Alexithymia and binge eating: Maladaptive emotion regulation strategy or deficient interoception?

Lyvers, Michael; Kelahroodi, Mazaheri; Udodzik, Emily; Stapleton, Peta; Thorberg, Fred Arne

Published in:
Appetite

DOI:
10.1016/j.appet.2022.106073

Alexithymia and Binge Eating: Maladaptive Emotion Regulation Strategy or Deficient Interoception?

Michael Lyvers, Ph.D.

Orcid ID 0000-0002-8355-3182

Mazaheri Kelahroodi, Graduate Diploma of Psychological Science

Emily Udodzik, Graduate Diploma of Psychological Science

Peta Stapleton, Ph.D.

Bond University, Gold Coast, Qld Australia 4229

Fred Arne Thorberg, Ph.D.

University of Queensland, Brisbane, Qld Australia 4072

Orcid ID 0000-0002-8835-7631

Declarations

Corresponding author: Michael Lyvers. Email: mlyvers@bond.edu.au

This research was funded by Bond University Research Grant BD39.

The research involved human participants and was approved by the Bond University Human Research Ethics committee (approval JT00322) prior to data collection. The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all individuals included in this study.

Michael Lyvers designed the study, conducted the analyses, and wrote the first draft. Mazaheri Kelahroodi and Emily Udodzik collected the data. All authors commented on previous versions of the manuscript, and read and approved the final manuscript.

The authors have no competing interests.

The data for this study are available from the corresponding author on request.

Abstract

Alexithymia has been linked to various excessive behaviors as a likely risk factor, including binge eating. Such relationships are often attributed to deficient emotional self-regulation in alexithymia, ostensibly leading to the use of maladaptive, externalized behaviors as strategies for coping with distress. An alternative view is that alexithymia reflects a fundamental deficit of interoceptive awareness that, in the case of binge eating, would suggest that internal satiety cues are poorly recognized, promoting overconsumption. The present study assessed the relationship between alexithymia and binge eating in the context of these competing hypotheses. A large online sample of young adults (n = 532) completed validated measures of alexithymia, emotion regulation, interoception, binge eating, emotional eating motivation, and sensitivity to reward and punishment. Correlations were as expected except for interoception, which showed minimal association with alexithymia or binge eating. In a hierarchical regression controlling for age, gender, education level and student status as covariates, binge eating was predicted by emotional eating motivation, emotion regulation (a negative predictor), alexithymia, and reward sensitivity, with the final model explaining 53% of variance in binge eating. Bootstrapped path analyses controlling for all other variables indicated that the relationship between alexithymia and binge eating was mediated by deficient emotion regulation but not deficient interoception, and that the relationships of both alexithymia and emotion regulation with binge eating were mediated by emotional eating motivation. Results are consistent with the notion that the association of alexithymia with binge eating reflects deficient emotion regulation in alexithymia, which can lead to adoption of maladaptive, externalized behaviors such as binge eating for coping with distress.

Keywords: alexithymia; emotion regulation; interoception; emotional eating; binge eating

Alexithymia is a subclinical trait dimension defined by difficulties identifying and describing feelings and an externally oriented thinking style (Bagby et al., 2020). High levels of this trait have been linked to a variety of excessive behaviors including risky or problematic use of alcohol (Cruise & Becerra, 2018; Lyvers et al., 2014a; Thorberg et al., 2009) or cannabis (Lyvers et al., 2013), pathological gambling (Marchetti et al., 2019; Toneatto et al., 2009), compulsive buying (Rose & Segrist, 2012), internet addiction (Kandri et al., 2014; Lyvers et al., 2016; Mahapatra & Sharma, 2018), exercise addiction (Lyvers et al., 2021; Van Landeghem et al., 2019) and eating disorders (Marsero et al., 2011; Westwood et al., 2017; Wheeler et al., 2005). Among eating disorders, alexithymia is most strongly associated with the most common eating disorder, binge eating disorder (BED; Aloi et al., 2017; Wheeler et al., 2005). BED is characterized by frequent overconsumption of food, often when not hungry, accompanied by a sense of loss of control but without the purging or other compensatory behaviors associated with bulimia nervosa (American Psychiatric Association [APA], 2013). BED is by far the most common eating disorder in Australia, comprising nearly half of all eating disorder diagnoses and reportedly affecting about 6% of the population (National Eating Disorders Collaboration [NEDC], 2017). Unlike other eating disorders, which are considerably more prevalent in females, BED rates are similar between genderss (Hay et al., 2015), with young adults showing the highest prevalence (McCuen-Wurst et al., 2018; Ward et al., 2019). Recent evidence suggests that the prevalence of eating disorders, including BED, has been increasing worldwide (Galmiche et al., 2019). Subclinical binge eating, which may in some cases progress to BED, has been reported to be even more common in young adults, with rates as high as 30-40% in a U.S. university student sample (Saules et al., 2009).

The association of alexithymia with excessive behaviors has often been attributed to deficient emotional self-regulation in alexithymia and the corresponding use of maladaptive,

externalized coping behaviors to regulate negative mood (Ghalehban & Besharat, 2011; Lyvers et al., 2014b, 2018, 2020; Thorberg et al., 2009, 2011b, 2017). A large-scale twin study (Jorgensen et al., 2007) indicated moderate heritability of alexithymia, which implicates developmental factors in its etiology. Alexithymia is reportedly associated with insecure adult attachment styles (Besharat et al., 2014; Lyvers et al., 2017; Thorberg et al., 2011a), suggesting that inadequate early bonding with the primary caregiver may lead to insecure relationships with peers and thus reduced opportunities for learning about emotions and appropriate self-regulation strategies during childhood development (Lyvers et al., 2019). An alternative hypothesis was offered by Brewer et al. (2016) who suggested that alexithymia reflects a fundamental deficit of interoceptive awareness of internal bodily processes, including those associated with emotional feeling states. Such a deficit would extend to deficient awareness of internal cues of overconsumption in excessive drinking or binge eating, and might account for such behaviors in those with high levels of alexithymia.

There is evidence consistent with both hypotheses. Alexithymia has been consistently linked to deficits of emotional self-regulation (Lyvers et al., 2014b; Thorberg et al., 2009), and such deficits have been linked to eating disorders (Harrison et al., 2010; Tonelli & de Siqueira Rotenberg, 2021). Alexithymia has been reported to be associated with emotional eating, or eating to alleviate distress (Larsen et al., 2006), consistent with the purported role of deficient emotion regulation in the relationship between alexithymia and excessive behaviors such as binge eating. Alexithymia was also reported to be associated with poorer interoceptive perception of heart rate (Herbert et al., 2011; Murphy et al., 2018), although recent evidence suggests that this measure may be too confounded to represent a valid and reliable index of interoception (Zamariola et al., 2018). On the other hand, brain areas that reportedly showed abnormalities in alexithymia overlap with those involved in both interoceptive awareness and emotions (Gu et al., 2013; Stevens et al., 2011). Despite the

evidence cited in their support, interpretations of the association between alexithymia and binge eating as reflecting either maladaptive efforts at emotion regulation, or deficient interoceptive awareness, have not previously been tested against each other in terms of their predicted relationships among measures of the relevant constructs, which the present study sought to do. The present study also assessed reward sensitivity, a trait that has been linked to excessive behaviors including binge eating (Dawe & Loxton, 2004) and reported to show a positive association with alexithymia (Lyvers et al., 2021) - hence the rationale for including a measure of this trait variable to assess and control for its potential influence in the present context.

The present study recruited a large online sample of young Australian adults – the age group with the highest prevalence of BED (McCuen-Wurst et al., 2018; Ward et al., 2019) - who completed validated measures of alexithymia, binge eating, emotional eating motivation, emotion regulation, interoceptive awareness, and reward sensitivity. Excessive behaviors are thought to be distributed along continua in the population, such that diagnosed disorders represent the extreme ends of these distributions (APA, 2013; SAMHSA, 2016); relationships of the traits of interest with binge eating were thus anticipated in the present nonclinical sample. Based on previous evidence and theory cited earlier, alexithymia and reward sensitivity were predicted to show positive associations with binge eating, whereas alexithymia was expected to be negatively associated with emotion regulation and/or interoceptive awareness. The latter two variables were assessed for their ability to mediate the association of alexithymia with binge eating, effectively pitting the two interpretations of the alexithymia-binge relationship against each other. Further, both alexithymia and emotion regulation were predicted to be linked to binge eating through emotional eating motivation based on the notion that binge eating reflects a maladaptive mood regulation strategy (Larsen

et al., 2006; McAtamney et al., 2021). These hypotheses were evaluated via hierarchical regression and mediation tests.

