaire [86], *RRV of Food* Relative Reinforcing Value of food task [87], *BIS/BAS-C* Behavioural Inhibition System and Behavioural Inhibition System—Children [88], *SPSRQ-C* Sensitivity to Punishment and Sensitivity to Reward Questionnaire—Children [89]

The general lack of association between self-reported reward sensitivity and food addiction is also contrary to other research that has found a multilocus genetic profile of heightened dopamine signalling (proposed as underlying the expression of reward sensitivity) to be associated with a score on an 'addictive personality' scale [96] and with food addiction [97]. Given the paucity of research that has used the SR scale or used the subscales of the BIS/BAS scales in food addiction, future research investigating reward sensitivity may be better served using measures that capture distinct BAS facets [98]. An alternate view is that the lack of association between self-reported reward sensitivity and food addiction specifically, relative to the consistent associations found with less severe overeating (external eating, emotional eating), is that while reward sensitivity increases the risk of overeating generally, rash impulsivity increases the escalation of occasional overeating to binge eating and food addiction in accord with Davis's spectrum model of eating [6].

In sum, the association between reward sensitivity and more extreme levels of over-consumption is less consistent than with less severe forms of overeating such as externally driven eating. Nonetheless, there is clear support for this trait to be involved in overeating and potentially compulsive food consumption.

Future Directions

Potential Mechanisms Involved in the Expression of Traits and Overeating

The conditions by which trait impulsivity and reward sensitivity, in particular, foster overeating remain unclear. One area of recent attention and worthy of further investigation is on the role of reward sensitivity and food-cued cravings in over-consumption. A key factor in overeating is exposure to highly rewarding food cues that trigger intense food cravings [99••]. Those who meet criteria for food addiction and binge eating behaviours tend to show greater food-cued cravings relative to those who do not [41, 97, 100]. It is well established that the mesolimbic reward pathways (the putative neural substrates of reward sensitivity) are involved in memory formation of associations between eating and pleasure when consuming highly palatable foods. The smells and sights associated with tasty foods (e.g. the smell of pizza, pictures of chocolate) and stimuli that consistently predicts the consumption of palatable foods (e.g. time of day, being in a bad mood) all activate these reward pathways. Notably, these cues (even in the absence of the actual rewarding stimulus) activate the reward pathways even more strongly than the consumption of food itself [101, 102]. As such, those high in reward sensitivity are proposed as being more sensitive to both conditioned and conditioned rewards and, thus, will more readily learn these positive associations between food and food cues than less reward-sensitive individuals.

In two recent studies [35, 37], we found that reward-sensitive university women showed stronger associations (e.g. endorsed the belief that eating is a good way to celebrate) than less reward-sensitive women when presented with pictures of food on a computerised 'expectancies' task. This stronger association between the food pictures and positive beliefs about food was, in turn, associated with greater problematic eating. In two subsequent studies [90, 103], university women viewed a television program with either embedded 'junk food' advertisements or non-food advertisements. Reward sensitivity moderated the effect of the 'junk food' advertisements and change in urge to eat, with higher reward sensitivity associated with a greater increase in the urge to eat following the program, but only for those participants who viewed the 'junk food' advertisements. This increase in urge to eat in the high reward-sensitive participants in the 'junk food' condition was also associated with greater food consumption (chocolate consumption) following a ten-minute filler task [90]. Thus, the strong positive associations that high reward-sensitive individuals form with food cues, such as still and television images, may be one mechanism that drives overeating in these individuals and may be a point of intervention at both public policy (e.g. limiting 'junk food' advertising) and individual levels (e.g. targeting food-cued cravings in high reward-sensitive clients).

Effect of Consuming Junk Food on the Brain

Much of the work investigating reward sensitivity and overeating has been cross-sectional and typically used adult samples already displaying a high level of problematic behaviour (although there is a growing program of research investigating eating behaviour and reward sensitivity in children [76, 79–81, 83]). One of the complications when examining associations between personality traits and addictive behaviours is whether an innate predisposition to seek out reward and act impulsively leads to an increased risk of developing a subsequent problem, or whether consumption of high caloric foods alters neurological underpinnings involved in reward sensitivity/impulsiveness. There is some evidence from animal studies that long-term consumption of junk foods leads to alterations in these regions [104]. However, there has been little longitudinal research to test such effects in human beings. Stice and colleagues have started to make progress on this front by examining neural differences in the reward regions in normal weight children of obese parents [105] and advocate for future research to include similar designs to disentangle the reciprocal effects of excessive consumption of highly processed food and individual differences in impulsivity and reward sensitivity [106••]. Further research using such targeted samples and following up over time would help tease apart this complexity.

Conclusion

This review aimed to examine very recent studies using trait impulsivity and reward sensitivity in relation to overeating and food addiction. As shown, relative to studies of food addiction that have included well-established measures of impulsivity, there has a dearth of studies explicitly investigating the role of reward sensitivity. Largely, studies that have incorporated a measure of reward sensitivity have used a total score of an instrument in which there are three subscales that assess different components of this trait, thus possibly masking any differences in association. The studies using this approach find no association between reward sensitivity and food addiction. The one published study that did find an association used an alternative measure. This measure is not without criticism. A recent analysis of current measures of reward sensitivity found that a (short version) of the Sensitivity to Reward Scale captures trait impulsivity as well as reward sensitivity [91]. As such, the associations we have found between the SR scale and YFAS [34] may reflect both reward sensitivity and rash impulsivity. However, even when we controlled for rash impulsivity in this study, the model still held. It should also be noted that the measurement of reward sensitivity and the distinction between reward sensitivity (as proposed by Gray [23]) and impulsivity are currently a point of particular interest and debate in the Reinforcement Sensitivity Theory field [28•, 29•]. A similar call to assess the three subscales (and potential interactions) of rash impulsivity measures has also been made [70, 71].

An alternate interpretation is that the relative consistency found between impulsivity and overeating across the overeating spectrum, including food addiction, and the inconsistency of reward sensitivity and food addiction may be that reward sensitivity plays a role in earlier stages of overeating, including responding to food cues, while rash impulsivity plays a greater role in the progression to more additive food consumption. This is in accord with the reviews by Schag and colleagues [8, 39••]. Stice and colleagues have also proposed that heightened sensitivity to reward may place individuals at risk of over-consumption, but with chronic, excessive overeating resulting in a blunted reward response, and associated reduction in inhibitory capacity [106••, 107]. To tease out these associations requires longitudinal studies using high-risk children and adolescents and well-designed experiments to make these distinctions.

While many studies in the area of overeating and food addiction allude to the importance of the reward and inhibitory pathways in the midbrain and prefrontal cortex in the attraction towards, and enjoyment of consuming highly palatable foods, only recently have biologically based personality factors, such as reward sensitivity, been a focus of attention. Granted that there still unresolved issues in the measurement of reward sensitivity, and to a lesser extent, impulsivity, attending to such individual differences may assist with more targeted prevention and intervention programs in overeating, and by extension, other addictive behaviours.

Compliance with Ethical Standards

Conflict of Interest The author declares that she has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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