# From BIS to Binge: The Role of Negative Affect in the Pathway Between Personality and Binge Eating

Daniel R. Wilson[a]

Natalie J. Loxton[ab]

Analise O'Donovan[c]

[a]School of Applied Psychology, Griffith University, Brisbane, Queensland, 4122, Australia.

[b]Centre for Youth Substance Abuse Research, The University of Queensland, Brisbane, Queensland, 4072, Australia.

[c]Health Group, Griffith University, Brisbane, Queensland, 4122, Australia

Corresponding Author:

Daniel Wilson

School of Applied Psychology, Griffith University, Brisbane, Queensland, 4122, Australia.

Email: dan.wilson2@griffithuni.edu.au

Phone: +61 3735 3325

Abstract

Recent research has highlighted the utility of using revised Reinforcement Sensitivity Theory (RST) to further understand the individual differences that influence binge eating behaviours. The current study draws on both RST and theoretical models that implicate negative affect in binge eating, with the aim of identifying indirect pathways between individual differences in RST systems and binge eating as mediated through negative affect. Undergraduate students ($n$ = 229, $M$ = 22.67 years of age, $SD$ = 8.95, 76% female) completed self-report measures of revised reinforcement sensitivities, negative affect and binge eating symptoms. Bootstrapped tests of indirect effects showed that negative affect mediated the pathway between the Behavioural Inhibition System (BIS) and binge eating symptoms. Additionally, negative affect mediated the pathway between rash impulsivity and binge eating symptoms. This study supports and extends previous research by highlighting the experience of negative affect as a possible mechanism through which heightened BIS and rash impulsivity leads to binge eating.

*Keywords*: Binge Eating, Anxiety, Impulsivity, Affect, Personality, Reward Sensitivity

## 1. Introduction

Binge eating is associated with a range of physical and psychological complications, with increased prevalence observed in the general population in recent years [1-3]. Increased understanding regarding why some people binge eat more frequently and the processes involved is critical in addressing this growing problem.

### 1.1 Revised Reinforcement Sensitivity Theory

Revised Reinforcement Sensitivity Theory [RST; 4] is a biologically based theory of personality based on the sensitivity of the brain systems that react to rewarding and punishing stimuli. The theory proposes three systems as being responsible for mediating approach and avoidance behaviour: the Behavioural Approach System (BAS); the Behavioural Inhibition System (BIS), and the Fight/Flight/Freeze System (FFFS).

The BAS is thought to mediate approach behaviour to rewarding stimuli, and can be thought of as a '*desire'* system [5]. Whilst the original theory proposed by Gray [6] labelled BAS at the personality level as representing impulsivity, subsequent research has since differentiated *reward sensitivity* (the tendency to desire and seek rewarding situations or experiences) and *rash impulsivity* [the tendancy to engage in risky or unplanned behaviours; the inability to inhibit approach behaviour; see 7].

The FFFS is thought to mediate active avoidance in response to all negatively valanced stimuli and is a threat detection or '*fear'* system. The behavioural output (i.e., fight, flight or freeze) is dependent on the proximity of the threat, and the opportunity/likelihood of escape. The BIS is considered the '*anxiety'* system and activates to resolve conflict when both the BAS and FFFS are activated in situations that involve both reward and punishment. The BIS is associated with the emotional state of anxiety and motivates towards cautious approach behaviour (if the reward outweighs the threat).

#### 1.2.1 The role of reward sensitivity and rash impulsivity in binge eating

Research has utilised RST to further understand binge eating behaviour. Much of the existing research is difficult to interpret due to older measures of BAS that do not reflect the revised RST, and in particular do not separate reward sensitivity and rash impulsivity according to Dawe and Loxton's (2004) two facet model of impulsivity. In the only study to utilise a measure of the revised theory with a clinical ED sample, individuals with binge-type eating disorders (i.e., Bulimia Nervosa, Anorexia Nervosa - binge/purge subtype and Binge Eating Disorder (BED)), displayed higher rash impulsivity scores, but were not different on measures of reward sensitivity compared to both non-binge eating disorders (i.e., Anorexia Nervosa – restrictive subtype (AN-R)), and healthy controls [8]. Although limited by the use of older measures, studies have typically found that those with binge-type ED score higher compared to AN-R on measures reflective of rash impulsivity, and lower on measures assessing the ability to inhibit impulsive responding [9-12].

