Temperament Dispositions, Problematic Eating Behaviours, and Overweight in Adolescents

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Abstract

Obesity, a common health condition in adolescence leading to severe medical complications, is assumed to be influenced by temperament factors. This paper investigates associations between reactive and regulative temperament, problematic eating behaviours, and excess weight. Several self-report instruments were completed by 130 adolescents (mean age 14.13 ± 0.61 years), including 27 overweight and obese individuals (20.8%). Bootstrap analysis revealed a mediating effect of restrained eating on the relation between reactive temperament and body mass index percentile, which differed according to gender: Restrained eating, which predicted weight gain, was more present in girls having a higher sensitivity to reward and in boys showing a higher sensitivity to punishment. No effect of regulative temperament was found. These results have important implications for weight management programs, as they suggest that reducing restrained eating by working on temperament may help to control weight.

Keywords: overweight; problematic eating behaviours; adolescents; temperament.

Introduction

Overweight and obesity, common conditions in adolescence (respectively 20% and 5% in Switzerland; Bovet, Chiolero, & Paccaud, 2008), are associated with serious medical complications and an increased risk of adult obesity (Doak, Visscher, Renders, & Seidell, 2006). Obesity is a complex disorder, which results from the interaction of multiple factors (World Health Organization [WHO], 2004). Associations between excess weight, temperament dispositions, and problematic eating behaviours (PEBs) have been documented in adults, but the evidence is sparse and inconclusive in adolescents. This article therefore aimed at exploring these associations in adolescents.

PEBs were studies using two concepts, Eating in the absence of hunger (EAH) and Disinhibited eating. EAH refers to eating when not physiologically hungry, usually in response to palatable foods (Fisher & Birch, 1999), and includes three subtypes of behaviour: negative affect eating (i.e., EAH triggered by negative emotions), external eating (i.e., EAH triggered by sensory properties of food or social factors), and fatigue/boredom eating (i.e., EAH triggered by fatigue or boredom) (Tanofsky-Kraff et al., 2008). EAH was found to be positively associated with overweight in both children (Fisher & Birch, 1999) and adolescents (Shomaker et al., 2010). Disinhibited eating is a problematic eating pattern similar to EAH observed in adults. It is characterised by overeating in response to cues other than hunger (Stunkard & Messick, 1985), and also includes three subtypes of behaviour: emotional eating (i.e., overeating in response to negative emotions), external eating (i.e., overeating in response to food-related stimuli), and restrained eating (i.e., the propensity for food restraint, often interspersed with episodes of overeating in presence of disinhibitors) (van Strien, Frijters, Bergers, & Defares, 1986). Disinhibited eating was found to be positively associated with overweight (McGuire, Wing, Klem, Lang, & Hill, 1999; Williamson et al., 1995) and binge-

eating (Howard & Porzelius, 1999) in adults. In contrast, the evidence is less conclusive in adolescents, where research sometimes documented gender-specific associations (i.e., emotional eating was sometimes positively associated with obesity in girls, or negatively in boys; Braet et al., 2008; Snoek, Van Strien, Janssens, & Engels, 2007), sometimes negative associations (Snoek et al., 2007), or even no association at all (van Strien, Herman, & Verheijden, 2009).

Temperament refers to "biologically rooted individual differences in behaviour tendencies that are present early in life and relatively stable across various kinds of situations and over the course of time" (Bates, 1987, p. 1101). Rothbart and Bates (1998) distinguish two main dimensions in temperament: first, reactive temperament, referring to automatic processes, consists of emotional, motor, and attentional reactivity; second, regulative temperament includes self-regulatory processes, allowing individuals to modulate their reactivity, therefore referring to more conscious and voluntary processes. Regarding reactive temperament, Reinforcement Sensitivity Theory (Gray, 1990) describes two basic brain systems controlling reactivity: The behavioural inhibition system (BIS) mediates sensitivity to punishment, underlying the personality trait of anxiety, while the behavioural activation system (BAS) mediates sensitivity to reward, underlying the personality trait of impulsivity (Gray, 1990). Regarding regulative temperament, Rothbart and Bates (1998) developed the concept of Effortful Control (EC), defined as "the ability to inhibit a dominant response to perform a subdominant response" (p.137).

