Etiology and Pathophysiology

The association between emotions and eating behaviour in an obese population with binge eating disorder

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Summary

There is utility in understanding the antecedents of binge eating (BE), with a view to explaining poorer weight loss treatment responses in this subgroup. A systematic review was completed according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with the aim of exploring associations between emotions and eating behaviour in a population affected by obesity and binge eating disorder (BED). A comprehensive literature search of four electronic databases (2004–2014) yielded 15 studies for inclusion. Included studies performed poorly on data quality analysis with respect to controlling for confounding variables, and sample size. Included papers largely focused on negative emotions as antecedents of BE; depression was consistently associated with a BED-obese classification and BE. Negative mood, sadness, tension and instability of emotions were found to be antecedents of BE in an adult BED-obese sample. However, findings were mixed regarding the role of stress, anger and positive emotions within the BED-obese population. Recommendations are presented for the identification of BED, and ecologically valid experimental designs that further understanding of the complex and varied emotions that associate with BE. The implications of these and other limitations for both researchers and practitioners are discussed. The paper concludes with recommendations for future research alongside suggestions for practitioners.

Keywords: Binge eating disorder, emotional eating, non-purging, obesity.

Abbreviations: BE; binge eating; BED; binge eating disorder; BMI; body mass index; DSM-IV; Diagnostic and Statistical Manual of Mental Disorders, 4th Edition; DSM-V; Diagnostic and Statistical Manual of Mental Disorders, 5th Edition; EMA; ecological momentary assessment; s-BED; sub-threshold binge eating disorder; SD; standard deviation.

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Background

Binge eating disorder (BED) is characterized by at least one episode per week of uncontrolled eating, where an objectively large quantity of food is consumed, along with a sense of loss of control, and in the absence of purging or compensatory behaviour (1). The World Mental Health Survey (2) estimated average lifetime prevalence of BED at 1.9% across the 14 countries surveyed (e.g. France, Germany, Italy, New Zealand, Colombia and USA). The recent Diagnostic and Statistical Manual of Mental Disorders (5th Edition) (3) recognizes BED as a discrete classification as opposed to ‘not otherwise specified’ (4), thus reflecting a growing acknowledgement of this condition.
The association between BED and obesity is complex (5). However, there is support for the contention that among those classified as obese, a subgroup of individuals can be identified as having BED (6). BED-obese individuals tend to have higher body mass (7,8), higher rates of mental disorders (e.g. depression, psychosis and anxiety) (9,10), higher distress (7) and poorer health outcomes (11) and quality of life (12). BED-obese individuals respond to treatment with varying patterns of success (5); there is therefore utility in understanding the antecedents of binge eating (BE), with a view to explaining the poorer outcome and treatment responses in this subgroup, and developing appropriate interventions.

Emotional antecedents are common to theories explaining the function of BE. Examples include the affect regulation model, which suggests that BE is intended to serve the function of reducing negative affect (13), and the escape awareness theory (14), which proposes bingeing as be a strategy to avoid negative emotion. Cognitive theory of eating disorders (15–17) explains BE as a temporary abandonment of restricted eating (15), which is associated with changes in mood, typically in an adverse direction among those with BED (18,19).

The concept of negative emotions as antecedents of eating has empirical support. Those with BED report BE being driven by expectations that mood will improve, rather than expectations around satisfying hunger (20), and there is evidence that BE is preceded by negative emotions (21) and stress (22) in this population. As such, it could be argued that BE is used as a form of emotion regulation and could be categorized as ‘emotional eating’.

Emotional eating refers to eating in order to regulate emotion states in a desired direction (23,24). Those with BED may use eating to regulate their emotions in place of more adaptive regulatory strategies (25). The use of food to regulate emotions is associated with a failure to maintain weight management goals (26). Carter and Jansen (27) highlight that in developing interventions for obesity, it is of central importance to consider the thoughts and feelings that are antecedents of eating.

The nature of emotional eating as a drive to binge has typically been studied through exploration of a single or limited number of largely negative emotions (e.g. stress and depression). This lacks consideration of the complex and ephemeral nature of emotions (28) and, consequently, the subtle differences in eating behaviour that different types of emotion may bring about. Consideration of the interaction between discrete emotions and BE would have both clinical and theoretical utility. The purpose of this review is to systematically identify and evaluate evidence of associations between emotions and eating in a BED-obese population. This will help establish evidence of trends for discrete emotions as antecedents of BE, and corroborate, or indeed contest, existing theoretical contentions regarding the role of negative emotions in BE.