Additionally, recent narrative [13] and systematic [14] reviews have investigated reward sensitivity and rash impulsivity in food addiction, which is conceptually similar to binge eating [defined as excessive overeating of high-calorie foods accompanied by loss of control and intense cravings: 15]. Both reviews reported consistent associations with rash impulsivity, whilst measures reflecting reward sensitivity displayed mixed results. Similarly, in two systematic reviews of food-related impulsivity in BED and obesity, Giel and colleagues concluded that those with BED are characterised most significantly by increased rash-spontaneous behaviour, with reward sensitivity implicated to a lesser degree – particularly when compared to weight matched controls [16, 17]. In sum, literature utilising the two factor model of impulsivity [7] provides support for the notion that rash impulsivity is related to binge eating, however reward sensitivity shows inconsistent relationships.

### 1.2.2 BIS/FFFS and Binge Eating

In addition to the literature on rash impulsivity and reward sensitivity, research has shown that both BIS and FFFS are associated with binge eating, although again, much of the literature is limited by the use of now outdated measures [see 8, 18]. A meta-analysis by Harrison, O'Brien [19] featuring studies using older measures of sensitivity to punishment reflective of combined BIS/FFFS, demonstrated that increased punishment sensitivity was transdiagnostically associated with eating disorders. In the only study to use a measure of the revised theory in an eating disordered sample, those with clinically diagnosed eating disorders featuring binge eating behaviours scored higher on self-report measures of BIS and FFFS compared to healthy controls, but did not differentiate from purely restrictive EDs [8]. Further, in non-clinical populations, both BIS and FFFS were associated with self-report measures of binge and disordered eating psychopathology [20, 21]. Consistently, in both clinical and non-clinical populations, it has been found that the BIS is of greater influence and explains more variance in binge eating behaviours compared to FFFS [8, 20, 21].

The role of BIS and FFFS transdiagnostically across eating disorders may be a result of biological vulnerability factors (i.e. RST) interacting with ubiquitous social factors. Particularly, those higher in BIS/FFFS may be more sensitive to the perceived threat of being overweight, and are more likely to attempt dietary restraint [8, 20]. Long term, the ongoing conflict between the inherently rewarding value of food, and the perceived threat of associated weight gain may be particularly salient for those high in BIS. This is consistent with the motivational conflict theory of binge eating, with evidence showing discrepant appetitive and aversive motivation towards food may operate simultaneously among those with binge eating [22, 23]. The motivational output of BIS according to RST theory would motivate towards cautious approach (i.e., the initiation of an eating episode) in response to the activation of this system. Furthermore, those with high rash impulsivity may be more susceptible to losing control and engaging in a binge episode following BIS-driven eating.

To summarise, research using RST to investigate binge eating is consistent in finding associations with rash impulsivity, BIS and to a lesser extent FFFS. Whilst research has linked constructs such as expectancies and response to food cues as mechanisms through which RST may influence eating behaviours [21, 24], no study has used a measure of revised RST to investigate the mediating role of negative affect in the pathway to binge eating.

### 1.3 RST and Affective States

RST is proposed to motivate approach or avoidance behaviour in part due to the experience of emotional states. The BAS has been proposed as being associated with activated, positive affect, the FFFS with fear, and the BIS with anxiety. Higher sensitivity of these systems is proposed to predispose individuals to experience related emotional states more frequently and/or intensely. For example, Stoeber and Corr [25] found that higher scores in all BAS subscales of the Reinforcement Sensitivity Theory Personality Questionnaire [RST-PQ; 26] were associated with higher self-reported measures of positive affect over a preceding two-week period, whereas those higher on BIS and FFFS reported higher negative affect. Interestingly, impulsivity was positively associated with both negative and positive affect. One explanation for this would be that whilst impulsive behaviours may be associated with short term increases in positive affect, the potential for maladaptive outcomes of rash action may also lead to longer term negative affect, which is consistent with the proposal by Zuckerman and Kuhlman [27] [although for an alternate explanation, see 28, 29]. With reference to binge eating, engaging in such behaviours may lead to ongoing negative affect, for example due to concerns about weight gain, and/or future binge episodes.