Temperament was linked with substance use disorder, as suggested by studies on alcohol, tobacco or cannabis use in adolescents: In sum, high BAS seemed to influence both onset and maintenance of substance use, while low BIS combined with low EC appeared to play a role in the persistence of consumption (Pardo, Aguilar, Molinuevo, & Torrubia, 2007; van Leeuwen, Creemers, Verhulst, Ormel, & Huizink, 2010; Willem, Bijttebier, & Claes,

2010). As similar neurological pathways were found to be involved in the reinforcing effect of

addictive drugs and palatable food, some authors supported the idea of a "food addiction"

(Blumenthal & Gold, 2010; Wang et al., 2001). Sensitivity to reward (STR), a

psychobiological trait comparable to BAS describing "the ability to derive pleasure or reward

from natural reinforcers like food, and from pharmacologic rewards like addictive drugs"

(Davis, Strachan, & Berkson, 2004, p. 131), proved to be implicated in overeating and obesity

in adults of both genders, but not consistently: While some studies identified high levels of

SRT as risk factors of excess weight (Davis et al., 2007; Davis, Strachan, & Berkson, 2004),

others blamed a lack of SRT (Pagoto, Spring, Cook, McChargue, & Schneider, 2006; Wang,

Volkow, Thanos, & Fowler, 2004). These two points of view were reconciled by evidence on

a curvilinear relationship between STR and body weight in adults (Davis & Fox, 2008),

adolescents (Stice, Yokum, Burger, Epstein, & Small, 2011) and children (Verbeken, Braet,

Lammertyn, Goossens, & Moens, 2012), with a positive association in normal weight and

overweight individuals (body mass index [BMI] between 25 and 29.9kg/m^2), and a negative

association in obese individuals (BMI of 30 kg/m^2 and more). Stice and colleagues (Burger &

Stice, 2011; Stice et al., 2011) explained these results by a "dynamic vulnerability model" of

obesity: individuals at risk for obesity initially show a higher STR, increasing thus the risk of

overeating. Overeating may result in a downregulation of reward-related brain regions,

reducing the reinforcing effect of palatable food, leading "people to overeating in an effort to

achieve the same subjective reward from palatable food they initially experienced" (Stice et

al., 2011, p. 4365). Although Dietrich and colleagues corroborated this curvilinear

association, they also discovered gender differences in the relationship between reactive

temperament (both BIS and BAS) and BMI, with a positive association in women and a

negative in men (Dietrich, Federbusch, Grellmann, Villringer, & Horstmann, 2014).

Reactive temperament was not only associated with excess weight, but also with PEBs and eating disorders. A review of the associations between BIS/BAS reactivity and psychopathology (Bijttebier, Beck, Claes, & Vandereycken, 2009) reported evidence indicating that dyfunctional eating patterns and eating disorders were mostly associated with both an excess of BIS and BAS, except for anorexia nervosa, which was usually linked with a lower BAS. A recent cluster analysis confirmed these results in adolescents by showing that the cluster representing a high sensitivity to both reward and punishment was associated with eating problems in this population (Matton, Goossens, Braet, & Vervaet, 2013).

Research also connected obesity and PEBs with regulative temperament. Appelhans (2009) reviewed the links between inhibitory processes controlled by the prefrontal cortex (i.e., regulative temperament) and hedonic feeding, defined as "an appetitive motivational state" inducing "palatable food consumption in the absence of an energy deficit" (p. 640). He reported evidence showing that the activation of the prefrontal cortex was positively associated with successful dieting, self-reported dietary restraint and reduced adiposity in obese men and women. As these results highlight the importance of regulative temperament in the inhibition of hedonic feeding, it seem reasonable to assume that PEBs, which are similar to hedonic eating, may be associated with a low level of regulative temperament. This is in line with research providing evidence for impaired executive functioning - including EC - in obese adults (Cserjési, Luminet, Poncelet, & Lénárd, 2009; Gunstad et al., 2007; Gunstad, Lhotsky, Wendell, Ferrucci, & Zonderman, 2010) and children (Cserjési, Molnár, Luminet, & Lénárd, 2007; Kamijo et al., 2012). Appelhans (2009) proposed a "hedonic inhibitory model", representing a balance between appetitive motivation and inhibitory control: "hedonic feeding results from dominance of appetitive motivation over inhibitory control, whereas dietary restraint results from dominance of inhibitory control over appetitive motivation" (p. 644).