Method

Participants

Approval for the project was granted by the university ethics committee prior to participant recruitment. Participants were recruited through an online survey hosting tool, Qualtrics Panels, and were incentivised for their time by the survey company via allocation of redeemable points. Quotas were requested for gender (1:1 male:female) and Australian state of residence proportionate to the population contribution of each state. Inclusion criteria required that participants be aged between 18 and 30 years. Participants were excluded if they were currently taking medication for a neurological or psychological disorder, or had suffered a traumatic brain injury; this was to minimize extraneous sources of variability in responses. Data were collected from 572 initial participants; after the survey hosting company removed cases with perseverative responses, missing data, or that did not meet criteria for inclusion, the sample consisted of 541 participants with complete data.

Materials

The following questionnaires were completed by all participants in the final sample.

Demographics questionnaire. This consisted of a series of questions requesting information on age, gender, student status, highest education level completed, and (for screening purposes) current use of medication for a psychological or neurological disorder and history of traumatic brain injury.

Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994ab). The TAS-20 consists of 20 items measuring alexithymia and encompasses three subscales: difficulty identifying feelings (DIF; e.g., “I am often confused about what emotion I am feeling”), difficulty

describing feelings (DDF; e.g., “It is difficult for me to find the right words for my feelings”), and externally oriented thinking (EOT; e.g., “I prefer to just let things happen rather than to understand why they turned out that way”). Respondents indicate the extent to which they agree or disagree with each statement on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Five items are reverse scored before summing to yield subscale or total scale scores. Total scores can range from 20 to 100, with higher scores indicating higher levels of alexithymia. Total scores were used in the present study as recommended by the authors of the TAS-20 (see Sekely et al., 2018). The total TAS-20 displayed good internal consistency in the present sample, $\alpha = .81$.

Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia et al., 2001). The SPSRQ is a 48-item measure comprised of two scales: sensitivity to reward (SR) and sensitivity to punishment (SP). These two scales assess the influences of the behavioural approach system (BAS; appetitive motivation) and the behavioural inhibition system (BIS; avoidance motivation) respectively, based on Gray’s (1987) influential theory of fundamental brain motivational systems. There are 24 items on the SR scale (even numbered items; e.g., “Do you often do things to be praised?”) and on the SP scale (odd numbered items; e.g., “Are you often afraid of new or unexpected situations?”). Participants provide a dichotomous response of either Yes (1) or No (0). Affirmative responses are summed to obtain total scores on SR and SP. Higher scores reflect stronger influences of the corresponding brain motivational systems. In the present sample, SR and SP showed good internal consistency, with $\alpha = .86$ for SP and $\alpha = .82$ for SR.

Negative Mood Regulation Scale (NMRS; Catanzaro & Mearns, 1990). The NMRS is a 30-item self-report questionnaire designed to measure generalized expectancies to reduce emotional distress by one’s own efforts (e.g., “I'll feel okay if I think about more pleasant times”). Each item response is anchored on a five-point Likert scale ranging from 1

(strongly disagree) to 5 (strongly agree). Once the 13 negatively worded questions are reversed, total scores are calculated by summation. Higher scores indicate greater ability to self-regulate to reduce negative moods. According to the authors the NMRS showed discriminant validity from social desirability, impulsivity, and depression. The NMRS had high internal consistency in the present sample, $\alpha = .92$.

Multidimensional Assessment of Interoceptive Awareness Revised (MAIA-2; Mehling et al., 2018). The MAIA-2 is a 37-item questionnaire assessing multiple dimensions of interoception. There are eight subscales corresponding to an eight-factor structure. The Noticing subscale assesses awareness of bodily sensations whether uncomfortable, neutral, or comfortable (e.g., "I notice when I am uncomfortable in my body"). Not-Distracting assesses the extent to which an individual cannot ignore sensations of discomfort or pain (e.g., "I distract myself from sensations of discomfort," reverse scored). Not-Worrying assesses the tendency to not worry about pain or discomfort (e.g., "I can stay calm and not worry when I have feelings of discomfort or pain"). Attention Regulation assesses the ability to maintain and control attention towards bodily sensations (e.g., "I can return awareness to my body if I am distracted"). Emotional Awareness assesses the emotion-body connection (e.g., "I notice how my body changes when I'm angry"). Self-Regulation assesses the ability to pay attention to body sensations to regulate distress (e.g., "I can use my breath to reduce tension"). Body Listening assesses gaining insight from the body by actively listening to the body (e.g., "Listen to my body to inform me about what to do"). Trusting the Body assesses the body's signals as reliable (e.g., "I trust my body sensations"). Respondents indicate how often the statements apply to them in daily life, using a Likert scale anchored at the extremes with 0 (Never) and 5 (Always). Nine items are reverse scored. Subscale scores are calculated by summing responses and dividing by the number of items in each subscale. An overall score can be calculated by summing and averaging all items. Higher scores indicate higher levels of

interoceptive awareness. In the present sample, the total MAIA-2 displayed good internal consistency, α = .85.

Dutch Eating Behaviour Questionnaire – Emotional Eating scale (DEBQ-EE; Van Strien et al., 1986). The DEBQ-EE consists of 13 items assessing motivation to eat in response to negative emotional states (e.g., "Do you have a desire to eat when you are feeling lonely?" and "Do you have a desire to eat when you are disappointed?"). Items are rated on a five-point Likert scale ranging from 1 (never) to 5 (very often). Responses are summed and then averaged for a total score, with higher mean scores indicating higher levels of emotional eating motivation. The DEBQ-EE was designed as a measure of eating motivation, which was a focus of the present study; however it does not assess actual eating behaviors in response to negative emotional states. Reliability in the current sample was very high, α = .95.

Binge-Eating Scale (BES; Gormally et al., 1982). The widely used BES is an index of binge eating severity via 16 items assessing binge eating behaviors and associated cognitions. Items referring to binge eating behaviors have four response options describing non-binge eating (e.g., "I don't have any difficulty eating slowly in the proper manner"), mild bingeing (e.g., "Although I seem to 'gobble down' foods, I don't end up feeling stuffed because of eating too much"), moderate bingeing (e.g., "At times, I tend to eat quickly and then, I feel uncomfortably full afterwards"), and severe bingeing (e.g., "I have the habit of bolting down my food, without really chewing it"). Other items refer to cognitions and concerns regarding binge eating, with four response options for all but two items, which have three; response options describe lack of concern about eating (e.g., "I don't think much about trying to control unwanted eating urges"), mild concern (e.g., " At least some of the time, I feel my thoughts are pre-occupied with trying to control my eating urges"), moderate concern (e.g., "I feel that frequently I spend much time thinking about how much I ate or about trying

not to eat anymore"), and severe concern (e.g., "It seems to me that most of my waking hours are preoccupied by thoughts about eating or not eating. I feel like I'm constantly struggling not to eat"). Responses are scored from 0 to 3 (or 0 to 2 for the two items with three response options) and are summed to yield a total score, where higher scores indicate greater severity of binge eating. Total scores can range from 0 to 46, with scores less than 17 indicating little or no binge eating or eating-related concerns, and scores above 27 indicating severe or problematic binge eating, although the BES is a screening tool only and not diagnostic of BED. In the present sample, the BES displayed high internal consistency, $\alpha = .93$.

