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ORIGINAL CONTRIBUTION

The interplay between self-regulation and affectivity in binge eating among adolescents

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Abstract
Binge eating among adolescents is associated with negative developmental outcomes. From a cognitive perspective, the role of impaired self-regulation is increasingly emphasized as an underlying factor in binge eating, whereas the affect regulation model proposes that affectivity is a key factor in explaining binge eating. Studies combining both perspectives are scarce, but necessary to add to the understanding of this pathological eating behavior. Therefore, the aim of the current study was to investigate unique and joint contributions of both factors in understanding binge eating among adolescents. Participants were 301 adolescents (10–17 years; 67.2% girls; $M_{age} = 13.46$ years; SD = 1.99) from the general community. Adolescents self-reported on different types of binge eating episodes (loss of control over eating in general, objective and subjective binge eating in particular), self-regulation (general self-regulation and inhibitory control) and affectivity (positive and negative). The parents were questioned about their children's self-regulatory capacities. Results revealed main effects of self-regulatory capacities (adolescent report) and negative affectivity in predicting objective binge eating. In addition, negative affectivity interacted with self-regulation (parent report) to predict objective binge eating, whereas positive affectivity interacted with self-regulation (adolescent report) to predict subjective binge eating. No significant effects were found for loss of control over eating specifically. Both self-regulation and affectivity each make unique as well as joint contributions to binge eating among adolescents, with results differing across types of binge eating episodes and informants. Theoretical and practical implications are discussed.

Keywords Adolescents · Binge eating · Self-regulation · Affectivity

Introduction

Binge eating

Recent prevalence rates suggest that worldwide approximately one third of adolescents report binge eating episodes [1–4]. Over the past decade, researchers have found that the subjective feeling of loss of control while eating [5] can be considered the key feature of binge eating [6–8]. However, based on the amount of food that is eaten during a binge eating episode, a distinction has been made between objective and subjective binge eating episodes. While both types are characterized by loss of control over eating (i.e., LOC), during an objective binge eating episode (i.e., OBE), an objectively large amount of food is consumed, whereas during a subjective binge eating episode (i.e., SBE) [9], the amount of food consumed is considered to be large according to the individual but not to others. Importantly, these different types of binge eating episodes have been shown to be clinically different constructs in adolescents and are differentially associated with clinical features such as depressive symptoms. For example, Fitzsimmons-Craft et al. [10] and Goldschmidt et al. [11] found that OBE may be indicative for eating-related distress, whereas SBE may reflect more generalized distress related to both eating and mood psychopathology such as depressive symptoms. In addition, Goossens, Soenens, and Braet [12] found that the combined presence of OBE and SBE was associated with more mood-related pathology. Despite these findings, previous studies have often focused on either LOC and/or OBE as the

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primary outcome variable, whereas SBE has largely been ignored. In addition, while these results seem to indicate that the binge eating episodes differ with regard to mood-related pathology, it tells little about whether temperament-based affectivity dimensions (i.e., traits) may add to the explanation of different types of binge eating.

Overall, binge eating episodes are associated with a wide range of physical (e.g., weight/fat gain, obesity) and psychosocial (e.g., depressive symptoms, low self-esteem) problems [13, 14]. In addition, high comorbidity rates have been reported between binge eating and other types of eating pathologies (e.g., restraint eating, food-related craving; [15]). Moreover, longitudinal research has shown that binge eating may be a precursor to clinical eating disorders (e.g., Boulimia Nervosa) or other types of psychopathology (e.g., addiction) [16]. Given the high prevalence rates of binge eating among adolescents and the many aversive and long-term consequences, research into the factors that add to the understanding of this pathological eating behavior is necessary in the context of prevention and early intervention. Over recent years, efforts have been made to examine these underlying factors in youth, but they remain to be fully understood (e.g., [2, 17–20]).

Binge eating and self-regulation

Self-regulation can be defined as the regulation of and by oneself to obtain long-term goals [21], and consists of different cognitive capacities such as working memory, cognitive flexibility, inhibitory control, problem solving and planning. It has been well established that difficulties with self-regulation are a transdiagnostic risk factor for developing psychopathology [22]. As maintaining healthy eating behavior requires a number of everyday self-regulatory skills (e.g., deciding what to do when confronted with palatable foods) and given the compulsive nature of binge eating [23], the role of self-regulation and specifically inhibitory control is increasingly emphasized in binge eating research. Empirical studies examining the relationship between inhibitory control and binge eating in adults show mixed results. Some studies have found evidence for impaired inhibitory control in adults who experience binge eating (e.g., [24–26]), whereas others have not, but instead found impairments in other aspects of self-regulation such as problem solving, cognitive flexibility and working memory (e.g., [27, 28]). Although self-regulation is still developing during adolescence [4, 29], only limited studies have focused on investigating its role in binge eating among younger samples. As in adult studies, findings have been inconclusive. For example, Goldschmidt et al. [17] showed that obese children (9–12 years old) who experience binge eating encountered more problems with working memory compared to obese children without binge eating and normal weight controls. In addition, Van Malderen et al. [2] found more overall self-regulatory impairments among adolescents (10–17 years old) who reported binge eating compared to those who did not, but they did not find any group differences for inhibitory control specifically. Despite this evidence for the underlying role of self-regulation in binge eating, it remains difficult to draw firm conclusions with respect to inhibitory control.

It is important to note that research regarding the role of self-regulation in binge eating has been conducted rather independently from other possible explanatory factors. However, it is assumed that problematic eating behavior such as binge eating may not be explained by one single factor (e.g., self-regulation), but rather is the result of a combination of multiple factors [30]. Therefore, an investigation of multiple explanatory factors will be crucial to furthering our understanding of binge eating in youth.