The present paper aimed at determining if PEBs, including EAH and disinhibited eating, play a mediating role in the associations between temperament and excess weight. We thus tested a mediational model, in which reactive (i.e., BIS and BAS) and regulative (i.e., EC) temperament were the independent variables, PEBs the mediators, and BMI percentile the dependent variable. More specifically, according to research showing that dyfunctional eating patterns were mostly positively associated with sensitivity to both punishment and reward, it was first expected that BIS and BAS would positively predict PEBs; second, following the evidence of a lack of inhibitory control in hedonic eating and obesity, it was hypothesised that EC would negatively predict PEBs; third, PEBs were expected to positively predict BMI percentile, since they proved to be associated with excess weight. Finally, as we assumed that the associations between temperament, PEBs, and excess weight may differ according to gender, we tested our mediational model separately for boys and girls. This assumption is derived from research identifying gender differences between reactive temperament (BIS and BAS) and BMI in adults, with positive associations in women and negative associations in men (Dietrich et al., 2014). This hypothesis is also based on research showing gender differences in children and adolescents concerning prevalence of PEBs (i.e., higher levels of external eating in boys, higher levels of emotional and restrained eating in girls; Brugman et al., 1997; Sánchez-Carracedo, Saldaña, & Domènech, 1996; Snoek et al., 2007; Wardle et al., 1992), and concerning associations between PEBs and excess weight (e.g., EAH was sometimes linked with obesity in boys only, emotional eating was sometimes positively associated with obesity in girls only, or negatively in boys only; Braet et al., 2008; Snoek, Van Strien, Janssens, & Engels, 2007).

Method

Recruitment and Sample

The study included 130 participants, recruited through the schools' medical service in the canton of Jura, a French speaking area of Switzerland. Participation in the study was suggested during mandatory medical examinations, during which youngsters' weight and height were systematically measured. In case of agreement, the nurse directly wrote down the weight and height on the questionnaire that was given to the student to be completed at home and returned by mail. As the school doctor considered participants as having sufficient capacity for discernment, parents' consent was not necessary. As a reward for participation, an iPod and ten movie tickets were offered to randomly selected adolescents. The study was approved by the Ethics Committee of the Department of Psychology of the University of Fribourg (Switzerland).

Participation was proposed to 680 youngsters, but only 130 returned the questionnaire completed (response rate: 19%). Participants, aged between 13 and 15 ($M = 14.13 \pm 0.46$), attended the second grade of secondary school. There were 74 girls (56.9%) and 56 boys (43.1%). Most of them came from Switzerland and had French as a native language ($N = 123$; 94.6%). Concerning schooling, 62 respondents attended the highest stream (47.7%), 37 the middle stream (28.5%) and 20 the lowest stream (15.4%). According to German BMI status norms established by Kromeyer-Hauschild et al. (2001), 6 participants (4.6%) were categorised as underweight ($< 10^{th}$ percentile), 97 (74.6%) as normal weight (10th - 89th percentiles), 27 (20.8%) as overweight ($\geq 90^{th}$ percentile), including 7 (5.4%) obese ($\geq 95^{th}$ percentiles). There were no significant gender differences on age, schooling, nationality, native language and BMI status ($p > .10$).

Instruments

Dutch Eating Behaviour Questionnaire (DEBQ)

PEBs were measured through the French version (Lluch et al., 1996) of the Dutch

Eating Behaviour Questionnaire (DEBQ; Van Strien, Frijters, Bergers, & Defares, 1986),

which includes three dimensions: the *Emotional Eating Scale* (EmE; 13 items) assesses the

tendency to eat in response to negative emotion; the *External Eating Scale* (ExE; 10 items)

refers to eating in response to food-related stimuli; and the *Restrained Eating Scale* (RE; 10

items) evaluates the tendency to food restraint. Items are answered on a five-point Likert

scale. The three subscales of the English version showed high internal consistency in both

normal weight and obese adults (EmE: $\alpha = .94$; ExE: $\alpha = .80$; RE: $\alpha = .95$). The French

version presented the same factorial structure and also exhibited high internal consistency

(EmE: $\alpha = .96$; ExE: $\alpha = .82$; RE: $\alpha = .91$) in normal weight and obese adults (Lluch et al.,

1996). In the present sample, internal consistency was high for the three subscales (EmE: $\alpha =$

.92; ExE: $\alpha = .79$; RE: $\alpha = .87$).