### 1.4 Negative Affective States and Binge Eating

Affective states and emotional regulation processes have been implicated in maladaptive food intake. For example, theoretical models of disordered eating hold negative affect as a central mechanism that precedes binge eating [e.g., 30, 31-33]. There is empirical

support for the role of negative affect in binge eating in clinical populations. Negative affect has been shown to predict the future onset of binge-type eating disorders [34], and ecological studies consistently show that negative affect increases prior to binge eating episodes [for review, see 35]. Additionally, a large body of work has investigated binge eating using an alternate model of impulsivity, the UPPS-P, which includes a subscale that captures the tendency to act rashly in response to extremes of negative affect [negative urgency; 28, 29]. Meta-analyses [36, 37] have consistently shown this construct to be associated with binge eating, further implicating both negative affect and rash behaviour in binge eating [although see 38 for a critique of the UPPS-P model of impulsivity]. Of note, one of the advantages of using an RST framework is the theory offers a strong theoretical explanation for behaviour (i.e., individual differences in the sensitivity of brain systems) which is not offered by the descriptive basis of the UPPS-P model [39].

Integration of evidence implicating negative affect and RST in binge eating may advance the field of binge eating by offering an explanation of why and how some people binge eat whilst others do not. The discussed evidence suggests that those higher on BIS may be more sensitive to the conflict between the rewarding and aversive properties of food, and more likely to experience negative affect due to this conflict. According to Gray and McNaughton [4], such BIS activation and associated affect would motivate towards cautious approach (i.e., initiation of an eating episode, with potential to turn into a binge) in response to the subjective experience of anxiety. Further, informed by the theory that rash impulsive behaviour leads to the further experience of negative affect [27], and the link between rash impulsivity, negative affect and binge eating [8, 25], it may be that those who are highly impulsive are more likely to experience ongoing negative affect as a result of their impulsive action (i.e., binge eating), which could mediate further binge eating though increased concerns over future binge eating, leading to further goal conflict as described previously.

### 1.5 The Current Study

The discussed literature presents evidence that both approach behaviour (rash impulsivity, and less consistently, reward sensitivity), avoidance behaviour (FFFS), goal conflict (BIS) and negative affect are associated with binge eating behaviour. No study has utilised RST as a framework for investigating the role of negative affect in binge eating behaviours. The study used a self-report measure of the revised RST [26], negative affect and binge eating symptoms to test indirect (i.e., mediated), relationships. First, it was hypothesised that binge eating behaviours would be associated with higher scores on FFFS, BIS, rash impulsivity, and negative affect. Second, negative affect was hypothesised to mediate the pathway between BIS and binge eating but was not expected to mediate the pathway between FFFS and binge eating. Third, negative affect was hypothesised to mediate the relationship between rash impulsivity and binge eating. The hypothesised indirect pathways are shown in Figure 1.

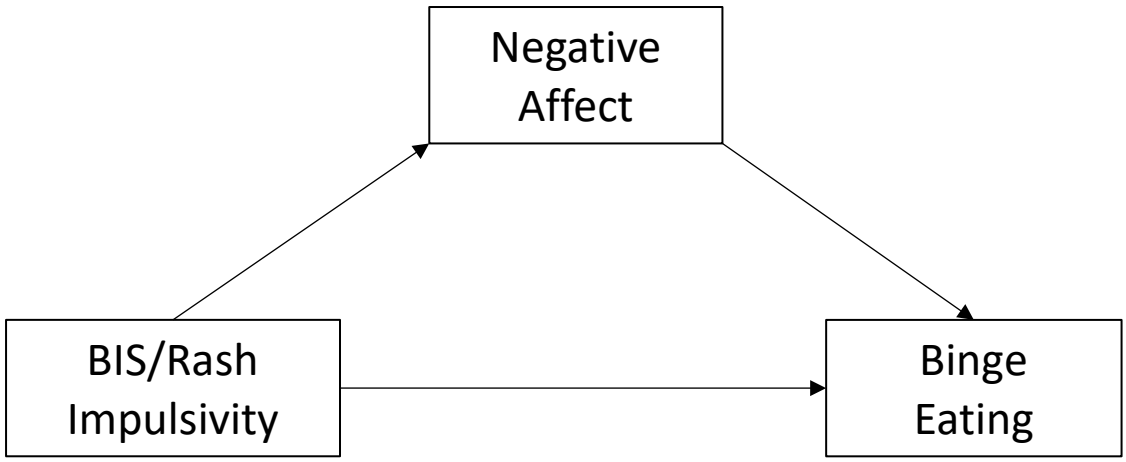


*Figure 1.* Hypothesised mediation relationships.