Method
To ensure methodological rigour, objectivity and replicability, standard methodology for systematic reviewing (29–31) was applied. The review was registered on PROSPERO (CRD42014013138), and aims, inclusion criteria, data extraction and data quality evaluation were specified at the outset.

Searches
A systematic search of four electronic databases (PsycINFO, Medline, the Cumulative Index to Nursing & Allied Health Literature and SportDiscus) was undertaken. Search terms described emotions, consumption of food and regulation (see Appendix A for example search). It was of importance that the review captured a wide range of discrete emotions. Therefore, descriptors from four measures of emotion (32–35) were pooled, to compile the search terms for ‘emotion’. In addition, the National Obesity Observatory knowledge update was hand-searched for relevant papers.

The search was limited to literature published over a 10-year period between July 2004 and July 2014. The rationale being that a systematic review conducted in 2004 (36), concluded there was insufficient knowledge on the nature of atypical eating disorders (including BED) to inform interventions. In addition, there has been a marked increase in severe obesity from 2004 to 2014 (37). The search was delimited to peer-reviewed articles, ‘human only’ studies (for Medline) and English language. No other restrictions were applied.

Inclusion assessment
Reference management software was used to organize citations (Endnote). The search yielded 54,283 references (Fig. 1). After deduplication, 43,988 titles were independently screened by two reviewers. Where there was disagreement, the full text manuscript was consulted by two reviewers to reach agreement. For a paper to be included, there had to be consensus that the following criteria were met:

(a) Empirical research;
(b) Published in a peer-reviewed journal;
(c) Measured, assessed (quantitative) or discussed (qualitative) emotion or emotional eating;
(d) Measured, assessed (quantitative) or discussed (qualitative) eating or eating behaviour;
(e) Reported on participants identified as having BED (non-purging);
(f) Positioned emotions as a causal factor in contributing to eating behaviour (i.e. papers describing emotions occurring as a result of eating were excluded); and
Following the title screen, the full text from 198 articles was assessed for eligibility. A further 183 papers were excluded at this stage. These included 112 papers without obese participants, 19 papers without participants identified as having BED, 15 without reports on the association of interest, 12 papers where participants engaged in purging behaviour, eight papers that did not report BMI (thus precluding inclusion assessment), four unpublished theses, three that were not peer-reviewed, four narrative reviews, three where data were collapsed across groups and no findings of relevance could be extracted, one case study, one with participants with anorexia nervosa and one addendum to an included paper. Following full inclusion assessment, 15 papers were included in the review.

Data quality
Quality of included papers was assessed by the first two authors using the standard quality assessment for evaluating primary research papers (38). Studies were evaluated against 20 criteria spanning design, sampling, methodology, analysis, results and conclusions. For each criterion, papers scored either 2 (good), 1 (partial fulfilment), 0 (not fulfilled) or X (not relevant). A mean score was calculated for each paper to give an overall rating of quality. The mean score across all papers for each criterion was calculated to indicate the relative strengths and limitations within the included studies.

Data extraction
Data extraction parameters were established in line with the aims of the systematic review and managed in a spreadsheet using Microsoft Excel. Data extraction headings facilitated the capture of pertinent information including participants, measures, reported outcomes, research limitations and implications for practice.

Results
Characteristics of the included studies
All 15 included studies (Table 1) used quantitative methods. The included studies were largely of Western origin including USA (n = 3), Germany (n = 5), Australia (n = 3), Italy (n = 1), Canada (n = 1), Netherlands (n = 1) and Switzerland (n = 1). With regards to the population recruited, six studies recruited both clinical (i.e. patients accessing treatment facilities) and non-clinical samples (i.e. community), four studies...
Table 1  Characteristics of included studies