Eating in the Absence of Hunger Questionnaire for Children and Adolescents (EAH-C)

The Eating in the Absence of Hunger Questionnaire for Children and Adolescents

(EAH-C; Tanofsky-Kraff et al., 2008) was translated into French and controlled through a

back translation procedure by a licenced translator (Hilbert et al. – unpublished manuscript).

This instrument includes three dimensions, referring to EAH in two circumstances, i.e. when

one continues to eat past satiation during a meal, and when one initiates eating when not

hungry: the *Negative Affect Eating Dimension* (NAE; six items) evaluates EAH produced by

three emotions (sad/depressed, angry/frustrated, anxious/nervous); the *External Eating*

Dimension (EE; four items) considers two external precipitants, i.e. sensory cues (smell or

sight of food) and social cues (being in the presence of other people eating); and the

Fatigue/Boredom Eating Dimension (FBE; four items) refers to eating when tired or bored. Frequency of each item is assessed on a five-point Likert scale. The three dimensions of the English version showed good internal consistency (NAE: α = .88; EE: α = .80; FBE: α = .83; Tanofsky-Kraff et al., 2008). In the present sample, internal consistency was high for NAE (α = .90), and satisfactory for EE (α = .70) and FBE (α = .69).

Behavioural Inhibition System and Behavioural Activation System Scales (BIS/BAS Scales)

Reactive temperament was measured through the French version (Caci, Deschaux, & Baylé, 2007) of the Behavioural Inhibition System and Behavioural Activation System Scales questionnaire (BIS/BAS; Carver & White, 1994). The subscale referring to *Behavioral Inhibition System* (BIS; 7 items) contains items pertaining to reactions to the anticipation of punishment; three subscales refer to the *Behavioral Activation System* (BAS): the *Reward Responsiveness Subscale* (RR; five items) focuses on positive responses to occurring or anticipated reward; the *Drive Subscale* (D; four items) refers to the pursuit of desired goals; and the *Fun Seeking Subscale* (FS; four items) pertains to the desire for new rewards or for potentially rewarding events. Items are rated on a four-point Likert scale. Internal consistency of the original English version was good for BIS (α = .74), RR (α = .73) and D (α = .76), and acceptable for FS (α = .66) (Carver & White, 1994). The French version presented the same factorial structure and revealed good internal consistency for BIS (α = .75), and acceptable internal consistency for the three BAS subscales (RR: α = .65; D: α = .63; FS: α = .67) (Caci et al., 2007). In the present sample, internal consistency was good for BAS (α = .75), and acceptable for BIS (α = .65) and for the BAS subscales (D: α = .65; FS: α = .63; RR: α = .62).

Early Adolescent Temperament Questionnaire – Revised Short Form (EATQ-R)

In order to explore regulative temperament, the *Effortful Control Factor* of the Early Adolescent Temperament Questionnaire – Revised Short Form (EATQ-R; Ellis & Rothbart, 2001) was translated into French and controlled through a back translation procedure (Walther – unpublished manuscript). The *Effortful Control Factor* contains three subscales: the *Attention Subscale* (EC-A; six items) refers to the ability to focus and shift attention when necessary; the *Activation Control Subscale* (EC-AC; five items) focuses on the capacity to perform an action despite a strong tendency to avoid it; and the *Inhibitory Control Subscale* (EC-IC; five items) relates to the aptitude for suppressing inappropriate responses. Items are evaluated on a five-point Likert scale. Internal consistency was satisfactory for all three subscales of the EC Factor (AC: $\alpha = .64$; A: $\alpha = .60$; IC: $\alpha = .82$) in the English short form (Ellis & Rothbart, 2001). In the present sample, internal consistency was high for EC ($\alpha = .80$), and acceptable for the other subscales (AC: $\alpha = .66$; A: $\alpha = .65$; IC: $\alpha = .63$).

Statistical Analyses

Principal Component Analysis

Our model initially included six PEBs as mediating variables (i.e., three for EAH and three other for disinhibited eating). However, as some PEBs were highly correlated and conceptually similar, we conducted a principal component analysis (PCA) in order to reduce the number of mediators. This PCA resulted in three variables: first, a variable representing the tendency to eat in response to negative emotions, consisting of the Emotional Eating scale of the DEBQ, and of the Negative Affect Eating and Fatigue/Boredom Eating scales of the EAH-C (referred as "Emotionality"); second, the Restrained Eating scale of the DEBQ, which remained as a unique variable representing the tendency to food restraint; third, a variable

focusing on the tendency to eat in response to external factors, comprising the External Eating

scales from the DEBQ and from the EAH-C (referred as "Externality").