Binge eating and affectivity

Another valuable research line in the binge eating domain focuses on the possible role of affectivity in binge eating among adolescents. Affectivity can be conceptualized as the way people react to and interact with the environment, therefore often being referred to as the reactive dimension of temperament [31, 33]. This reactive dimension of temperament consists of two factors: (1) negative affectivity, which can be described as the susceptibility to experience negative feelings and distress and (2) positive affectivity, which can be defined as the susceptibility to experience positive feelings and joy [33]. Like self-regulation, negative affectivity has been related to different kinds of psychopathology (e.g., [34, 35]). The affect regulation model proposes that high levels of negative affectivity are a key factor in the development and maintenance of binge eating [36–38]. In support, negative affectivity has been found to be a robust risk factor for binge eating in adults (e.g., [39–41]). In children and adolescents, negative affectivity has been associated with binge eating cross-sectionally, longitudinally and experimentally (e.g., [42, 43]).

As negative and positive affectivity are two distinct temperamental traits in which people can vary independently, the literature on positive affectivity in adolescent psychopathology has grown in recent years [44]. In the area of depression in particular, low levels of positive affectivity are considered to be a robust risk factor [45]; however, the role of positive affectivity has also been acknowledged in other types of psychopathology [46]. Although in the area of eating problems, research on positive affectivity is still in its infancy; some studies have demonstrated a role for this affectivity dimension [38]. For example, Smyth et al. [47] observed a decrease in positive affectivity in women with eating disorders. Furthermore, a recent lab study showed that a decrease in positive affectivity may cause body

dissatisfaction in early adolescence [48]. However, the role of positive affectivity in binge eating among adolescents is currently unknown and its examination may increase our understanding of the contribution of affectivity to this pathologic eating behavior.

Binge eating, self-regulation and affectivity

As self-regulatory processes and affectivity can influence each other bi-directionally [49–51], researchers have shown increasing interest in combining these factors in eating pathology research. Within this line of research, negative urgency (i.e., the tendency to act impulsively when distressed) has been found to play an important role in binge eating (e.g., [38, 52]). However, because the construct of negative urgency constitutes a combination of both self-regulatory and affective processes, it is not possible to distinguish the unique and combined influences of these processes. Thus, our understanding of the nature of the complex interplay between these two factors in the context of binge eating remains to be fully understood.

Therefore, over recent years, efforts have been made to increase our understanding of both the unique and combined influences of self-regulatory and affective processes on binge eating; however, studies have mainly been conducted in adult samples. Moreover, in these studies, only LOC or OBE episodes have been included as outcome variables, without considering SBE. For example, both Racine et al. [53] and Mason et al. [54] showed that adult women from the general community who experience LOC or OBE could be characterized by a combination of high impulsive behavior (i.e., low self-regulation) and high levels of negative affectivity. In addition, in clinical populations, Manasse et al. [55] found that adult women with binge eating disorder (i.e., at least 12 OBE episodes over the last 3 months according DSM-5) [57] who experienced more inhibitory control difficulties (i.e., low self-regulation), as well as higher levels of negative affectivity, showed fewer benefits from treatment and any treatment effects were slower to emerge. Furthermore, Leehr et al. [57] found evidence for an interaction between high impulsivity (i.e., low self-regulation) and impaired emotion regulation capacities (reflected in high levels of negative affectivity) in binge eating disorder among adults with the use of neuroimaging techniques. It is important to emphasize that all these studies focused exclusively on negative affectivity without investigating the possible role of positive affectivity. Smith et al. [58] did examine both affectivity dimensions (negative and positive) in interaction with self-regulation in predicting the probability of binge eating in an adult community sample. They found significant interactions between high levels of impulsive decision making (i.e., low self-regulation) and high levels of both negative and positive affectivity in predicting the probability of experiencing binge eating in adult women. To date, only one study has explored the interaction between self-regulation and affectivity in an adolescent sample experiencing binge eating [59]. Results revealed that impaired inhibitory control in combination with high levels of negative affectivity were related to greater overall severity of loss of control over eating [5].

To our knowledge, no study has yet examined both self-regulation and affectivity (i.e., both negative and positive affectivity) as explanatory factors in an adolescent sample experiencing different types of binge eating (i.e., LOC, OBE and SBE). However, knowledge gained from such a study will add considerably to our understanding of the underlying mechanisms of these types of binge eating episodes in adolescence, because it can distinguish the unique and joint contributions of both vulnerability factors. Accordingly, outcomes may determine which (combination of) aspects should be targeted in prevention and early intervention programs.

Current study

Thus, the aim of the current study was to investigate the unique and joint contributions of self-regulation and affectivity in predicting binge eating among adolescents. Importantly, we included different types of binge eating (i.e., OBE, SBE and LOC), as previous research has already shown that differences between these types exist in terms of their associations with, for example, depressive symptoms [10–12]. To this end, the study addressed two main research questions.[1] First, it was examined whether self-regulatory capacities in general, and inhibitory control in particular, and positive and negative affectivity (i.e., unique effects) significantly contribute to different types of binge eating. In line with previous research, it was hypothesized that greater self-regulatory difficulties, as well as lower levels of positive affectivity and higher levels of negative affectivity would independently increase the likelihood of experiencing binge eating (e.g., [18, 43, 48]). Second, the current study investigated whether, and how, both self-regulation and affectivity as vulnerability factors interact to predict binge eating among adolescents (i.e., joint effects). Based on recent research in adult samples [53, 55], the combination of specifically poor self-regulatory skills and high negative affectivity was predicted to produce the most vulnerable profile for experiencing binge eating. Because limited studies investigated the interaction between self-regulation and positive affectivity in the explanation of binge eating in adolescents, no a priori prediction was made

[1] Importantly, hypotheses for both research questions were based on the available evidence in the current literature and consequently included only for LOC or OBE as outcome variables. Including SBE as a third outcome variable was exploratory in nature and therefore no a priori predictions were made for this type of binge eating.

about this relationship. Similarly, since previous research is inconclusive regarding the specific contribution of inhibitory control in adolescent binge eating, no a priori predictions were made about this aspect of self-regulation.