## 2. Method

### 2.1 Participants and Procedure

The study was approved by the university's Human Research Ethics Committee (reference number: 2018/211). Participants were recruited through the university's first year psychology student pool and participated for course credit and a chance to enter a prize draw for a $50 AUD gift card. Participants completed a battery of self-report questionnaires electronically in their own time. Two hundred and sixty-six participants commenced the questionnaires, with 239 (90%) completing all questionnaires. Inspection of the 10% who did not complete the entire battery revealed attrition at various points throughout the survey (e.g., stopping halfway). Data screening revealed eight participants had completed the questionnaire twice, and the second response surveys were excluded for each. Two participants were identified as outliers (as determined by a studentised deleted residual +/- 3 standard deviations and Cooks distance of greater than 1) and were removed from further analysis, leaving 229 (mean age = 22.67, SD = 8.95, 76% female) for the final sample.

**2.2 Measures**

**2.2.1 Demographic information.** Participants responded to items regarding their age, weight, height and sex.

**2.2.2 Personality.** Revised RST was measured using the Reinforcement Sensitivity Theory Personality Questionnaire [RST-PQ; 26]. The current study used the BIS (23 items), FFFS (10 items), and the four BAS subscales. Of the BAS subscales, rash impulsivity was measured using the Impulsivity subscale (IMP, 8 items). This scale has been utilised in other studies as a measure of rash impulsivity, and correlates with other traits reflective of rash impulsivity [26, 40]. The other BAS subscales were included to control for reward sensitivity: BAS Reward Interest (RI, 7 items) BAS Goal-Drive Persistence (GDP, 7 items); BAS Reward Reactivity (RR, 10 items). The scales are summed from a 1-4 Likert scale, with higher scores reflecting greater sensitivity. Previous studies have reported Cronbach's alphas for the subscales ranging from good to excellent [e.g., 0.76-0.96; 8].

**2.2.3 Binge Eating.** The Bulimia subscale of the Eating Disorders Inventory-3 [EDI-3; 41] was used to measure binge eating behaviours[1]. The Bulimia scale consists of eight items, with greater scores indicating greater binge eating symptoms. The measure has been identified as an adequate measure of binge eating symptoms, displays good psychometric properties, and displays excellent sensitivity and specificity in predicting binge-type ED diagnoses [e.g., Bulimia Nervosa; 42, 43]. Previous studies have reported very good to excellent Cronbach's alphas [e.g., 0.87-0.94; 43, 44].

**2.2.4 Affect.** The Negative Affect Schedule (NAS) of the Positive and Negative Affect Schedule [PANAS; 45] was used to measure negative affect. The NAS is a 10 item self-report inventory tapping the experience of negative affect. Participants respond through 5-point Likert scales, to the instruction '*Indicate to what extent you have felt the listed emotion in the last year',* with respect to prompts such as '*nervous'*, '*afraid'.* Higher scores indicate greater negative affect. Previous studies have reported excellent Cronbach's alphas [e.g., 46].

**2.3 Analysis Plan**

Data was analysed using SPSS version 24. Relationships between the variables were first explored using bivariate Pearson correlations. Mediation models were tested using a bootstrapping approach. RST systems were the predictor variables, negative affect the mediator and binge eating symptoms the outcome variable. For each analysis, age, sex and BMI were included as covariates. Further, Stautz, Dinc [47] have argued that research investigating affect and impulsivity should control for other relevant personality traits. As such, the full range of RST-PQ variables exclusive of the predictor variable were controlled for in each analysis. The 'PROCESS' macro model 4 (Hayes, 2013) using bias-corrected

[1]The Bulimia scale contains 8 items, one of which refers to purging behaviour, as opposed to binge eating. The results were run with and without this item included in the scale with no difference to the interpretation of results.

95% confidence intervals was used to test the significance of the indirect (i.e., mediated) effects. Significant effects were indicated by the absence of zero within the confidence intervals.

## 3. Results

### 3.1 Descriptive Statistics and Correlations

Descriptive statistics are shown in Table 1 and bivariate correlations in Table 2. Mean scores for variables were similar to those reported in previous literature [8, 26]. Of the sample, 46% scored above the recommended cut-off score of 9 [43]for identifying Bulimia Nervosa. As expected, FFFS, BIS, rash impulsivity and the NAS were positively correlated with the EDI-Bulimia subscale. The NAS was positively correlated with FFFS, BIS and rash impulsivity.