Procedure

Data were collected over three weeks from 3 September to 24 September 2021. Interested participants received an online link to the questionnaire battery. Upon accessing the link, participants were presented with an explanatory statement which outlined the purpose of the study as an investigation of personality, body awareness, and health habits such as eating and exercise; their assured anonymity and right to withdraw their participation at any time without penalty; data storage procedures; the contact details of the researchers; and a distress hotline (Lifeline) was provided should they experience distress as a result of their participation. There was a brief disclaimer stating that some of the questions were of a sensitive nature, followed by a question asking if the participant agreed to participate in the study. Those who did not click Yes were immediately released from participation. Those who agreed to participate were presented with the demographic questionnaire first, which included questions assessing whether the participant met inclusion criteria; if their responses indicated they did not, they were automatically exited from the survey and thanked for their time. For those who met inclusion criteria, the demographics questionnaire was followed by the other measures in uniquely randomized orders per participant. Participants had to answer each item

per page before they could proceed to the next page. Estimated completion time was 20 to 30 minutes, after which participants were thanked for their time.

Analytic Plan

The hypotheses were tested by hierarchical regression followed by bootstrapped mediation modelling, controlling for demographic variables (age, gender, education level, student status). Demographic factors were controlled given that alexithymia has been reported to vary by age (Mattila et al., 2006), gender (Levant et al., 2009), and education (Lennartsson et al., 2017). Reward sensitivity was also assessed (via SPSRQ) to be included in the regression model as this trait has been reported to show positive associations with both alexithymia (Lyvers et al., 2021) and binge eating (Dawe & Loxton, 2004) in previous work; in the present sample both SR and SP scales from the SPSRQ showed positive correlations with alexithymia and binge eating, thus both were entered prior to alexithymia in the regression model and controlled along with the demographic variables in the mediation tests. The strength of correlations was interpreted based on Cohen's (1988) conventions, i.e., $r = .10$ is weak, $r = .30$ is moderate, $r = .50$ is strong.

Results

Removal of 9 multivariate outliers identified by Mahalanobis distance ($p < .001$) yielded a final sample of 532 participants aged 18 to 30 years ($M = 24.77$, $SD = 3.57$), of whom 379 (71%) identified as female and 153 (29%) identified as male. There were 353 (66%) non-students and 179 (34%) students in the sample. Highest education level achieved was less than high school for 27 (5%) participants, high school for 189 (36%) participants, undergraduate or trade school degree for 246 (46%) participants, and postgraduate degree for 70 (13%) participants.

IBM's Statistical Package for Social Sciences (SPSS) version 28 was used for all analyses except the mediation tests. Skewness and kurtosis were well within +/- 1 for all

continuous variables, indicating normal or near normal distributions. Given the sample size (n = 532), a conservative alpha level of .01 was chosen to denote statistical significance. To assess for gender differences in the sample, male and female participants were compared on the variables of interest via multivariate analysis of variance (MANOVA). The omnibus F test was significant according to Pillai's Trace, $F(7, 524) = 7.77$, $p < .001$, partial eta squared = .09, observed power = 1. Between-subjects effects were significant only for the two SPSRQ scales SP and SR. Females (M = 15.80, SD = 5.31) scored significantly higher than males (M = 13.36, SD = 6.00) on the index of punishment sensitivity SP, $F(1, 530) = 21.39$, $p < .001$, partial eta squared = .04, power = 1. Males (M = 11.69, SD = 4.87) scored higher than females (M = 10.09, SD = 5.06) on the index of reward sensitivity SR, $F(1, 530) = 11.07$, $p < .001$, partial eta squared = .02, observed power = .90. Based on the suggested BES binge eating cutoff scores (Gormally et al., 1982), 59 males and 169 females were classed as non-binge eaters, 63 males and 115 females as mild to moderate binge eaters, and 31 males and 95 females were classed as severe binge eaters; the proportion of females in the latter group (75%) was nonsignificantly higher than in the non-binge (74%) or mild-moderate binge (65%) groups, $\chi^2(2) = 5.81$, $p = .06$.

Means, standard deviations and Pearson correlations among continuous variables are shown in Table 1. Significant correlations were generally in expected directions, with the BES measure of binge eating showing significant moderate positive correlations with the DEBQ-EE index of emotional eating motivation, the TAS-20 index of alexithymia, and the SR and SP indices of reward and punishment sensitivity respectively; BES showed a significant moderate negative correlation with the NMRS measure of emotional self-regulation. Contrary to prediction based on the hypothesized role of deficient interoception in alexithymia and binge eating, the total MAIA-2 index of interoceptive awareness was uncorrelated with the other variables except for a small, unexpected positive correlation with

NMRS and an unexpected moderate positive correlation with SR. Alexithymia was moderately positively correlated with BES, DEBQ-EE, SP and SR, and strongly negatively correlated with NMRS, as per expectations (see Table 1).

Given the unexpected absence of correlation between total MAIA-2 scores and TAS-20 alexithymia or the BES and DEBQ-EE measures of disordered eating, correlations of the eight MAIA-2 subscales with alexithymia and binge or emotional eating were subsequently assessed, with only a few significant correlations found. TAS-20 alexithymia showed a small positive correlation with the Not Distracting subscale ($r = .15$, $p < .001$), small negative correlations with Attention Regulation, Self Regulation and Body Listening ($r = -.14$, $p = .001$; $r = -.12$, $p = .005$; $r = -.13$, $p = .003$, respectively), and a moderate negative correlation with Trusting the Body ($r = -.25$, $p < .001$). The BES index of binge eating showed only a small negative correlation with Trusting the Body ($r = -.17$, $p < .001$), whereas the DEBQ-EE index of emotional eating motivation was not correlated with any MAIA-2 subscale. Overall the correlation results did not indicate substantial relationships of alexithymia or disordered eating with deficits of interoceptive awareness as measured by MAIA-2. Nevertheless, total MAIA-2 scores were included in the planned regression and mediation analyses due to the possibility of suppressor variable effects (e.g., see Watson et al., 2013, on how planned regression analyses can still be justified even when a relevant correlation is not significant, given the possibility of suppressor variables in the model).

Regression on Binge Eating

Hierarchical regression was conducted on the BES index of binge eating, with demographic variables of gender, age, education level and student status as covariates at step 1, the SR and SP indices of the fundamental BAS and BIS brain motivational systems at step 2, the TAS-20 index of alexithymia at step 3, the NMRS index of emotion regulation and the total MAIA-2 index of interoception at step 4, and the DEBQ-EE index of emotional eating

motivation at step 5 as a hypothesized proximate driver of binge eating in the context of alexithymia and deficient emotion regulation. Step 1 explained less than 1% of variance and was not significant, $F = 1$. Step 2 accounted for a significant 10% of additional variance, $R^2 = .11$, $Fchange(2, 522) = 29.27$, $p < .001$; both SR and SP were significant positive predictors (see Table 2). TAS-20 alexithymia was entered at step 3 and explained a significant 11% of additional variance as a positive predictor, $R^2 = .22$, $Fchange(1, 521) = 71.61$, $p < .001$; SR remained significant but SP did not. Emotion regulation (NMRS) and interoception (total MAIA-2) were entered at step 4, explaining a significant 5% of additional variance, $R^2 = .27$, $Fchange(2, 519) = 17.75$, $p < .001$; as expected, emotion regulation was a significant negative predictor, and alexithymia and SR remained significant positive predictors, however interoception did not approach significance. Finally at step 5 the DEBQ-EE index of emotional eating motivation accounted for a significant 26% of additional variance as a positive predictor, $R^2 = .53$, $Fchange(1, 518) = 286.78$, $p < .001$. The final model was significant, $F(10, 518) = 57.79$, $p < .001$, and accounted for 53% of the variance in binge eating. As can be seen in Table 2, which displays the regression coefficients at each step, in the final model emotional eating motivation was the strongest (and positive) predictor, followed by emotion regulation as a negative predictor, and alexithymia and reward sensitivity as positive predictors, in descending order.

When the regression was repeated with the eight MAIA-2 subscale scores in place of the total score, none of the subscales were significant predictors of binge eating in the model. The regression results thus did not support a role of deficient interoception in binge eating.