Method

Participants and procedure

Participants were 301 adolescents (10–17 years; 67.2% girls; $M_{age} = 13.46$ years; SD = 1.99) and their parents from the general community. Participants were recruited by 3rd year psychology students in the context of a practical course. Each student was instructed to recruit two participants between 10 and 17 years old. All youngsters signed an informed consent which provided information about the study. As all participants were underage, their parents also provided active consent for their own participation in the study as well as that of their child. Data collection took place in the participant's home. Participants completed several questionnaires on paper under supervision of the psychology student. All students were carefully instructed and trained in the data collection protocol, and contact details of the main researcher were provided in case there were any questions during the home visit. No incentives were provided for participation. The procedure was approved by Ghent University's Faculty Ethics Committee. The study is part of a larger PhD project on binge eating among adolescents.

Materials

Binge eating

To assess binge eating, participants self-reported on this eating behavior using the 'Children's Eating Disorder Examination Questionnaire' (ChEDE-Q; [60]). This questionnaire is a Dutch translation and adaptation for children and adolescents of the 'Eating Disorder Examination Questionnaire' (EDE-Q; [61]). It can be used in youngsters between 8 and 18 years of age and differentiates different forms of binge eating. The questionnaire provides a measurement of objective binge eating episodes (OBE) as well as subjective binge eating episodes [9]. Youngsters were categorized into one or other group if they had at least one such episode over the past month. Thus, a particular participant could be classified into both the OBE and the SBE group. Moreover, as the feeling of loss of control over eating [5] is inherent in both forms of binge eating, this additional outcome measure can be derived from the responses to the OBE and SBE questions. More specifically, adolescents were categorized as experiencing LOC when they reported at least one OBE or SBE episode during the last month [20]. Previous research has shown that the ChEDE-Q has good reliability and validity for assessing eating pathology among adolescents [62, 63].

Self-regulation

All participants and their parents filled out the 'Behavior Rating Inventory of Executive Function' (BRIEF; [64, 65]). The adolescent version of the BRIEF is suitable for children and adolescents between the ages of 5 and 18 years and consists of 68 items; the parent variant of the BRIEF has 75 items. Response options for items range from 1 (never) to 3 (often) in both versions of the questionnaire, with higher scores reflecting greater self-regulatory difficulties. Both versions of the questionnaire comprise two broad indices: a 'Behavioral Regulation' index and a 'Metacognition' index. Each index is further subdivided into different underlying subscales. In the current study, the 'Behavioral Regulation' index (BEH; e.g., 'I/my child have/has trouble going from one activity to another') and the 'Inhibition' subscale [INH; e.g., 'I/my child interrupt(s) others'] were used to assess self-regulatory skills. The BRIEF has been shown to have good reliability and validity [66]. Internal consistency in the current study was very good for both the adolescent version (BEH-A: $\alpha = .86$ and INH-A: $\alpha = .72$) and the parent version (BEH-P: $\alpha = .92$ and INH-P: $\alpha = .80$).

Affectivity

The trait version of the 'Positive and Negative Affectivity Schedule for Children' (PANAS-C; [67]) was used to capture levels of positive and negative affectivity. This self-report questionnaire consists of 30 items/emotions on a 5-point scale (ranging from 1 = not at all to 5 = a lot). Youngsters indicate to which extent they usually experience each emotion. The PANAS-C has two subscales, one for assessing positive affectivity (PA; e.g., 'happy') and the other for assessing negative affectivity (NA; e.g., 'sad'). Each subscale consists of 15 items. The PANAS-C has good validity [67]. Internal consistency in the current study was very good for both subscales ($\alpha = .87$ for NA and $\alpha = .83$ for PA).

Control variables

Age and gender were self-reported. In addition, each participant was measured and weighed at home using calibrated instruments, from which an adjusted body mass index (km/m^2) was computed [(actual body mass index (kg/m^2)/percentile 50 of body mass index for age and gender) × 100] [68]. Percentile 50 of body mass index was calculated using Flemish normative data which includes age and gender of the participants [69]. As previous research has shown associations between binge eating and age, gender and adjusted body

mass index [4, 13, 20], these demographics were included as control variables in all analyses.