*Table 1.* Means, ranges and standard deviations for RST-PQ, NAS and EDI-Bulimia measures.

| Measure | Range (minimum-maximum possible) | Mean | Standard Deviation |
|---|---|---|---|
| Age | 17-56 | 22.67 | 8.95 |
| BMI | 15.57-62.11 | 23.86 | 5.70 |
| Reward Interest | 7-28 (7-28) | 17.66 | 4.32 |
| Goal Drive Persistence | 8-28 (7-28) | 20.80 | 4.21 |
| Reward Reactivity | 14-38 (10-40) | 27.01 | 5.01 |
| Rash Impulsivity | 8-30 (8-32) | 19.28 | 4.59 |
| Fight Flight Freeze System | 10-37 (10-42) | 23.52 | 6.02 |
| Behavioural Inhibition System | 27-90 (23-92) | 62.99 | 14.15 |
| Negative Affect Schedule | 12-45 (10-50) | 27.28 | 7.59 |
| EDI-Bulimia | 0-32 (0-32) | 8.59 | 7.59 |

*Table 2.* Bivariate correlations for RST-PQ, NAS and EDI-Bulimia measures.

| Measure | Cronbach's Alpha | Age | Sex | BMI | RI | GDP | RR | IMP | FFFS | BIS | NAS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sex | | .02 | | | | | | | | | |
| BMI | | .33** | .09 | | | | | | | | |
| RI | .81 | .06 | -.16* | -.01 | | | | | | | |
| GDP | .88 | .23** | -.02 | .00 | .53** | | | | | | |
| RR | .80 | -.05 | -.04 | .02 | .56** | .38* | | | | | |
| IMP | .75 | -.19** | .02 | -.08 | .33** | .04 | .45** | | | | |
| FFFS | .78 | -.09 | .33** | .08 | -.12 | .00 | .18** | .23** | | | |
| BIS | .94 | -.23** | .17* | .02 | -.12 | -.10 | .09 | .33** | .44** | | |
| NAS | .88 | -.17* | .11 | .06 | -.05 | -.15* | .04 | .35** | .30** | .69** | |
| EDI-Bulimia | .87 | -.13* | .19** | .23** | -.09 | -.15* | .07 | .22** | .26** | .43** | .41** |

*Note: BMI* = Body Mass Index; RI = Reward Interest; GPD = Goal Drive Persistence; RR = Reward Reactivity; IMP = Rash Impulsivity; BIS = Behavioural Inhibition System; FFFS = Fight, Flight, Freeze System; NAS = Negative Affective Schedule; EDI-Bulimia = Eating Disorders Inventory 3 – Bulimia subscale. Sex coded male = 0, female = 1.
** $p < .05$, ** $p < .01$*

**3.2 Tests of Indirect Effects on EDI-Bulimia subscale scores**

Three mediation models were tested with RST subscales as predictor variables as shown in Figure 2. Shared variance in RST subscales was controlled by including all other RST variables as covariates in each analysis, as well as age, sex and BMI. Figure 2 shows the effects when using EDI-Bulimia scale scores. Negative affect was found to mediate the relationship between BIS and EDI-Bulimia scale (indirect effect = 0.05, SE 0.03, 95CI: 0.01; 0.11). The total model accounted for 29% of the variance in EDI-Bulimia scale scores. Negative affect was also found to significantly mediate the relationship between impulsivity and EDI-Bulimia scale, with the total model accounting for 29% of the variance in EDI-Bulimia scale scores (indirect effect = 0.05, SE 0.03, 95CI: 0.01, 0.12). Negative affect did not mediate the relationship between FFFS and EDI-Bulimia scale scores (indirect effect = 0.00, SE 0.01, 95CI: -0.02, 0.03).