Mediation Analysis

In order to detect potential mediating effects of PEBs in the associations between

temperament and BMI percentile, a meditation analysis was conducted to test the hypothetical

model presented in Figure 1.

Insert Figure 1 here.

The tested model included nine independent variables (IVs): first, for the BAS

dimension, the global BAS scale and the three subscales: Reward Responsiveness, Drive, and

Fun Seeking; then, the BIS scale; finally, for the EC dimension, the global EC scale and the

three subscales: Attention, Activation Control, and Inhibitory Control. Regarding mediating

variables (MVs), the three variables obtained via PCA were used: Emotionality, Externality,

and Restrained Eating. Finally, the model included one dependent variable (DV), the BMI

percentile.

A mediation analysis allows to calculate the direct effect of an IV on a DV, as well as

its indirect effect going through a MV (i.e., the mediating effect), which is the product of the

effect of the IV on the MV (path a) and of the effect of the MV on the DV (path b). The

amount of mediation of a variable thus corresponds to the indirect effect (path ab) of this

variable (Kenny, 2013). The mediation analysis was conducted using bootstrapping (Shrout &

Bolger, 2002), "a non-parametric method based on resampling with replacement which is

done many times" (Kenny, 2013, sect. Bootstrapping, para. 1), allowing to calculate the

indirect effect of several MVs. An SPSS macro developed by Preacher and Hayes (2004;

2008) was used, which allows to evaluate several indirect effects in case of multiple IVs, by

successively testing the effect of each IV, while controlling for the other IVs (which are

considered as covariates). According to our model, we thus tested the direct effect of our nine

IVs on BMI percentile, and the indirect effect of the nine IVs going through our three MVs.

The three mediating variables (Emotionality, Externality, and Restrained eating) were

included simultaneously in the model. As the model was tested separately for boys and girls,

the macro was run nine times for boys, and nine times for girls (i.e., one time for each IV).

Results were interpreted according to the nonzero coefficients method, using a 95% interval

confidence.

Results

Mediation Analysis

Bootstrap analyses identified restrained eating as a mediating variable between temperament dispositions and BMI percentile in both girls and boys, but not for the same variables. In girls (see Figure 2), restrained eating significantly mediated the association between the three BAS subscales and BMI percentile (RR: ab_1 = 0.914, 95% CI [0.272, 3.164]; D: ab_2 = 0.715, 95% CI [0.249, 2.137]; FS: ab_3 = 0.716, 95% CI [0.261, 2.197]): the three subscales positively predicted restrained eating (RR: a_1 = 4.569; D: a_2 = 3.401; FS: a_3 = 3.506), which, in turn, positively predicted BMI percentile (b = .29).

Insert Figure 2 here.

In boys (see Figure 3), restrained eating significantly mediated the relation between BIS and BMI percentile (ab = 0.083, 95% CI [0.001, 0.196]): BIS positively predicted restrained eating (a = .477), which, in turn, positively predicted BMI percentile (b = .151).

Insert Figure 3 here.

The analyses did not reveal any significant direct effect of BIS, BAS, and EC on BMI percentile, nor significant indirect effect through other PEBs than restrained eating. Finally, no mediating effect of PEBs was found between EC and BMI percentile.

Discussion

Bootstrap analysis revealed a mediating effect of restrained eating on the relation between reactive temperament and overweight, which differed according to gender: Girls with a higher sensitivity to reward showed a greater tendency to restrained eating, while boys having a higher sensitivity to punishment were more prone to this PEB. Restrained eating, in turn, positively predicted BMI percentile.