Mediation of Alexithymia to Binge Eating by Emotion Regulation vs. Interoception

The planned mediation test pitting deficient emotion regulation against deficient interoception as hypothesized mediators of the relationship between alexithymia and binge eating was conducted using JASP 0.14.1 with 1000 bias-corrected replications, controlling

for age, gender, education level, student status, SR and SP as covariates. Interoception was not a significant mediator as the confidence interval for the indirect effect included zero; however, emotion regulation was a significant mediator, as the confidence interval for the indirect effect did not include zero (see Table 3). The direct effect was also significant however, indicating partial mediation. Figure 1 depicts the direct and indirect paths.

Mediation of Alexithymia and Emotion Regulation to Binge Eating by Emotional Eating

The planned mediation test for emotional eating motivation as mediator of the relationships of both alexithymia and emotion regulation with binge eating was conducted using JASP 0.14.1 with 1000 bias-corrected replications, controlling for age, gender, education level, student status, MAIA-2 interoception, SR and SP as covariates. The indirect effects of both alexithymia and emotion regulation through emotional eating motivation were significant, as the confidence intervals did not include zero (see Table 4). The direct effects remained significant however, indicating partial mediation. Figure 2 shows the direct and indirect paths.

Discussion

The results of the present study clearly favored the emotion regulation deficit interpretation of the relationship between alexithymia and binge eating, with no support for an alternative interpretation based on deficient interoceptive awareness. Alexithymia (as measured by TAS-20) was negatively correlated with emotion regulation (as measured by NMRS) and positively correlated with binge eating (as measured by BES), which in turn showed a negative correlation with emotion regulation. By contrast neither alexithymia nor binge eating were correlated with the overall index of interoceptive awareness (total MAIA-2). Examination of MAIA-2 subscales showed that four of the eight subscales were significantly negatively correlated with alexithymia, consistent with deficits in some aspects of interoception, but all but one of those relationships were weak. Further, only the Trusting

the Body subscale showed a significant negative correlation with binge eating, and the correlation was also weak. The SR index of BAS or reward sensitivity showed positive correlations with binge eating and emotional eating motivation (the latter measured by DEBQ-EE) as well as alexithymia and interoception, whereas the SP index of BIS or punishment sensitivity showed positive correlations with binge eating, emotional eating motivation and alexithymia but a negative correlation with emotion regulation. The positive correlations of SR and SP with both disordered eating measures in the present study parallel previous findings of associations of both high impulsivity (SR) and high neuroticism (SP) with binge eating (Lee-Winn et al., 2016). The role of reward sensitivity as a form of impulsivity associated with binge eating has long been recognized (Dawe & Loxton, 2004) and would seem obvious given that food is a primary reward. The positive correlation of SP with alexithymia has also been reported in previous research (Lyvers et al., 2012) and presumably reflects high neuroticism associated with alexithymia as measured by TAS-20 (Zimmerman et al., 2005).

The final hierarchical regression model indicated that emotional eating motivation was the strongest predictor of binge eating, consistent with poor emotion regulation and the urge to use food to alleviate negative emotions in binge eaters. The other significant predictors were emotion regulation, a negative predictor, and alexithymia and reward sensitivity, which were positive predictors, all as expected. By contrast, neither the total MAIA-2 index of interoception nor any of the eight MAIA-2 subscales were significant predictors of binge eating. A mediation model, controlling for all other variables, that directly pitted the deficient emotion regulation vs. interoceptive deficit interpretations of the relationship between alexithymia and binge eating clearly supported only the former interpretation. Further, another mediation model that controlled for all other variables indicated that emotional eating motivation mediated the relationships of both alexithymia and

emotion regulation to binge eating. However, in both mediation models the indicated mediation was only partial, leaving other possible contributing factors to these relationships unaccounted for. One variable that has been linked to binge eating is BMI, which was not assessed in the present sample but which has been proposed to be a relevant causal factor in disordered eating in conjunction with emotional eating (Černelič-Bizjak & Guiné, 2021), although BMI has often been treated as an outcome (McCuen-Wurst et al., 2018). A potential complication with BMI is that binge eaters who engage in frequent intense exercise are not necessarily overweight, due to their high caloric expenditure (Stapleton et al., 2014).

Limitations

The present study had some limitations that should be considered. The study was cross-sectional in nature, hence the significant relationships among variables cannot be interpreted as reflecting causation; longitudinal evidence would be required for such conclusions to be drawn. The most that can be said about the present findings is that they are consistent with the emotion regulation deficit interpretation of the association of alexithymia with binge eating, but not the interoception deficit interpretation. The use of self-report indices of the variables of interest entails well-known issues with such forms of measurement including the possibility of biased responding; however the use of validated self-report measures of the relevant constructs, and the lack of multicollinearity among them, argues against shared method bias as an explanation of the observed directional relationships. The use of a self-report index of alexithymia (TAS-20) may seem particularly questionable given that alexithymia is defined by difficulties in accessing, describing and understanding feelings. Nevertheless, there is reported convergence between TAS-20 scores and clinician ratings of alexithymia, with the TAS-20 even proving superior to clinician ratings in some respects (see Ogrodniczuk et al., 2018; Thorberg et al., 2010ab). Due to such evidence, and its sound psychometric

properties, the TAS-20 is the most widely used index of alexithymia (Bagby et al., 2020).

A degree of caution is applicable to the use of the MAIA-2 as a self-report index of interoceptive awareness. Those with limited or biased self-awareness overall would seem likely to be limited in their ability to provide meaningful responses on self-report measures of emotional or interoceptive self-awareness. Research that has supported interoceptive deficits in alexithymia, as measured by TAS-20, used perception of heartbeats as the index of interoceptive awareness (Herbert et al., 2011; Murphy et al., 2018). However, use of perception of heartbeats to measure interoception is complicated by a number of likely confounding variables, including level of prior knowledge of resting heart rate and the significant negative correlation between heart rate and counting accuracy (Zamariola et al., 2018). In support of the validity of the MAIA-2, it was reported by its authors to distinguish in expected ways between experienced and inexperienced practitioners of mind-body therapy and yoga (Mehling et al., 2012). Nevertheless the MAIA-2, as a relatively new instrument, should be assessed in relation to direct measures of interoception to further evaluate its construct validity. A further issue concerns the present use of the DEBQ-EE, which assesses the motivation to eat in response to negative emotional states but not eating behavior in response to such states. Future work on these issues could use a measure such as the Adult Eating Behaviour Questionnaire (Hunot et al., 2016), which includes a self-report index of emotional overeating. A more ambitious approach would be to assess eating behavior in response to stress via diary reports of everyday mood variations and associated eating behaviors over time.

A potentially concerning issue with the present sample was the unusually high mean score on the TAS-20, which was in the borderline-high range (Bagby et al., 1994b). Previous research using online samples has also reported unusually high mean TAS-20

scores, which were attributed to highly alexithymic individuals tending to spend much more time on the internet than those with low or no alexithymia (Lyvers et al., 2021). Another consideration in this regard, however, is that the data were collected during the COVID-19 pandemic when many regions of Australia were subjected to lockdowns, social distancing, employment-related stress, and travel restrictions, with corresponding negative impacts on mental health in the population (Newby et al., 2020; Rossell et al., 2021). Much evidence supports the general concept of alexithymia as a stable personality trait with an early developmental onset (Hiirola et al., 2017; Lyvers et al., 2019; Salminen et al., 2006; Tolmunen et al., 2011), however a distinction has been made between so-called primary or trait alexithymia and secondary or state alexithymia as an acute response to depression or stress (Messina et al., 2014); the TAS-20 used in the present study does not distinguish between these types of alexithymia. The unexpectedly high mean score on the BES – just above the established cutoff for low or no binge eating – in the present sample could also be attributable to the COVID-19 pandemic context, although the promotion of the study as an investigation of eating habits may have tended to disproportionally attract participants with eating-related concerns. In any case the unexpectedly high levels of self-reported alexithymia and binge eating in the current sample may limit the generalizability of the findings. Finally, the current findings were from a nonclinical sample and thus may not apply to clinical BED samples. Future work could investigate these issues in clinical samples.