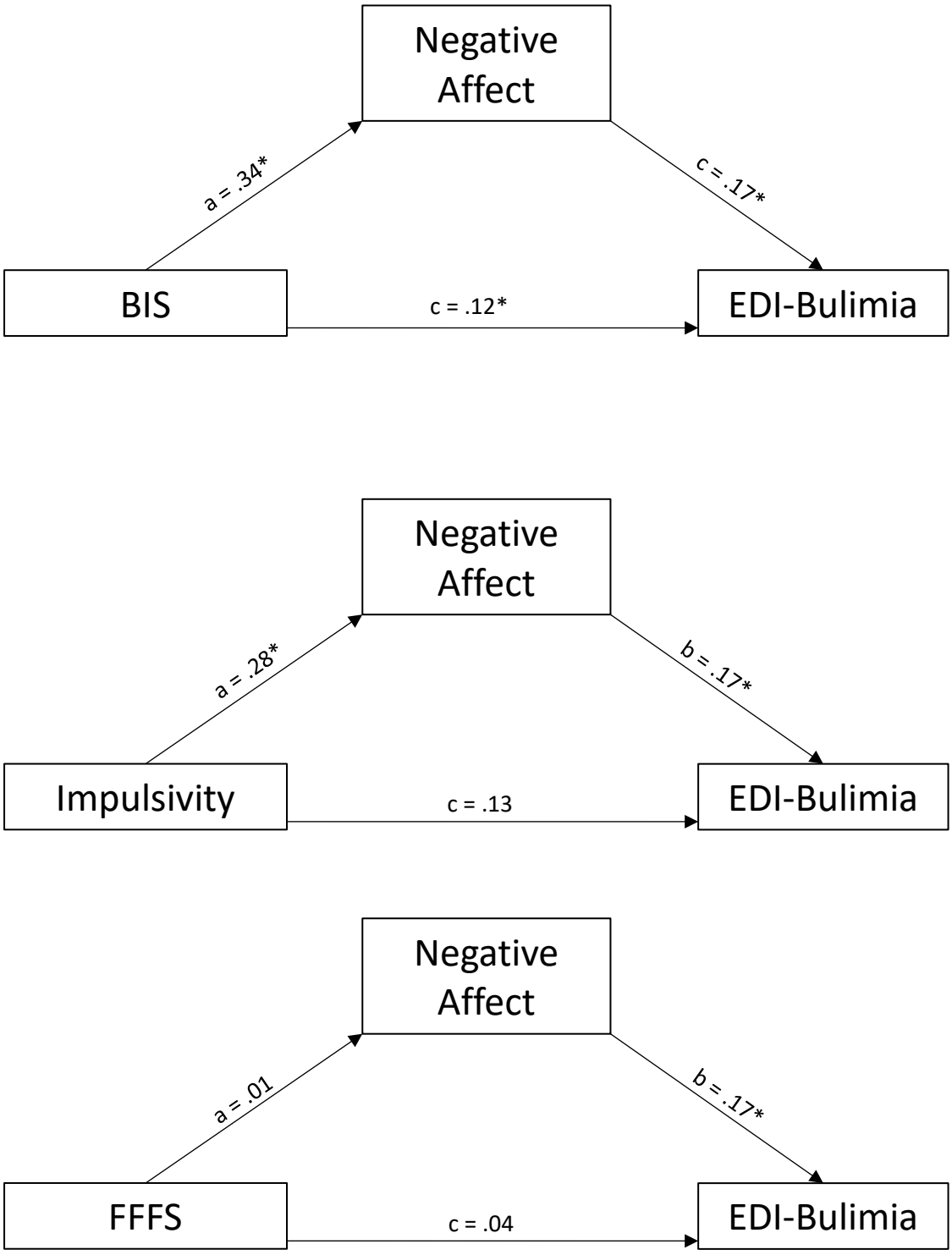


*Figure 2.* Unstandardized effects of RST subscales on EDI-Bulimia scale scores via negative affect. *Note*. Unstandardized effects reported. Each 'a' path is the effect of the RST variable on the mediating variable. The 'b' paths represent the associations between Negative Affect Schedule and EDI-Bulimia scores. * = effect is significantly different from zero

## 4. Discussion

The current study is the first to investigate the role of the revised RST and affective states in binge eating behaviours in a non-clinical population. Consistent with a previous study in an eating disordered population [8], we found that elevated BIS, FFFS and rash impulsivity were associated with binge eating, proposing similar biological sensitivities may be at play in non-clinical compared to clinical populations. These results using the RST-PQ highlight the utility of measures consistent with the revised theory to further understand disordered eating behaviour.

With respect to affect, BIS, FFFS and rash impulsivity was associated with a greater likelihood to experience negative affect, in line with the results from Stoeber and Corr [25]. Consistent with theoretical underpinning of RST, these results are suggestive that those with higher FFFS and BIS, are more likely to detect threatening or conflicting stimuli, and react more strongly to such stimuli with negative emotion. In terms of impulsivity, it may be that the rash maladaptive behaviours associated with impulsive action may lead to the experience of negative affect, although the construct of negative urgency would also fit with these results (i.e., negative affect predicts rash impulsive action).