Statistical analysis

To investigate the research questions, a series of binary logistic regression analyses were conducted using SPSS (version 24.0). This type of analysis can predict the probability of a categorical outcome variable (i.e., LOC, OBE or SBE) by different independent variables. Binge eating was considered a categorical variable (0 = no episode, 1 = at least one episode over the last month). Before running the analyses, all continuous variables were centered around their means [70]. All analyses were performed with the same hierarchical structure of inputting variables. First, a specific type of binge eating was entered as the categorical dependent variable (either LOC, OBE or SBE). Second, age, gender and adjusted body mass index were entered as control variables in block 1. Third, self-regulation (either BEH-A, INH-A, BEH-P or INH-P) and affectivity (NA and PA) were entered as independent variables in block 2 (main effects). Lastly, the interactions between self-regulation and affectivity (NA × self-regulation and PA × self-regulation) were included in block 3. Given the different outcome measures for self-regulation (four BRIEF outcomes), this procedure resulted in four logistic regressions for each type of binge eating. For the sake of brevity, only the full logistic regression model (including independent variables of all blocks) was displayed in tables in the result section. Furthermore, only significant main and interaction effects are interpreted further, and when there was a significant interaction effect, the remaining main effects were not interpreted further.

Significant interaction effects were interpreted using PROCESS (model 1), an add-on utility in SPSS [71] to test the conditional effect of the independent variable on the dependent variable. To interpret the interaction effects, the Johnson–Neyman technique was used [72]. This technique reports the region of significance for the conditional interaction in terms of standard deviations from the mean of the moderator, as well as the percentile of the distribution corresponding to that point. The significant interaction effects were represented graphically showing the simple slopes for the independent variable (self-regulation) at low (10th percentile) and high (90th percentile) levels of the moderator (affectivity). For all analyses, p values ≤ .050 were considered statistically significant. Odds ratios (OR) were used as the effect size measure in all analyses.

Results

Descriptive results

Adjusted body mass index of all participants ranged from 58.62 to 189.36 (M = 104.76, SD = 21.47). Of the sample, 9.8% of participants were classified as underweight (adjusted body mass index ≤ 85), 74.7% as normal weight (85 < adjusted body mass index < 120), 7.3% as overweight (120 < adjusted body mass index < 140) and 8.2% as obese (adjusted body mass index ≥ 140) [73]. According to the ChEDE-Q [60], 31.5% of all adolescents reported having had at least one episode of LOC over the past month (range 0–20). For OBE and SBE, the percentages were 18.2% (range 0–16) and 19.1% (range 0–15), respectively. All descriptive statistics (sample characteristics and correlations between all variables of interest) can be found in Table 1.

The role of self-regulation and affectivity in LOC

Results of all logistic regressions with self-regulation, affectivity and their interaction in predicting the probability of LOC revealed no significant main or interaction effects. More specifically, no significant effects were found with NA as the moderator in the relationship between self-regulation and LOC, nor with PA as the moderator in this relationship.[2]

The role of self-regulation and affectivity in OBE

Results of the logistic regressions with self-regulation, affectivity and their interaction in predicting the probability of OBE revealed significant main and interaction effects (Table 2).

Model 1, including BEH-A, was significant with significant main effects of BEH-A (p = .050, OR = 1.549) and NA (p = .020, OR = 1.660). Specifically, high BEH-A and high NA significantly increased the probability of OBE.

Model 2, including INH-A, was significant with a significant main effect of NA (p = .005, OR = 1.724) such that high NA significantly increased the probability of OBE.

Model 3, including BEH-P, was significant with a significant main effect of NA (p = .005, OR = 1.743) as well as a significant BEH-P x NA interaction (p = .035, OR = .690). The interaction effect was significantly positive for NA < −.200 *SD*s (44.58th percentile). Figure 1 shows the interaction by way of simple slopes representing the association between BEH-P and OBE at low (10th percentile) and high (90th percentile) levels of NA. As shown, at

[2] For the sake of brevity, we have simply noted non-significant results. Tables with an overview of the full results can be obtained from the first author upon request.

Table 1 Descriptive statistics

	M or % (SD)	Min–max	BEH-A	INH-A	BEH-P	INH-P	NA	PA
Gender	67.2% female							
Age	13.46 (1.99)	10–17	.180	.158**	−.062**	−.041	.120*	−.223**
AdjBMI	104.76 (21.47)	58.62–189.36	.034	.092	.035	.113	.036	.098
LOC	31.5% LOC	0–20						
OBE	18.2% OBE	0–16						
SBE	19.12% SBE	0–15						
BEH-A	48.15 (9.29)	31–81	1	.816**	.315**	.305**	.484**	−.297**
INH-A	19.89 (4.26)	12–43		1	.214**	.371**	.236**	−.070
BEH-P	39.89 (8.97)	28–75			1	.791**	.306**	−.194**
INH-P	13.44 (3.22)	10–27				1	.134**	−.092
NA	31.56 (8.99)	15–58					1	−.301**
PA	42.41 (7.33)	13–59						1

AdjBMI adjusted body mass index, *LOC* loss of control over eating, *OBE* objective binge eating, *SBE* subjective binge eating, *BEH-A* BRIEF Behavioral Regulation index (adolescent report), *INH-A* BRIEF Inhibition subscale (adolescent report), *BEH-P* BRIEF Behavioral Regulation index (parent report), *INH-P* BRIEF Inhibition subscale (parent report), *NA* negative affectivity, *PA* positive affectivity

*$p \leq .050$

**$p \leq .010$

***$p \leq .001$

low levels of NA (solid line), high scores on BEH-P significantly increased the probability of OBE ($b = .781$, SE = .334, $p = .019$). However, at high levels of NA (dashed line), BEH-P did not significantly change the probability of OBE ($b = -.152$, SE = .231, $p = .512$).

Model 4, including INH-P, was significant with a significant main effect of NA ($p = .004$, OR = 1.737) whereby high NA again significantly increased the probability of OBE.

The role of self-regulation and affectivity in SBE

Results of the logistic regressions with self-regulation, affectivity and their interaction in predicting the probability of SBE revealed one significant interaction effect in *model 1*, including BEH-A (Table 3).