| Authors          | Mean data quality (SD) | Sample size | Age mean (SD or range (years)) | % Female participants in sample | Type of sample          | BMI mean (SD) | Method of assessing BED                                      | Sample size classified as BED n (%) | Emotion                          | Eating behaviour or emotional eating |
|------------------|------------------------|-------------|---------------------------------|--------------------------------|---------------------------|----------------|-------------------------------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|
| Allen et al.     | 1.73 (0.46)            | 259 (healthy weight n = 154, overweight n = 72, obese n = 33) | 51                             | 8–13                           | Clinical and non-clinical | Mean z-scores; objective BE = 1.72 (0.64), subjective BE = 1.02 (1.04), objective overeating = 0.81 (0.63), non-BE = 0.66 (1.04) | Interview: Eating Disorder Examination Adapted for Children (ChEDE) (78) | Objective BE n = 11 (4.2%), subjective BE n = 13 (5%), objective overeating n = 15 (5.8%) | Child Depression Inventory (79)            |
| Amianto et al.   | 1.69 (0.63)            | 103 (BED n = 44, s-BED n = 47) | 88.35                           | 100%                           | Clinical BED = 41 (13), s-BED = 44 (12) | BED = 36.6 (4.9), s-BED = 38.54 (5.9) | Interview: applying DSM-IV-TR criteria (81); Self-report: Binge Eating Scale (BES), a score of 17 or over (63) | 103 (100%)                          | Beck Depression Inventory (BDI) (82), Hypomania Checklist (83) | BES (63)                             |
| Burmeister et al.| 1.47 (0.72)            | 57 (obese BED) | 68.4                            | 47.4 (13.7)                     | Non-clinical              | 38.2 (8.1) | Interview: applying BDI (82); a bespoke list of emotional factors that were precursors to food consumption was used | 57 (100%)                          | Center for Epidemiological Studies Depression Scale (84) | Dutch Eating Behaviour Questionnaire, emotional eating subscale (DEBQ) (85), Eating Self-Efficacy Scale (86) |
| Colles et al.    | 1.13 (0.35)            | 180 (BED-obese n = 18, uncontrolled eater obese n = 40, grazer obese n = 34, obese n = 88) | 80                             | 45.2 (11.5)                    | Clinical              | 44.3 (6.8) n.b. not reported separately per group | Interview applying the DSM-IV criteria; self-report: the Questionnaire on Eating and Weight Patterns–Revised (QEWP-R) (87,88) | 18 (10%)                           | BDI (82); a bespoke list of emotional factors that were precursors to food consumption was used | Three-Factor Eating Questionnaire (TFEQ) (88) |
| Colles et al.    | 1.08 (0.28)            | 431 (BED-obese n = 38, BED comparison group n = 38, non-BED obese n = 307, other comparison groups n = 130) | 81.21                           | 81.3 (11.5)                    | Clinical and non-clinical | BED-obese = 42.7 (8.2), BED BMI mean (SD) | Interview: semi-structured clinical face to face (70%) or phone interview (30%) applying DSM-IV criteria; self-report: the Questionnaire on Eating and Weight Patterns–Revised (QEWP-R) (89,87) | 38 (8.82%)                          | BDI (82)                           | TFEQ (88)                           |