Conclusions

Despite its limitations, the present study offers support for the emotion regulation deficit interpretation of the association between alexithymia and binge eating, while offering no support for the interoceptive deficit interpretation. The evidence for the role of reward sensitivity in binge eating was consistent with previous research as noted

earlier. Overall the findings point to the roles of both reward sensitivity and alexithymia in binge eating, and the importance of emotion regulation skills as a likely protective factor. The current findings also reinforce the targeting of such skills in current psychotherapies for BED such as Dialectical Behavior Therapy (Safer et al., 2009), and which may be particularly beneficial for alexithymic clients with BED.

References

Aloi, M., Rania, M., Caroleo, M., de Fazio, P., & Segura-García, C. (2017). Social cognition and emotional functioning in patients with Binge Eating Disorder. *European Eating Disorders Review*, *25*, 172–178. https://doi.org/10.1002/erv.2504

American Psychiatric Association (APA) (2013). *Diagnostic and statistical manual of mental disorders: DSM-5™(5th ed.).* Washington DC: APA.

Bagby, R.,M., Parker, J., & Taylor, G. (1994a). The twenty-item Toronto Alexithymia Scale—I. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research, 38,* 23-32. https://doi.org/10.1016/0022-3999(94)90005-1

Bagby, R. M., Parker, J. D. A., & Taylor, G. J. (2020). Twenty-five years with the 20-item Toronto Alexithymia Scale. *Journal of Psychosomatic Research*, *131*, 109940 https://doi.org/10.1016/j.jpsychores.2020.109940

Bagby, R.M., Taylor, G., & Parker, J. (1994b). The twenty-item Toronto Alexithymia Scale—II. Convergent, discriminant, and concurrent validity. *Journal of Psychosomatic Research, 38*, 33-40. https://doi.org/10.1016/0022-3999(94)90006-x

Besharat, M. A., Naghshineh, N., Ganji, P., & Tavalaeyan, F. (2014). The moderating role of attachment styles on the relationship of alexithymia and fear of intimacy with marital satisfaction. *International Journal of Psychological Studies, 6,* 106-117. https://doi.org/10.5539/ijps.v6n3p106

Brewer, R., Cook, R., & Bird, G. (2016). Alexithymia: A general deficit of interoception. *Royal Society Open Science, 3*, 150664. https://doi.org/10.1098/rsos.150664

Catanzaro, S. J., & Mearns, J. (1990). Measuring generalized expectancies for negative mood regulation: Initial scale development and implications. *Journal of Personality Assessment, 54*, 546-563. https://doi.org/10.1207/s15327752jpa5403&4_11

Černelič-Bizjak, M., & Guiné, R.P.F. (2021). Predictors of binge eating: Relevance of BMI, emotional eating and sensitivity to environmental food cues. *Nutrition & Food Science, 52.* https://www.emerald.com/insight/0034-6659.htm

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Routledge.

Corr, P. J. (2009). The reinforcement sensitivity theory of personality. In P. J. Corr & G. Matthews (Eds.), *The Cambridge handbook of personality psychology* (pp. 347–376). Cambridge University Press. https://doi.org/10.1017/CBO9780511596544.024

Cruise, K., & Becerra, R. (2018). Alexithymia and problematic alcohol use: A critical update. *Addictive Behaviors*, *77*, 232-246. https://doi.org/10.1016/j.addbeh.2017.09.025

Dalbudak, E., Evren, C., Topcu, M., Aldemir, S., Coskun, K., Bozkurt, M., Evren, B., & Canbal, M. (2013). Relationship of internet addiction with impulsivity and severity of psychopathology among Turkish university students. *Psychiatry Research*, *210*, 1086-1091. https://doi.org/10.1016/j.psychres.2013.08.014

Dawe, S., & Loxton, N.J. (2004). The role of impulsivity in the development of substance use and eating disorders. *Neuroscience & Biobehavioral Reviews, 28,* 343-351. https://doi.org/10.1016/j.neubiorev.2004.03.007

Galmiche, M., Déchelotte, P., Lambert, G., & Tavolacci, M. P. (2019). Prevalence of eating disorders over the 2000–2018 period: A systematic literature review. *American Journal of Clinical Nutrition, 109,* 1402- 1413. https://doi.org/10.1093/ajcn/nqy342

Ghalehban, M., & Besharat, M. (2011). Examination and comparison of alexithymia and self regulation in patients with substance abuse disorder and normal individuals. *Procedia - Social and Behavioral Sciences*, *30*, 38-42. https://doi.org/10.1016/j.sbspro.2011.10.008

Gormally, J., Black, S., Daston, S., & Rardin, D. (1982). The assessment of binge eating

severity among obese persons. *Addictive Behaviors, 7,* 47–55. https://doi.org/10.1016/0306-4603(82)90024-7

Gray, J. A. (1987). *The psychology of fear and stress*. Cambridge University Press.

Gu, X., Hof, P. R., Friston, K. J., & Fan, J. (2013). Anterior insular cortex and emotional awareness. *Journal of Comparative Neurology*, *521*, 3371–3388. https://doi.org/10.1002/cne.23368

Harrison, A., Sullivan, S., Tchanturia, K., & Treasure, J. (2010). Emotional functioning in eating disorders: Attentional bias, emotion recognition, and emotion regulation. *Psychological Medicine, 40,* 1887-1897. https://doi.org/10.1017/S0033291710000036

Hay, P., Girosi, F., & Mond, J. (2015). Prevalence and sociodemographic correlates of DSM-5 eating disorders in the Australian population. *Journal of Eating Disorders. 3,* 1-7. https://doi.org/10.1186/s40337-015-0056-0

Herbert, B. M., Herbert, C., & Pollatos, O. (2011). On the relationship between interoceptive awareness and alexithymia: Is interoceptive awareness related to emotional awareness? *Journal of Personality*, *79*, 1149–1175. https://doi.org/10.1111/j.1467-6494.2011.00717.x

Hiirola, A., Pirkola, S., Karukivi, M., Markkula, N., Bagby, R.M., Joukamaa, M., Jula, A., Kronholm, E., Saarijarvi, S., Salminen, J.R., Suvissari, J., Taylor, G., & Mattila, A.K. (2017). An evaluation of the absolute and relative stability of alexithymia over 11 years in a Finnish general population. *Journal of Psychosomatic Research*, *95*, 81-87. https://doi.org/10.1016/j.jpsychores.2017.02.007

Hunot, C., Fildes, A., Croker, H., Llewellyn, C.H., Wardle, J., & Beeken, R.J. (2016). Appetitive traits and relationships with BMI in adults: Development of the Adult Eating Behaviour Questionnaire. *Appetite, 105,* 356-363. https://doi.org/10.1016/j.appet.2016.05.024

Jorgensen, M., Zachariae, R., Skytthe, A., & Kyvik, K. (2007). Genetic and environmental factors in alexithymia: A population-based study of 8,785 Danish twin pairs. *Psychotherapy and Psychosomatics*, *76*, 369-375. https://doi.org/10.2307/48511040

Kandri, T., Bonotis, K., Floros, G., & Zafiropoulou, M. (2014). Alexithymia components in excessive internet users: A multi-factorial analysis. *Psychiatry Research*, *220*, 348-355. https://doi.org/10.1016/j.psychres.2014.07.066

Larsen, J.K., van Strein, T., Eisinga, R., & Engels, R.C.M.E (2006). Gender differences in the association between alexithymia and emotional eating in obese individuals. *Journal of Psychosomatic Research, 60,* 237-243. https://doi.org/10.1016/j.jpsychores.2005.07.006

Lee-Winn, A.E., Townsend, L., Reinblatt, S.P., & Mendelson, T. (2016). Associations of neuroticism and impulsivity with binge eating in a nationally representative sample of adolescents in the United States. *Personality & Individual Differences, 90,* 66-72. https://doi.org/10.1016/j.paid.2015.10.042.