Although the overall model itself was not significant, adding the interaction terms to the model (block 3) significantly improved the previous model which contained only the main effects [$\chi^2(2) = 6.108$, $p = .047$]. BEH-A and PA significantly interacted in predicting the probability of SBE ($p = .030$, OR = 1.590). The interaction effect was significantly positive for PA < −1.534 SDs (6.67th percentile) and significantly negative for PA > 1.974 SDs (98.75th percentile). Figure 2 shows the interaction by way of simple slopes representing the association between BEH-A and SBE at low (10th percentile) and high (90th percentile) levels of PA. As shown, both at low levels of PA (solid line) and at high levels of PA (dashed line), BEH-A did not significantly change the probability of SBE ($b = -.629$, SE = .335, $p = .061$ and $b = .408$, SE = .267, $p = .127$, respectively). However, when inspecting the regions of significance, it is clear that the influence of PA is only statistically significant at very low and very high levels of PA. More specifically, at very low levels of PA (−4.01 < PA < −1.53), low BEH-A significantly increased the probability of SBE ($p < .05$), whereas at very high levels of PA (1.97 < PA < 2.26), high BEH-A significantly increased the probability of SBE ($p < .05$).

Discussion

The aim of the current study was to further elucidate the underlying mechanisms of binge eating among adolescents. To this end, both the unique and the joint contributions of self-regulation (general self-regulation and inhibitory control specifically) and affectivity (positive and negative) were investigated in predicting the likelihood of experiencing different types of binge eating (i.e., LOC, OBE and SBE).

Unique and joint contributions of self-regulation and affectivity in binge eating

To address the first research question, the main effects of self-regulation and affectivity were examined as explanatory factors for LOC, OBE and SBE. Results revealed significant main effects of self-regulatory capacities and negative affectivity, but only in predicting the probability of OBE. Specifically, greater self-regulatory problems (self-reported by the adolescent) and high negative affectivity independently increased the likelihood of reporting OBE in youngsters. The independent contributions of self-regulatory problems and high negative affectivity

Table 2 Logistic regression analysis: self-regulation × affectivity in predicting the probability of OBE

	Model 1[a]			Model 2[b]			Model 3[c]			Model 4[d]		
	Wald χ^2	*B* (SE)	*p*	Wald χ^2	*B* (SE)	*p*	Wald χ^2	*B* (SE)	*p*	Wald χ^2	*B* (SE)	*p*
Covariates												
Gender	.677	−.376 (.448)	.410	.985	−.442 (.446)	.321	.734	−.386 (.450)	.392	.722	−.380 (.448)	.396
Age	1.312	.220 (.192)	.252	2.024	.274 (.193)	.155	2.098	.283 (.195)	.147	1.886	.264 (.192)	.170
AdjBMI	2.499	.303 (.192)	.114	3.121	.333 (.188)	.077	2.298	.290 (.191)	.130	2.755	.317 (.191)	.097
NA	5.420	.507 (.218)	.020*	8.008	.545 (.193)	.005**	7.844	.556 (.198)	.005**	8.388	.552 (.191)	.004**
PA	.411	−.138 (.215)	.521	.378	−.119 (.193)	.539	.464	−.137 (.201)	.496	.554	−.145 (.195)	.457
Self-regulation	3.801	.437 (.224)	.050*	.001	.004 (.185)	.981	2.568	.309 (.193)	.109	.057	.045 (.188)	.812
NA × self-regulation	2.274	−.215 (.190)	.259	.187	−.081 (.188)	.666	4.444	−.372 (.176)	.035*	2.766	−.317 (.191)	.096
PA × self-regulation	.189	.093 (.214)	.664	.015	.024 (.195)	.902	.053	−.038 (.165)	.818	.205	−.079 (.175)	.650
Constant	41.003	−1.563 (.244)	.000***	45.516	−1.545 (.229)	.000***	44.056	−1.538 (.232)	.000***	47.449	−1.573 (.228)	.000***
Model test	χ^2 (8) = 26.198, *p* = .001**			χ^2 (8) = 21.413, *p* = .006**			χ^2 (8) = 26.312, *p* = .001**			χ^2 (8) = 23.250, *p* = .003**		
−2LL (Nagelkerke R^2)	198.669 (.171)			203.454 (.141)			199.349 (.170)			202.412 (.151)		

OBE objective binge eating, *NA* negative affectivity, *PA* positive affectivity, *AdjBMI* adjusted body mass index

*$p \leq .050$

**$p \leq .010$

***$p \leq .001$

Each model includes a different aspect of self-regulation:

[a]BRIEF Behavioral Regulation index (adolescent report)

[b]BRIEF Inhibition subscale (adolescent report)

[c]BRIEF Behavioral Regulation index (parent report)

[d]BRIEF Inhibition subscale (parent report)

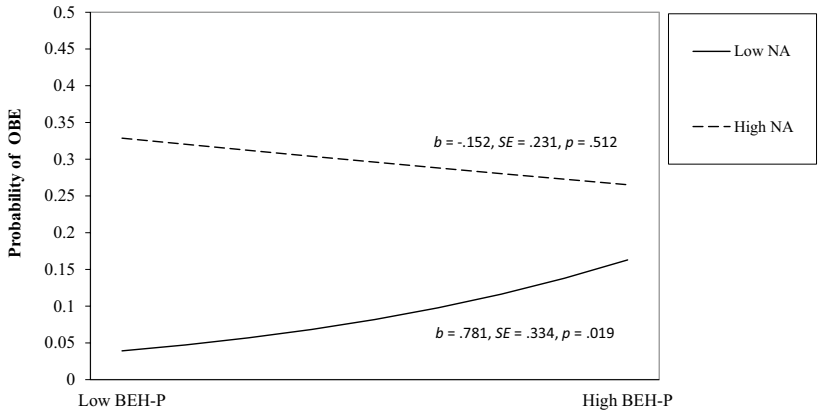

Fig. 1 Interaction between BEH-P and NA in predicting the probability of OBE

Note. BEH-P = BRIEF Behavioral Regulation index (parent report); NA = Negative Affectivity; OBE = Objective Binge Eating