The mediation analysis demonstrated that negative affect mediated the pathway between both BIS and rash impulsivity, and binge eating behaviours. The role of BIS and negative affect is suggestive that goal conflict may be central to binge eating behaviours. When considering goal conflict, food is inherently rewarding, and in particular, the types of food that are typically binge eaten are hyperpalatable, energy dense, foods [48] that may be even more rewarding than traditional non-processed foods [49]. In contrast to the rewarding aspects, there is also the threat associated with food intake (e.g., weight and shape concern, distress and fear of loss of control), which is supported by evidence showing that those with binge eating may simultaneously hold negative and positive appraisals of food [23]. This conflict sensitivity is highlighted by previous findings that those with increased BIS are both

more likely to rate eating as pleasurable and rewarding, and more likely to be concerned about their body shape and dietary intake [20, 21]. The theory behind RST would dictate that in such situations, BIS would activate the subjective experience of negative affect (i.e., anxiety), to motivate cautious approach behaviour towards threat (i.e., eating) in an attempt to resolve to this goal conflict. In terms of rash impulsivity, this system may lead to a range of rash, maladaptive behaviours, including loss of control leading to a binge as a result of BIS-driven eating. Such behaviours could lead to ongoing negative affect, as well as concern over future binge eating and loss of control, leading to further goal conflict as described above.

In contrast, as expected, whilst FFFS was correlated with both binge eating and negative affect, there was no support for negative affect as an indirect pathway from FFFS to binge eating. This is consistent with the motivational output of FFFS (i.e., avoid as opposed to approach), and suggested that unlike BIS, the association between FFFS and binge eating is not mediated through negative affect. This is consistent with the model of emotional eating proposed by Macht [50], which suggests that intense emotion (i.e., fear) results in suppressed appetite, whereas emotions of moderate intensity (i.e., anxiety) are more likely to result in increased food intake.

Taken in context, the current findings show further support for the role of FFFS, BIS and rash impulsivity in binge eating. Further, these results extend previous findings by highlighting the role of negative affect as a pathway between BIS and rash impulsivity and binge eating. From a treatment perspective, these results provide possible mechanisms through which evidence-based treatments for binge eating that focus on the constructs in this study (i.e., anxiety, impulsivity, negative affect) may achieve their effects [e.g., Dialectical Behaviour Therapy for Binge Eating Disorder; 51]. The evidence in support of such therapies and the current results suggest that for those presenting for treatment for binge eating,

targeting rash impulsivity, anxiety and negative affect in addition to core eating pathology (i.e., dietary restriction) may be warranted.

### 4.1 Limitations

The current study is limited by the use of cross-sectional self-report data, which means the study may include common method variance, and prevents the ability to draw conclusions about casual effects between variables. In particular, any differences in short and long-term changes in negative affective in relation to binge eating are not detectable with the current methodology. Significantly, the current study used theory consistent with RST and Dawe and Loxton's two facet model of impulsivity to derive hypotheses and interpret results. However, the current results would also be explained by alternate models of impulsivity, in particular the UPPS-P and construct of negative urgency. Again, due to the cross-sectional nature of the study, the results cannot delineate whether impulsivity leads to negative affect (as hypothesised), as opposed to negative affect leading to rash behaviour, as assumed by negative urgency. Indeed, an integration of these theories may be the best explanation for the role of impulsivity and negative affect in binge eating. For example, compared to those low in negative urgency, women high on negative urgency show elevated chronic negative affect (supportive of the role of impulsivity leading to higher longer term negative affect), and binge eat in response to smaller changes in negative affect [supportive of the role of impulsivity leading to higher long-term negative affect; 46]. Last, as the sample consisted entirely of undergraduate students, the sample population may be of limited diversity (ethnic information was not collected) and results may not be generalisable.

### 4.2 Conclusion

The current study supports recent evidence suggesting personality variables are associated with binge eating and highlights the utility of using revised RST to investigate disordered eating. Specifically, it provides further support that BIS, FFFS and rash

impulsivity are associated with binge eating. Further, it extends previous RST research by identifying negative affect as a mediator from BIS and rash impulsivity to binge eating. Understanding such pathways to maladaptive behaviour is important for refining treatment strategies and informing selective prevention.

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