First, our results suggest that reactive temperament may be a factor promoting restrained eating in adolescents. Consistent with our hypothesis, this result is in line with Bijttebier et al.'s review (2009), which reported positive associations of both BIS and BAS in dysfunctional eating patterns and in most eating disorders as well as with results of Matton et al.'s study (2013). Second, our results also indicate that restrained eating is a PEB potentially implicated in the development of excess weight, which corroborates our hypotheses and previous research: restrained eating, characterised by constant food restriction interspersed with overeating episodes (Herman & Polivy, 1980; van Strien et al., 1986), was positively linked with obesity in adolescents of both genders (Snoek et al., 2007; Stice, Presnell, Shaw, & Rohde, 2005; Wardle et al., 1992). Third, our data suggest that reactive temperament may be a factor promoting excess weight, although indirectly. Consistent with our hypothesis, this result is in accordance with previous literature reporting positive associations between sensitivity to reward and excess weight (Davis, Strachan, & Berkson, 2004; Davis, Patte, levitan, Reid, Tweed, & Curtis, 2006).

The fact that sensitivity to both punishment and reward has a positive impact on restrained eating may seem contradictory, but may be explained by the dual nature of this PEB, sensitivity to punishment affecting the "restraint" component of restrained eating, while sensitivity to reward its "overeating" component. Adolescents having a high sensitivity to

punishment may restrict their food intake because of the anticipation of negative outcomes of

eating, that is, for fear of becoming obese. In contrast, adolescents with a high sensitivity to

reward are generally prone to act impulsively in order to get positive reinforcements, inducing

overeating episodes typically found in restrained eating. Since BAS was a predictor of

restrained in girls and BIS a predictor of this PEB in boys, our data may indicate that

sensitivity to reward contributes to overeating in adolescent girls, while sensitivity to

punishment promotes food restraint in adolescent boys.

Restrained eating was the only PEB implicated in the final mediational models, which is

inconsistent with our hypotheses. Nevertheless, the absence of significant results for PEBs

linked to emotionality and externality is in line with previous literature, as restrained eating is

the PEB whose associations with excess weight are the best documented, results regarding

emotional eating and external eating being mixed and inconsistent in adolescents (Braet et al.,

2008; Lluch, Herbeth, Méjean, & Siest, 2000; Snoek et al., 2007; Snoek, Engels, van Strien,

& Otten, 2013; Stice et al., 2005; Wardle et al., 1992). According to Snoek et al. (2007), the

reasons why emotional and external eating are not consistently linked to excess weight in

adolescents are, first, because problematic emotional eating may develop later in life, and

second, because food intake in adolescents is mostly controlled by parents: it seems likely that

parents of an overweight adolescent will try to avoid as much as possible to expose him to

external food cues (e.g. unhealthy snacks), limiting thus his tendency to external eating.

The analyses revealed no mediating effect of effortful control on the association

between PEBs and BMI percentile. This result is inconsistent with our hypothesis as well as

with data reported in Appelhans' review (2009) demonstrating the importance of regulative

temperament in the inhibition of hedonic feeding and also with literature reporting impaired

executive functioning in obese people (Cserjési et al., 2007, 2009; Gunstad et al., 2007, 2010;

Kamijo et al., 2012). The absence of significant result for EC may be due methodological

issues, in particular to a lack of power of our analyses. Indeed, the limited size of the final sample (due to a poor response rate) probably reduced statistical power, which may have prevented us from detecting other significant results. The lack of result for EC may also be attributed to potential comprehension difficulties of the items pertaining to EC by the participants. As the French version of the EATQ-R used in this study has not been validated yet, the relatively low internal consistency of the three EC subscales may indicate that the items were not adequately formulated. Finally, the scope of our study is limited by its cross-sectional design, which did not allow drawing causal inferences from the results. It may thus be useful to replicate our study on a larger sample, in particular with more overweight or obese participants, and with a validated instrument to assess regulative temperament. It may also be beneficial to test the associations between temperament, PEBs and excess weight with a longitudinal design in order to draw causal inferences. Finally, in order to evaluate the hedonic model proposed by Appelhans, it could be interesting to assess the impact of interaction effects between reactive and regulative temperament on PEBs and excess weight.

Despite these few limitations, this study made significant contributions to the understanding of the mechanisms implied in adolescence excess weight. First, it indicated that reactive temperament influenced overweight in adolescents through the mediating effect of restrained eating. This is consistent with the current view of excess weight, considered as a complex disorder resulting from the interaction of multiple factors (WHO, 2004). This study also identified gender differences in the mediating influence of restrained eating on the association between reactive temperament and excess weight: In girls, a higher sensitivity to reward contributed to the "overeating" component of restrained eating, while in boys, a higher sensitivity to punishment promoted its "food restraint" component.