$^{*}p \leq .050$, $^{**}p \leq .010$, $^{***}p \leq .001$

were in line with expectations based on similar findings in adolescent samples [2, 17, 18, 42, 43]. The results provide further evidence for the important roles of both cognitive (i.e., role of self-regulation; [22]) and affective (i.e., role of negative affectivity; [38]) perspectives on vulnerability factors of binge eating in adolescents.

Contrary to expectations, these main effects were observed only for one type of binge eating, namely OBE. However, as OBE is recognized by the DSM-5 [57] as the main symptom of eating disorders such as bulimia nervosa and binge eating disorder, this specific type of binge eating episode may be the most clinically relevant and thus the only one in which the main effects of general self-regulation and negative affectivity are fully expressed.

It is important to note that our results did not provide evidence for unique effects of inhibitory control, nor for positive affectivity in predicting binge eating. The lack of a main effect of inhibitory control is at odds with some previous studies showing impaired inhibitory control in binge eating (e.g., [25, 26]), but in line with others that similarly showed no impairments in this aspect of self-regulation (e.g., [2, 17]). It is important to note that all these studies differed in the assessment methods they used to capture inhibitory control (e.g., questionnaires, fMRI, neuropsychological tasks). Different assessment methods may capture different constructs, which may contribute to the mixed results (e.g., [74, 75]). This highlights the need for future research to operationalize the construct of inhibitory control not only using 'trait-like' measures of self-regulation in daily life (e.g., with questionnaires such as the BRIEF) but also with 'state-like' measures of self-regulation in a specific situation (e.g., go/no-go task). The lack of a main effect of positive affectivity, will be discussed below as this variable did not independently predict binge eating, but did so in interaction with self-regulation.

The second research question focused on whether and how self-regulation and affectivity interact to predict LOC, OBE and SBE. Results revealed a significant interaction between self-regulation (reported by the parent) and negative affectivity in predicting OBE. Closer examination of the nature of this interaction showed that, when negative affectivity was low (i.e., low susceptibility to experience negative feelings and distress), youngsters with poor self-regulatory capacities are significantly more at risk of OBE. By contrast, youngsters with high negative affectivity (i.e., high susceptibility to experience negative feelings and distress) appear to be at greater risk of experiencing OBE independent of their self-regulatory capacities. This finding highlights the importance of high levels of negative affectivity for predicting OBE, which is in line with the central focus of the affect regulation model of binge eating [38]. Moreover, this interaction effect between self-regulation and negative affectivity seems to suggest that the role of self-regulation in predicting OBE is subordinate to the role of negative affectivity, as its detrimental association with binge eating is expressed only in youngsters with low negative affectivity. Importantly, this interaction between self-regulation and negative affectivity was observed only when self-regulation was reported by the parent. Adolescence can be described as a turbulent period with numerous challenges, for example, attaining increasing independence from parents. This may result in more frequent parent–child conflicts, which are often accompanied by high levels of negative affectivity [76, 77]. Thus, it is possible that adolescents' negative affectivity becomes more noticeable or striking to parents in this age group. Particularly for youngsters with high levels of negative affectivity, this emotionality may dampen the role of poor self-regulatory skills in predicting OBE. To explore this possibility, it is important that self-regulation as well as affectivity are reported by both the adolescent and the

Table 3 Logistic regression analysis: self-regulation × affectivity in predicting the probability of SBE

	Model 1[a]			Model 2[b]			Model 3[c]			Model 4[d]		
	Wald χ^2	*B* (SE)	*p*	Wald χ^2	*B* (SE)	*p*	Wald χ^2	*B* (SE)	*p*	Wald χ^2	*B* (SE)	*p*
Covariates												
Gender	.004	.023 (.385)	.951	.007	−.032 (.386)	.934	.003	−.020 (.381)	.958	.003	−.023 (.382)	.953
Age	1.036	.187 (.183)	.309	.916	.176 (.184)	.339	1.160	.197 (.183)	.281	1.451	.219 (.182)	.228
AdjBMI	.017	−.023 (.178)	.896	.002	−.009 (.175)	.961	.050	−.040 (.179)	.823	.044	−.038 (.179)	.833
NA	.000	−.002 (.195)	.922	.006	−.014 (.184)	.939	.094	−.057 (.185)	.759	.071	−.047 (.178)	.790
PA	.484	−.136 (.195)	.487	.015	−.023 (.188)	.903	.214	−.090 (.183)	.623	.081	−.052 (.182)	.776
Self-regulation	.077	−.056 (.203)	.781	.085	−.050 (.173)	.771	.114	−.066 (.195)	.735	.475	.120 (.175)	.491
NA × self-regulation	.047	.039 (.181)	.828	1.672	−.238 (.184)	.196	2.690	−.361 (.220)	.101	2.177	−.292 (.198)	.140
PA × self-regulation	4.706	.464 (.214)	.030*	.015	.023 (.186)	.904	.805	−.164 (.182)	.370	.746	−.149 (.172)	.388
Constant	41.200	−1.443 (.225)	.000***	47.871	−1.460 (.211)	.000***	47.692	−1.446 (.209)	.000***	50.414	−1.471 (.207)	.000***
Model test	χ^2 (8) = 7.522, *p* = .482			χ^2 (8) = 3.860, *p* = .870			χ^2 (8) = 4.912, *p* = .767			χ^2 (8) = 4.492, *p* = .810		
−2LL (Nagelkerke R^2)	221.156 (.050)			224.817 (.026)			227.552 (.033)			227.972 (.030)		