Lennartsson, A.K., Horwitz, E.B., Theorell, T., & Ullen, F. (2017). Creative artistic achievement is related to lower levels of alexithymia. *Creativity Research Journal*, *29*, 29–36. https://doi.org/10.1080/10400419.2017.1263507

Levant, R. F., Hall, R. J., Williams, C. M., & Hasan, N. T. (2009). Gender differences in alexithymia. *Psychology of Men & Masculinity, 10*, 190–203. https://doi.org/10.1037/a0015652

Lyvers, M., Coundouris, S., Edwards, M.S., & Thorberg, F.A. (2018). Personality, drinking motives and risky alcohol use: The role of internal drinking motives. *Addiction Research & Theory, 26,* 114-122. https://doi.org/10.1080/16066359.2017.1333110

Lyvers, M., Davis, S., Edwards, M.S., & Thorberg, F.A. (2017). Alexithymia, fear of intimacy and attachment in young adults. *IAFOR Journal of Psychology & Behavioral Sciences, 3,* 1-11. https://doi.org/10.22492/ijpbs.3.2.01

Lyvers, M., Hasking, P., Albrecht, B., & Thorberg, F.A. (2012). Alexithymia and alcohol: The roles of punishment sensitivity and drinking motives. *Addiction Research & Theory, 20,* 348-357. https://doi.org/10.3109/16066359.2011.63649420

Lyvers, M., Hinton, R., Gotsis, S., Roddy, M., Edwards, M., & Thorberg, F.A. (2014). Traits linked to executive and reward systems functioning in clients undergoing residential treatment for substance dependence. *Personality & Individual Differences*, *70*, 194-199. https://doi.org/10.1016/j.paid.2014.07.004

Lyvers, M., Holloway, N., Needham, K., & Thorberg, F.A. (2020). Resilience, alexithymia, and university stress in relation to anxiety and risky alcohol use among female university students. *Australian Journal of Psychology*, *72,* 59-67. https://doi.org/10.1111/ajpy.12258

Lyvers, M., Jamieson, R., & Thorberg, F.A. (2013). Risky cannabis use is associated with alexithymia, frontal lobe dysfunction, and impulsivity in young adult cannabis users. *Journal of Psychoactive Drugs*, *45*, 394-403. https://doi.org/10.1080/02791072.2013.844525

Lyvers, M., Karantonis, J., Edwards, M. S., Thorberg, F.A. (2016). Traits associated with internet addiction in young adults: Potential risk factors. *Addictive Behaviors Reports, 3,* 56-60. https://dx.doi.org/10.1016/j.abrep.2016.04.001

Lyvers, M., Makin, C., Toms, E., Thorberg, F.A., & Samios, C. (2014b). Trait mindfulness in relation to alexithymia, emotion regulation, mood and everyday executive functioning. *Mindfulness, 5,* 619-625. https://doi.org/10.1007/s12671-013-0213-y

Lyvers, M., Mayer, K., Needham, K., & Thorberg, F.A. (2019). Parental bonding, adult attachment, and theory of mind: A developmental model of alexithymia and alcohol-related risk. *Journal of Clinical Psychology, 75,* 1288-1304. https://doi.org/10.1002/jclp.22772

Lyvers, M., Sweetnam, T., & Thorberg, F.A. (2021). Alexithymia, rash impulsiveness, and reward sensitivity in relation to symptoms of exercise dependence in physically active young adults. *Australian Journal of Psychology,* early online. https://doi.org/10.1080/00049530.2021.1981747

Mahapatra, A., & Sharma, P. (2018). Association of internet addiction and alexithymia – A scoping review. *Addictive Behaviors*, *81*, 175-182. https://doi.org/10.1016/j.addbeh.2018.02.004

Marchetti, D., Verrocchio, M., & Porcelli, P. (2019). Gambling problems and alexithymia: A systematic review. *Brain Sciences*, *9*, 191. https://doi.org/10.3390/brainsci9080191

Marsero, S., Ruggiero, G., Scarone, S., Bertelli, S., & Sassaroli, S. (2011). The relationship between alexithymia and maladaptive perfectionism in eating disorders: A mediation moderation analysis methodology. *Eating and Weight Disorders*, *16*, 182-187. https://doi.org/10.1007/bf03325130

Matthews, G. (2019). *Extraversion-introversion. Reference Module in Neuroscience and Biobehavioral Psychology.* Elsevier. https://doi.org/10.1016/B978-0-12-809324-5.21765-3

Mattila, A.K., Salminen, J.K., Nummi, T., & Joukamaa, M. (2006). Age is strongly associated with alexithymia in the general population. *Journal of Psychosomatic Research*, *61*, 629–635. https://doi.org/10.1016/j.jpsychores.2006.04.013

McAtamney, K., Mantzios, M., Egan, H., & Wallis, D.J. (2021). Emotional eating during

COVID-19 in the United Kingdom: Exploring the roles of alexithymia and emotion dysregulation. *Appetite, 161,*105120. https://doi.org/10.1016/j.appet.2021.105120

McCuen-Wurst, C., Ruggieri, M., & Allison, K.C. (2018). Disordered eating and obesity: Associations between binge-eating disorder, night-eating syndrome, and weight-related comorbidities. *Annals of the New York Academy of Sciences, 1411,* 96-105. https://doi.org/10.1111/nyas.13467

McGillivray, L., Becerra, R., & Harms, C. (2016). Prevalence and demographic correlates of alexithymia: A comparison between Australian psychiatric and community samples. *Journal of Clinical Psychology*, *73*, 76-87. https://doi.org/10.1002/jclp.22314

Mehling, W.E., Price, C., Daubenmier, J.J., Acree, M., Bartmess, E., & Stewart, A. (2012). The Multidimensional Assessment of Interoceptive Awareness (MAIA). *Plos One.* https://doi.org/10.1371/journal.pone.0048230

Messina, A., Beadle, J., & Paradiso, S. (2014). Towards a classification of alexithymia: Primary, secondary and organic. *Journal of Psychopathology, 20,* 38-49.

Murphy, J., Brewer, R., Hobson, H., Catmurd, C., & Birdae, G. (2018). Is alexithymia characterised by impaired interoception? Further evidence, the importance of control variables, and the problems with the Heartbeat Counting Task. *Biological Psychology, 136,* 189-197. https://doi.org/10.1016/j.biopsycho.2018.05.010

National Eating Disorders Collaboration (NEDC) (2017). *Eating disorders prevention, treatment and management an updated evidence review.* Sydney: NEDC.

Newby, J.M., O'Moore, K., Tang, S., Christensen, H., & Faasse, K. (2020). Acute mental health responses during the COVID-19 pandemic in Australia. *Plos One*. https://doi.org/10.1371/journal.pone.0236562

Ogrodniczuk, J.S., Kealy, D., Hadjipavlou, G.A., & Cameron, K. (2018). Therapeutic issues. In O. Luminet, R.M. Bagby & G.J. Taylor (Eds.), *Alexithymia: Advances in research, theory, and clinical practice* (pp. 190-206). Cambridge.

Rose, P., & Segrist, D. (2012). Difficulty identifying feelings, distress tolerance and compulsive buying: Analyzing the associations to inform therapeutic strategies. *International Journal of Mental Health and Addiction*, *10*, 927-935. https://doi.org/10.1007/s11469-012-9389-y

Rossell, S.L., Neill, E., Phillipou, A., Tan, E.J., Toh, W.L., Van Rheenen, T.E., & Meyer, D. (2021). An overview of current mental health in the general population of Australia during the COVID-19 pandemic: Results from the COLLATE project. *Psychiatry Research, 296,* 113660. https://doi.org/10.1016/j.psychres.2020.113660.

Safer, D.L., Telch, C.F., & Chen, E.Y. (2009). *Dialectical Behavior Therapy for binge eating and bulimia*. Guilford.