Our findings have important clinical implications, since they indicate that reducing restrained eating in adolescents may help to control weight. This could be achieved either

directly or indirectly, by working on temperament. A direct way may be to teach adolescent restrained eaters to adopt a more flexible dietary restraint. Two types of restrained eating have been identified (Westenhoefer, 1991): rigid restraint, associated with more frequent and severe overeating episodes and a higher BMI, and flexible restraint, associated with less frequent and severe binge episodes, and with a lower BMI (Westenhoefer, Stunkard, & Pudel, 1999). This suggests that adopting a less rigid dietary control could help adolescents to control their weight by limiting overeating episodes.

In order to reduce restrained eating by working on temperament, our results suggest that it may be possible to act on the "overeating" component in adolescent girls by trying to lower their impulsivity (i.e., BAS tendency), and on the "restraint" component in adolescent boys by trying to dampen their sensitivity to punishment (i.e., BIS tendency). However, working on reactive temperament seems to be difficult as it refers to automatic processes, thus beyond individual's conscious control (Rothbart & Bates, 2006). Therefore, in order to lower sensitivity to reward and punishment, it could be easier to try strengthening regulative temperament (Muris & Ollendick, 2005), representing conscious and voluntary processes allowing individuals to modulate their reactivity (Rothbart & Bates, 2006). Even though we did not find any significant effect of EC (probably because of a lack of statistical power), research indicates that PEBs may be due to an interaction between high levels of reactive temperament and low capacities in EC (e.g., Appelhan's hedonic inhibitory model, 2009). Thus, promoting EC in adolescent restrained eaters might help diminishing BIS and BAS tendencies and therefore reducing restrained eating. For example, a method aimed at lowering delay discounting (i.e., the inability to delay gratification) called "Episodic future thinking" proved to be effective in reducing food intake during overeating in obese adults (Daniel, Stanton, & Epstein, 2013). Further research is warranted on the efficacy of such methods in adolescents.

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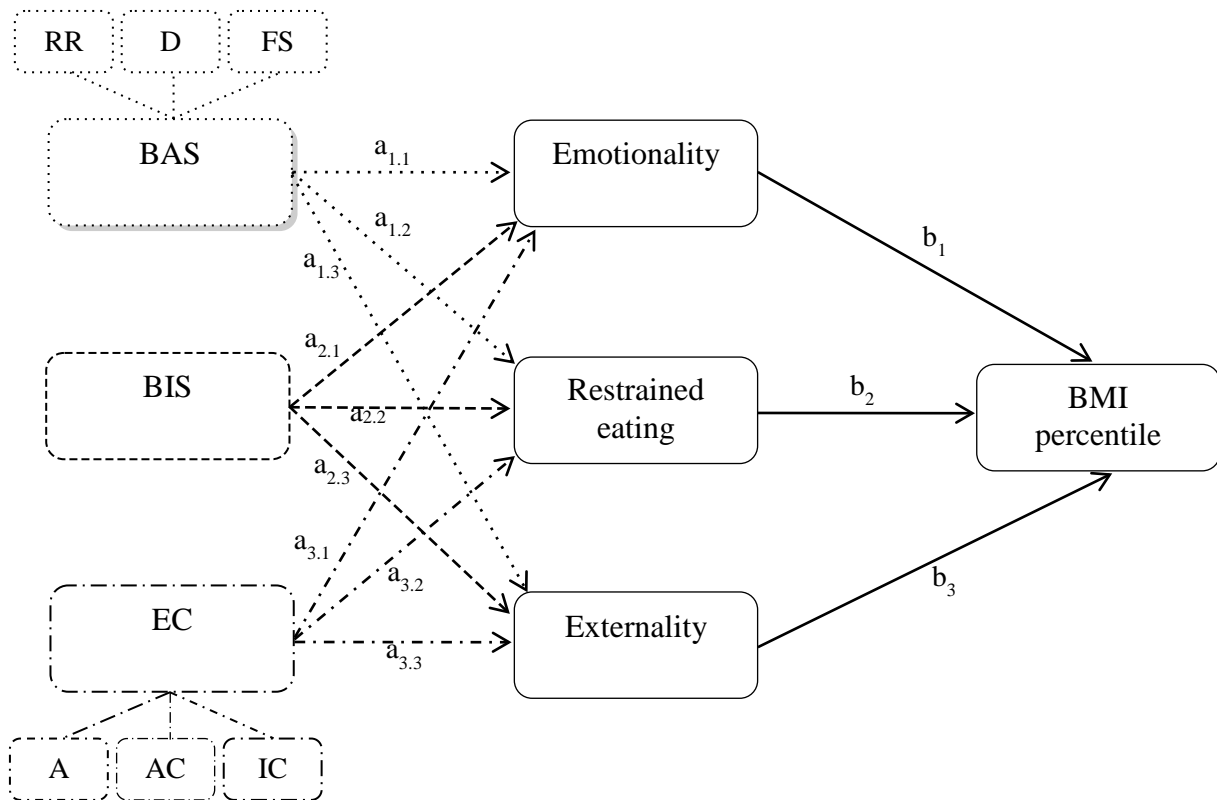
Figure 1. The mediational model illustrating the hypothetical associations between reactive and regulative temperament, problematic eating behaviours, and body mass index percentile.