SBE subjective binge eating, *NA* negative affectivity, *PA* positive affectivity, *AdjBMI* adjusted body mass index

*$p \leq .050$

**$p \leq .010$

***$p \leq .001$

Each model includes a different aspect of self-regulation:

[a]BRIEF Behavioral Regulation index (adolescent report)

[b]BRIEF Inhibition subscale (adolescent report)

[c]BRIEF Behavioral Regulation index (parent report)

[d]BRIEF Inhibition subscale (parent report)

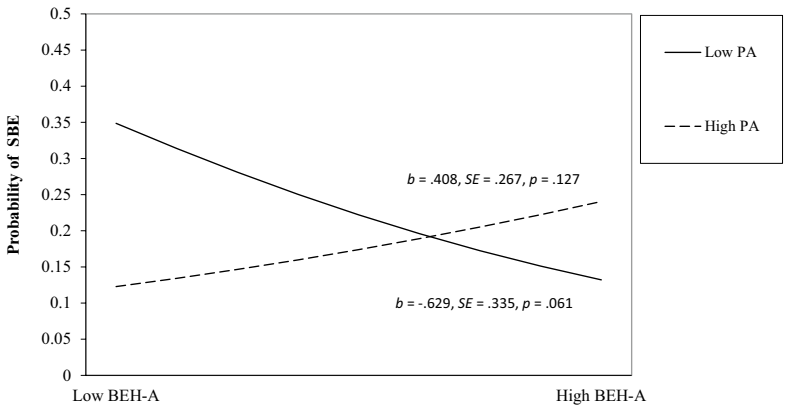

Fig. 2 Interaction between BEH-A and PA in predicting the probability of SBE

Note. BEH-A = BRIEF Behavioral Regulation index (adolescent report); PA = Positive Affectivity; SBE = Subjective Binge Eating

$^{*}p \leq .050$, $^{**}p \leq .010$, $^{***}p \leq .001$

parent. As noted above, when self-regulation was reported by the adolescents themselves, self-regulation and negative affectivity each individually predicted OBE, but not in interaction. In line with the reasoning above, it may be that both factors are equally relevant from the adolescents' perspective (i.e., main effects), whereas negative affectivity may be more important than self-regulation from the parents' perspective (i.e., interaction effect).

We further found that self-regulation (reported by the adolescent) interacted with positive affectivity to predict SBE. Contrary to expectations (e.g., based on [53, 55]), it was not the combination of poor self-regulatory skills and low positive affectivity that was associated with the greatest likelihood of experiencing SBE. Rather, both high and low levels of positive affectivity were associated with a greater risk of SBE. In particular, good self-regulatory skills were associated with a greater risk of SBE when positive affectivity was very low (i.e., very low susceptibility to experience positive feelings and joy), whereas poor self-regulatory skills was associated with a greater risk of SBE when positive affectivity was very high (i.e., very high susceptibility to experience positive feelings and joy).

Interestingly, the interaction between self-regulation and positive affectivity produced two 'vulnerable profiles' for experiencing SBE. Because the affect regulation model does not make specific predictions about the role of positive affectivity in binge eating [38], the current results have important added value in showing two possible affect regulatory pathways for explaining SBE. In the first profile, youngsters with good self-regulatory skills have a higher probability of experiencing SBE when they have very low levels of positive affectivity. Although good self-regulatory skills are generally considered to be a protective factor in the context of eating pathology (e.g., [78]), the current results show that these can have an adverse impact in youngsters with very low levels of positive affectivity. More specifically, it may be that good self-regulatory skills in combination with low positive affectivity corresponds to the typical profile of unsuccessful restrained eaters. Restrained eaters often impose strict dietary rules but may be perfectly able to regulate themselves throughout the day. However, in certain circumstances, they may fail in their attempts for weight control which may result in experiences of binge eating episodes [79–81]. Results of the present study may add to the understanding of the circumstances that may cause this breakdown. More specifically, especially youngsters who are characterized by low levels of positive affectivity may experience SBE as a strategy to increase positive affectivity when confronted with attractive food cues in the environment. Thus, SBE may function as an emotion regulation strategy to 'up-regulate' positive affectivity. This extends the affect regulation model of binge eating by showing that the positive reinforcement of binge eating may not only be driven by decreased levels of negative affectivity but also by increased levels of positive affectivity [38].