Salminen, J., Saarijärvi, S., Toikka, T., Kauhanen, J., & Äärelä, E. (2006). Alexithymia behaves as a personality trait over a 5-year period in Finnish general population. *Journal of Psychosomatic Research*, *61*, 275-278. https://doi.org/10.1016/j.jpsychores.2006.01.014

Saules, K. K., Collings, A. S., Hoodin, F., Angelella, N. E., Alschuler, K., Ivezaj, V., Saunders-Scott, D., & Wiedemann, A. A. (2009). The contributions of weight problem perception, BMI, gender, mood, and smoking status to binge eating among college students. *Eating Behaviors, 10*, 1-9. https://doi.org/10.1016/j.eatbeh.2008.07.010

Sekely, A., Bagby, R. M., & Porcelli, P. (2018). Assessment of the alexithymia construct. In O. Luminet, R. M. Bagby & G. J. Taylor (Eds.), *Alexithymia: Advances in research,*

theory, and clinical practice (pp. 17-32). Cambridge University Press. https://doi.org/10.1017/9781108241595.004

Stapleton, P., McIntyre, T., & Bannatyne, A. (2014). Body image avoidance, body dissatisfaction, and eating pathology: Is there a difference between male gym users and non–gym users? *American Journal of Men's Health, 10,* 100-109. https://doi.org/10.1177/1557988314556673

Stevens, F. L., Hurley, R. A., & Taber, K. H. (2011). Anterior cingulate cortex: Unique role in cognition and emotion. *Journal of Neuropsychiatry and Clinical Neurosciences*, *23*, 121–125. https://doi.org/10.1176/jnp.23.2.jnp121

Substance Abuse and Mental Health Services Administration (SAMHSA); Office of the Surgeon General (2016). *Facing addiction in America:* Washington, D.C.: US Department of Health and Human Services.

Thorberg, F.A., Young, R., Sullivan, K., & Lyvers, M. (2009). Alexithymia and alcohol use disorders: A critical review. *Addictive Behaviors*, *34*, 237-245. https://doi.org/10.1016/j.addbeh.2008.10.016

Thorberg, F. A., Young, R. McD., Sullivan, K. A., Lyvers, M., Connor, J. P., & Feeney, GFX. (2010a). A psychometric comparison of the Toronto Alexithymia Scale (TAS-20) and the Observer Alexithymia Scale (OAS) in an alcohol dependent sample. *Personality & Individual Differences, 49,* 119-123. https://doi.org/10.1016/j.paid.2010.03.018

Thorberg, F. A., Young, R. McD., Sullivan, K. A., Lyvers, M., Hurst, C., Connor, J. P., & Feeney, GFX. (2010b). A confirmatory factor analysis of the Toronto alexithymia scale (TAS-20) in an alcohol dependent sample. *Psychiatry Research, 178,* 565-567. https://doi.org/10.1016/j.psychres.2009.09.015

Thorberg, F.A., Young, R., Sullivan, K.A., & Lyvers, M. (2011a). Parental bonding and

alexithymia: A meta-analysis. *European Psychiatry, 26,* 187-193. https://doi.org/10.1016/j.eurpsy.2010.09.010

Thorberg, F. A., Young, R. M., Sullivan, K. A., Lyvers, M., Connor, J. P. & Feeney, G. F. (2011b). Attachment security and alexithymia in a heavy drinking sample. *Addiction Research and Theory, 19,* 566-570. https://doi.org/10.3109/16066359.2011.580065

Thorberg, F. A., Young, R. McD., Lyvers, M., Connor, J. P., Tyssen, R., London, E. D., & Feeney, GFX. (2017). Alexithymia in alcohol-dependent patients is mediated by stress, anxiety and loss of self-control over drinking. *Drug and Alcohol Dependence, 171,* e201-e202. https://doi.org/10.1016/j.drugalcdep.2016.08.551

Tolmunen, T., Heliste, M., Lehto, S., Hintikka, J., Honkalampi, K., & Kauhanen, J. (2011). Stability of alexithymia in the general population: An 11-year followup. *Comprehensive Psychiatry*, *52*, 536-541. https://doi.org/10.1016/j.comppsych.2010.09.007

Toneatto, T., Lecce, J., & Bagby, M. (2009). Alexithymia and pathological gambling. *Journal of Addictive Diseases*, *28*, 193-198. https://doi.org/10.1080/10550880903014775

Tonelli, H., & de Siqueira Rotenberg, L. (2021). Emotion perception and theory of mind in obesity: A systematic review on the impact of social cognitive deficits on dysfunctional eating behaviors. *Surgery for Obesity and Related Diseases*, *17,* 618–629). https://doi.org/10.1016/j.soard.2020.10.016

Torrubia, R., Ávila, C., Moltó, J., & Caseras, X. (2001). The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) as a measure of Gray's anxiety and impulsivity dimensions. *Personality & Individual Differences*, *31*, 837-862. https://doi.org/10.1016/s0191-8869(00)00183-5

Van Landeghem, C., Jakobson, L.S., & Keough, M.T. (2019). Risk of exercise dependence in university students: A subtyping study utilizing latent profile analysis,

Psychology of Sport and Exercise, 45, 101575. https://doi.org/10.1016/j.psychsport.2019.101575

Van Strien, T., Frijters, J. E., Bergers, G. P., & Defares, P. B. (1986). The Dutch eating behavior questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International Journal of Eating Disorders, 5*, 295-315. https://doi.org/10.1002/1098-108x(198602)5:2<295::aid-eat2260050209>3.0.co;2-t

Ward, Z.J., Rodriquez, P., Wright, D.R., Austin, B., & Long, M.W. (2019). Estimation of eating disorders prevalence by age and associations with mortality in a simulated nationally representative US cohort. *JAMA Network Open, 2,* e1912925. https://doi.org/10.1001/jamanetworkopen.2019.12925

Watson, D., Clark, L.A., Chmielewski, M., & Kotov, R. (2013). The value of suppressor effects in explicating the construct validity of symptom measures. *Psychological Assessment, 25,* 929-941. https://doi.org/10.1037/a0032781

Westwood, H., Kerr-Gaffney, J., Stahl, D., & Tchanturia, K. (2017). Alexithymia in eating disorders: Systematic review and meta-analyses of studies using the Toronto Alexithymia Scale. *Journal of Psychosomatic Research, 99,* 66-81. https://doi.org/10.1016/j.jpsychores.2017.06.007

Wheeler, K., Greiner, P., & Boulton, M. (2005). Exploring alexithymia, depression, and binge eating in self-reported eating disorders in women. *Perspectives in Psychiatric Care*, *41*, 114-23. https://doi.org/10.1111/j.1744-6163.2005.00022.x.

Wise, T., Mann, L., & Shay, L. (1992). Alexithymia and the five-factor model of personality. *Comprehensive Psychiatry*, *33*, 147-151. https://doi.org/10.1016/0010-440x(92)90023-j

Zamariola, G., Maurage, P., Luminet, O., & Corneille, O. (2018). Interoceptive accuracy

scores from the heartbeat counting task are problematic: Evidence from simple bivariate correlations. *Biological Psychology, 137,* 12-17. https://doi.org/10.1016/j.biopsycho.2018.06.006

Zimmermann, G., Rossier, J., Meyer de Stadelhofen, F. & Gaillard, F. (2005). Alexithymia assessment and relations with dimensions of personality. *European Journal of Psychological Assessment, 21,* 23–33. https://doi.org/10.1027/1015-5759.21.1.23

Table 1

Means (M), Standard Deviations (SD), and Intercorrelations of Variables (N=532)

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*M (SD)*
1. Binge Eating	-							18.70 (10.61)
2. Emo Eating	.67**	-						2.77 (.97)
3. Alexithymia	.42**	.34**	-					59.21 (10.65)
4. Interoception	-.01	.05	-.07	-				2.68 (.69)
5. Emo Reg	-.39**	-.27**	-.49**	.16**	-			95.82 (15.46)
6. Sens Punish	.26**	.26**	.42**	.05	-.40**	-		15.10 (5.62)
7. Sens Reward	.27**	.24**	.23**	.27**	-.06	.32**	-	10.55 (5.06)

Note. Emo Eating = Emotional Eating Motive; Emo Reg = Emotion Regulation; Sens Punish = Sensitivity to Punishment; Sens Reward = Sensitivity to Reward. ** $p < .001$.

Table 2

Hierarchical regression on binge eating, controlling for demographic variables (N = 532).