BAS = Behavioural Activation System; RR = reward responsiveness; D = drive; FS = fun seeking; BIS = Behavioural Inhibition System; EC = Effortful Control; A = Attention; AC = Activation Control; IC = Inhibitory Control; BMI = body mass index.
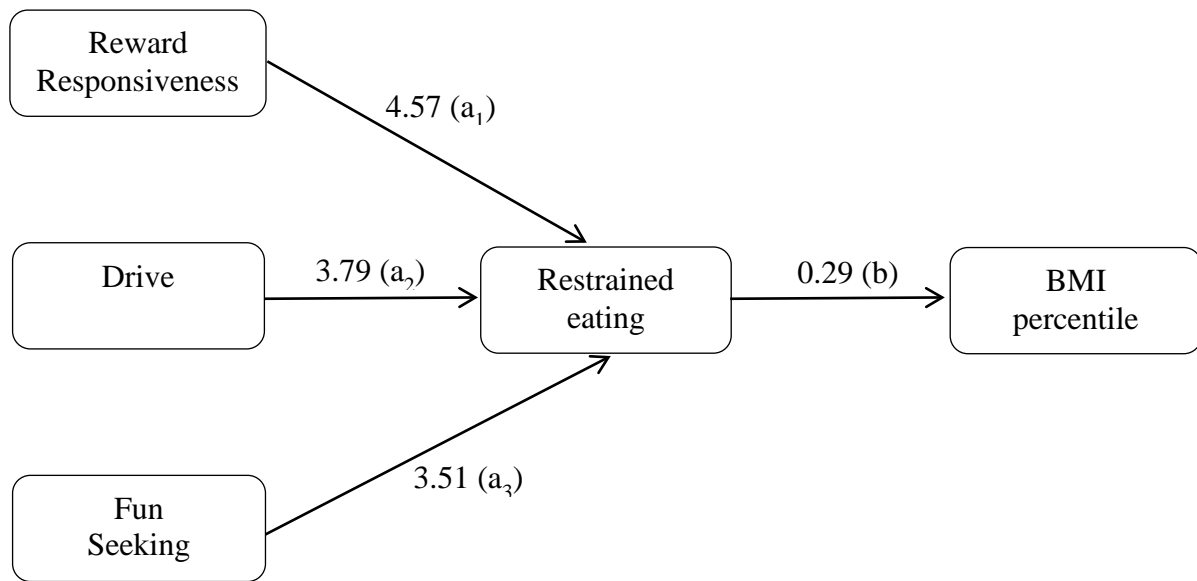
Figure 2. The final mediational model illustrating the effect of Behavioural Activation System subdimensions on body mass index percentile mediated by restrained eating in adolescent girls.
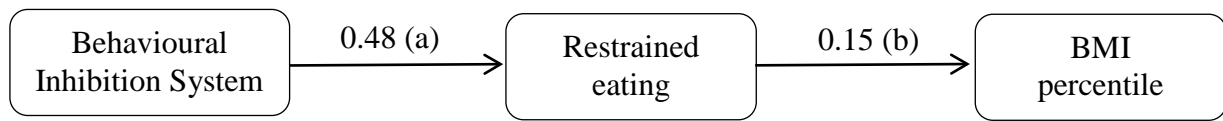
BMI = body mass index percentile.

Figure 3. The final mediational model illustrating the effect of Behavioural Inhibition System on body mass index percentile mediated by restrained eating in adolescent boys.

BMI = body mass index percentile.