In the second profile, youngsters with poor self-regulatory skills have a higher probability of experiencing SBE when they have very high levels of positive affectivity. Similar to self-regulation, positive affectivity has also been described as a protective factor in adolescents' development (e.g., [46]); however, the present results reveal detrimental effects of very high levels of positive affectivity in combination with poor self-regulatory skills. Previous findings in the temperament literature may help to explain this result. More specifically, Rothbart et al. [33] stated that high levels of positive affectivity are a reflection of high positive emotional reactivity to the environment, which places additional demands on self-regulatory capacities. In the current study, adolescents may find it difficult to lower their high positive emotional reactivity due to their poor self-regulatory skills, whereby SBE functions as an emotion regulation strategy to 'down-regulate' positive affectivity. The potential risk

of high levels of positive affectivity has similarly been acknowledged in the eating disorders domain (e.g., [82, 83]). Especially, Haynos et al. [84] examined the effect of positive affectivity across different types of eating disorders. They found that the role of high positive affectivity was particularly relevant for individuals with anorexia nervosa of the binge–purge type, in which SBE may be a core symptom [57, 85]. Although the focus of previous research in the binge eating domain has been predominantly on LOC and/or OBE, the present findings strengthen the relevance of poor self-regulatory skills in combination with very high levels of positive affectivity specifically in predicting SBE. Moreover, as this interaction between self-regulation and positive affectivity was found only when adolescents themselves reported on their self-regulatory skills, it emphasizes the subjective experience of SBE.

To summarize, self-regulation and affectivity both play unique and combined roles in predicting OBE and SBE. Although LOC is inherent in both types of binge eating, no significant effects were found for LOC. As demonstrated by the current findings, there appears to be a substantial difference in the underlying vulnerability patterns for OBE and SBE, which may have obviated any effects for LOC.

Strengths and limitations

The current study has several strengths. First, it sought to gain further insight into the complex reality of binge eating by considering different types of risk factors (i.e., self-regulation and affectivity), both individually and in interaction with each other. As research has previously documented important differences between different types of binge eating episodes [12], three types of episodes (i.e., OBE, SBE and LOC) were included as outcome variables. Second, we recruited a large sample of 301 adolescents from the general community (10–17 years old). This age group is of particular significance, as adolescence has been found to be a risk period for developing eating problems such as binge eating [4]. Third, the self-regulatory skills of adolescents were assessed by the adolescents themselves as well as their parents (i.e., multi-informant). Finally, the current study extends on previous research based on the affect regulation model by including not only negative affectivity but also positive affectivity [38]. In doing so, the role of affectivity in the context of binge eating in adolescents could be examined more comprehensively.

The current study also has some limitations that need to be acknowledged. While the chosen data analytic technique could test the probability of binge eating given a specific set of independent variables, the cross-sectional design of the study means that we cannot draw inferences about the predictive role of self-regulation and affectivity in binge eating, nor can we conclude about causality. In addition, the present design did not allow us to test whether these risk factors also serve an important role in predicting the severity of binge eating. Longitudinal and experimental designs in samples with more individuals experiencing a broader range of binge eating episodes (e.g., subclinical or clinical samples) are therefore needed. Furthermore, we exclusively used questionnaires to operationalize all variables. To overcome the possible mono-method bias in results [86], it is important that the current findings are replicated with different assessment methods (e.g., behavioral tasks for self-regulation, experimental mood induction).

Implications

The current study has some important theoretical and practical implications. First, the results provide further evidence for the role of self-regulatory problems as a risk factor for binge eating [2, 18]. Because this points to a general contribution of self-regulation, and because the role of inhibitory control is still unclear, future research will need to disentangle the underlying factors of this umbrella term. In doing so, it is important that not only inhibitory control is examined but also other cognitive aspects of self-regulation (e.g., cognitive flexibility, working memory) and that a combination of various assessment methods (e.g., questionnaires and behavioral tasks) will be used to measure these constructs [87]. Second, the present results provide further insight into the affect regulation model of binge eating by examining both positive and negative affectivity in binge eating. More specifically, results seem to indicate that binge eating may serve as an emotion regulation strategy to regulate levels of negative or positive affectivity. While previous research found that OBE was most associated with eating-related distress, whereas SBE was indicative for mood-related psychopathology [10–12], the present study showed preliminary evidence for the role of trait affectivity in both types of binge eating episodes. Specifically, the results seem to suggest that negative affectivity may be relevant in explaining OBE, while positive affectivity seems to be more important in the context of SBE. Importantly, the current study assessed these concepts as traits through the use of questionnaires. Thus, future research endeavoring to replicate the current findings with, for example, an experimental mood induction design to measure state affectivity will be necessary.

Knowledge derived from research that focuses on clarifying the roles of self-regulation and affectivity can be used to refine theoretical models about the development and maintenance of eating problems in youth. Such models can provide a starting point for setting up screening programs to identify high-risk populations. The results of the present study demonstrate that there may be several important points to consider in such screening. In particular, the differentiation of types of binge eating seems important, because

different types are associated with (a combination of) different explanatory factors. Both self-regulation and affectivity seem to be important adolescent characteristics to take into account while screening for binge eating, and their role seems to depend on the type of binge eating (e.g., negative affectivity for OBE, positive affectivity for SBE) and the informant.

Conclusion

In conclusion, the current study provides evidence for the importance of cognitive as well as affective perspectives on binge eating. Specifically, self-regulation and affectivity both play unique and combined roles in predicting binge eating. However, results largely depended on the type of binge eating and the informant. For OBE, main effects of self-regulation (adolescent report) and negative affectivity were found, as well as an interaction between self-regulation (parent report) and negative affectivity. For SBE, however, only an interaction effect between self-regulation (adolescent report) and positive affectivity was observed. Replication of these findings with different assessment methods and designs is warranted.

Author contributions LG, EK and EVM designed the study and wrote the protocol. EVM and EB were responsible for the data collection, under supervision of LG. EVM conducted the statistical analyses and wrote the first draft of the manuscript. All other authors edited subsequent drafts of the manuscript, and have approved the final manuscript.

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Compliance with ethical standards

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

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