	Step 1			Step 2			Step 3			Step 4			Step 5		
	B	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Constant	15.59	4.46		4.81	4.47		-18.46	4.99		5.19	6.25		-2.51	5.04	
Age	.15	.15	.05	.16	.14	.05	.26	.13	.09	.32	.13	.11	.30	.10	.10
Gender	.46	1.03	.02	.39	1.02	.02	.65	.96	.03	1.05	.93	.05	.23	.75	.01
Education	-1.02	.65	-.07	-.45	.62	-.09	.11	.59	.01	.22	.57	.02	-.17	.46	-.01
Student	1.10	1.04	.05	.45	.99	.02	1.38	.94	.06	1.40	.91	.06	1.27	.73	.06
SensRew				.43	.10	.20**	.35	.09	.17**	.44	.09	.21**	.24	.07	.12**
SensPun				.36	.09	.19**	.10	.09	.05	-.05	.09	-.03	-.11	.07	-.06
Alexithymia							.37	.04	.37**	.26	.05	.26**	.14	.04	.14**
EmoReg										-.18	.03	-.27**	-.13	.03	-.19**
Interocept													-.54	.49	-.04
EmoEating													.47	.03	.56**

Note. B = unstandardized coefficient; *SE B* = standard error of *B;* β = standardized coefficient. SensRew = Sensitivity to Reward; SensPun = Sensitivity to Punishment; EmoReg = Emotion Regulation; Interocept = Interoception; EmoEating = Emotional Eating Motive. ***p* < .001.

Table 3

Mediation of the alexithymia – binge eating relationship by deficient emotion regulation but not interoception, controlling for all other variables (N = 532)

Direct effects

					95% Confidence Interval	
	Estimate	Std. Error	z-value	p	Lower	Upper
Alexithymia → Binge Eating	0.264	0.046	5.782	< .001	0.175	0.354

Note. Delta method standard errors, normal theory confidence intervals, ML estimator.

Indirect effects

					95% Confidence Interval	
	Estimate	Std. Error	z-value	p	Lower	Upper
Alexithymia → Interoception → Binge Eating	0.002	0.005	0.343	0.732	-0.009	0.012
Alexithymia → Emotion Reg → Binge Eating	0.105	0.021	5.027	< .001	0.064	0.146

Note. Delta method standard errors, normal theory confidence intervals, ML estimator.

Total effects

					95% Confidence Interval	
	Estimate	Std. Error	z-value	p	Lower	Upper
Alexithymia → Binge Eating	0.371	0.043	8.527	< .001	0.286	0.456

Note. Delta method standard errors, normal theory confidence intervals, ML estimator.

Total indirect effects

					95% Confidence Interval	
	Estimate	Std. Error	z-value	p	Lower	Upper
Alexithymia → Binge Eating	0.107	0.021	5.090	< .001	0.066	0.148

Note. Delta method standard errors, normal theory confidence intervals, ML estimator.

Table 4

Mediation of relationships of emotion regulation and alexithymia to binge eating by emotional eating motivation, controlling for all other variables (N = 532)

Direct effects

						95% Confidence Interval	
		Estimate	Std. Error	z-value	p	Lower	Upper
Emotion Reg	→ Binge Eating	-0.187	0.037	-5.086	< .001	-0.256	-0.113
Alexithymia	→ Binge Eating	0.135	0.037	3.607	< .001	0.050	0.207

Note. Delta method standard errors, bias-corrected percentile bootstrap confidence intervals, ML estimator.

Indirect effects

							95% Confidence Interval	
			Estimate	Std. Error	z-value	p	Lower	Upper
Emotion Reg	→ Emotional Eat	→ Binge Eating	-0.081	0.027	-2.94	.003	-0.141	-0.031
Alexithymia	→ Emotional Eat	→ Binge Eating	0.129	0.028	4.57	< .001	0.073	0.195

Note. Delta method standard errors, bias-corrected percentile bootstrap confidence intervals, ML estimator.

Total effects

						95% Confidence Interval	
		Estimate	Std. Error	z-value	p	Lower	Upper
Emotion Reg	→ Binge Eating	-0.267	0.045	-5.896	< .001	-0.348	-0.173
Alexithymia	→ Binge Eating	0.264	0.046	5.782	< .001	0.159	0.350

Note. Delta method standard errors, bias-corrected percentile bootstrap confidence intervals, ML estimator.

Figure 1. *Mediation of the alexithymia – binge eating relationship by deficient emotion regulation but not interoception, controlling for all other variables. *p < .01. **p < .001.*

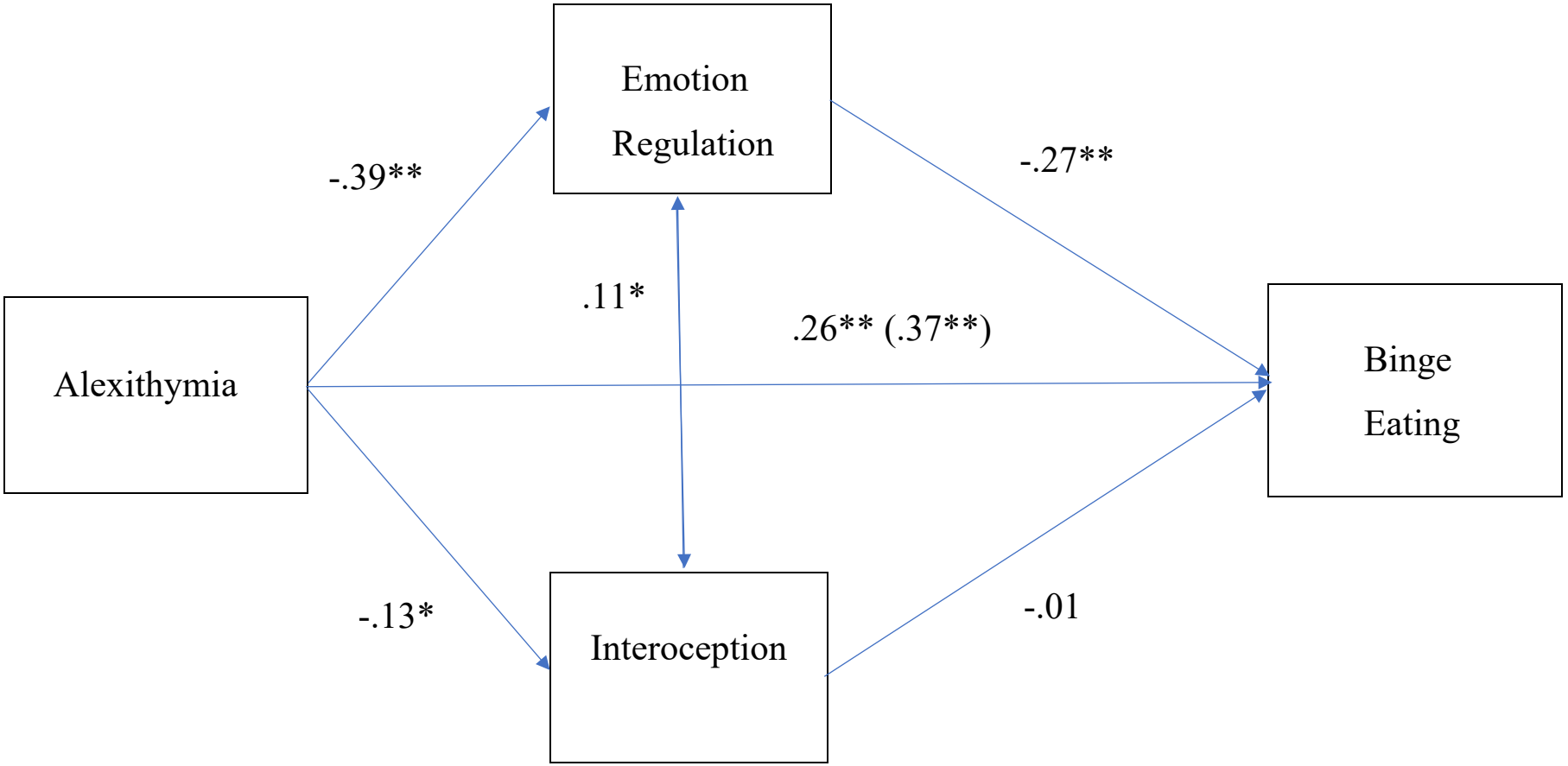

Figure 2. *Mediation of relationships of emotion regulation and alexithymia to binge eating by emotional eating motivation, controlling for all other variables. **p < .001.*