(Continues)
| Authors | Mean data quality (SD) | Sample size (in groups where appropriate) | % Female participants | Age mean (SD) or range (years) | Type of sample | BMI mean (SD) | Method of assessing BED | Sample size classified as BED n (%) | Emotion | Eating behaviour or emotional eating |
|---------|------------------------|-------------------------------------------|-----------------------|------------------------------|----------------|---------------|------------------------|------------------------------------|---------|----------------------------------|
| Davis et al. (57) | 1.50 (0.67) | 164 (BED-obese n = 53, non-BED obese n = 52, control n = 59) | 79.87 | BED-obese = 35 (6.5), non-BED obese = 36.4 (6.5), control = 33.5 (7.5) | Non-clinical | BED-obese = 35.2 (8.9), non-BED obese = 39 (8.5), control = 22.4 (2.8) | Interview: Eating Disorder Examination (EDE) (58) and applying DSM-IV criteria | 53 (31.31%) | Not measured explicitly | DEBQ, emotional eating subscale (65), Eating Behaviour Patterns Questionnaire (EBPQ) (90) |
| Dingemans et al. (48) | 1.41 (0.62) | 66 obese and s-BED | 100 | 39 (9.6) | Clinical and non-clinical | Experimental group 1 = 32.6 (8.18), experimental group 2 = 33.8 (6.48) | Interview: EDE (58), and applying DSM-IV criteria | 66 (100%) | BDI (82), visual analogue scale (VAS) to assess emotions on a 10 cm scale | Loss of control and perceived intake of food using VAS, Taste Test Questionnaire (91) |
| Goldschmidt (43) | 1.69 (0.60) | 46 | 100 | 10.5 (1.9) | Clinical and non-clinical | Mean z-score = 2.27 (0.40), BMI percentiles = 98.25 (2.00) | Interview: ChEDE (78) | 46 (50%) | The Face Scale (adapted from Wong & Baker (92)) a VAS assessing mood via a sequence of seven emotionally valenced faces | Food intake during test meal; hunger, fullness and desire to eat was assessed using a five-point Likert-type scale; semi-structured interviews were completed to determine loss of control (adapted from (93)) |
| Hilbert & Tuschen-Caffer (41) | 1.67 (0.49) | 60 (BED-obese n = 20, bulimia nervosa n = 20, control n = 20) | 100 | BED-obese = 36.65 (10.1), clinical bulimia nervosa = 24.47 (5.83), control = 36.3 (9.43) | Non-clinical | BED-obese = 32.9 (6.9), bulimia nervosa = 23.13 (4.61), control = 32.18 (6.53) | Interview: applying DSM-IV criteria | 20 (33%) | Ecological Momentary Assessment (EMA): using a minicomputer, mood was rated on seven-point rating scale (ranging from 0 = very bad to 6 = very good), at random intervals and before, during and after eating | Diary: type and quantity of foods consumed; start and end of an episode; whether participant qualified an eating episode as binge eating episode and inappropriate compensatory behaviour; caloric intake during test period of 2 d |
| Laessle & Schultz (49) | 1.54 (0.52) | 48 (BED-obese n = 17, non-BED obese n = 31) | 100 | BED-obese = 33.6 (8.0), non-BED obese = 34.5 (8.1) | Non-clinical | BED-obese = 36.7 (5.7), non-BED obese = 37.1 (6.3) | Interview: the Structured Diagnostic Interview for DSM-IV, German version (SKID) (94) | 17 (35.42%) | The Trier Social Stress Test (TSST) (69), VAS to assess stress on a 10 cm scale | Universal Eating Monitor (UEM): this is a desk equipped with hidden electronic scale that records weight changes on the plate every 0.5 s (95) and measured eating rate, size of spoonfuls, frequency of spoonfuls and total intake |
| Mitchell (40) | 1.58 (0.51) | 2,266 | 78.6 | 18-78 | Clinical | Self-report: applying DSM-IV criteria with DSM-350 (15.7%) | BDI (82) | (Continues) | (Continues) |
| Authors                  | Mean data quality (SD) | Sample size (in groups where appropriate) | % Female participants in sample | Age mean (SD) or range (years) | Type of sample | BMI mean (SD) | Method of assessing BED | Sample size classified as BED n (%) | Emotion | Eating behaviour or emotional eating |
|-------------------------|------------------------|------------------------------------------|--------------------------------|-------------------------------|----------------|--------------|------------------------|-------------------------------------|---------|-----------------------------------|
| Munsch (56)             | 1.58 (0.51)            | 22 (obese BED)                           | 100                            | 45.5 (12)                     | Clinical       | Median = 45.6 (range = 41.3–51.6) | V cut-off of one binge per week       | 22 (100%) | Two items measured loss of control; three items measured night eating |
| Schulz & Laessle (50)   | 1.42 (0.65)            | 71 (BED n = 35, non-BED n = 36)          | 100                            | BED group = 32.4 (8.0)         | Non-clinical   | BED group = 37.0 (5.5), non-BED group = 36.9 (6.1) | Interview: Eating Disorder Examination (96), SKID (94) | 35 (49.3%) | Electronically administered question “Did you experience a binge episode?” UEM |
| Svaldi et al. (51)      | 1.50 (0.67)            | 52 (BED n = 27, healthy control [HC] n = 25) | 100                            | BED = 42.7 (11.6) HC = 38.3 (13.8) | Clinical BED group = 36.7 (3.89), non-BED group = 33.6 (6.53) | Interview: SKID (94), EDE (96) | 27 (51.9%) | Sadness was rated on a Likert scale ranging from 1 (not at all) to 8 (extremely), BDI (82) |
| Zeeck et al. (46)       | 1.75 (0.62)            | 63 (BED-obese n = 20, non-BED obese n = 23, HC n = 20) | 100                            | BED-obese = 39.3 (12.7), non-BED-obese = 45.4 (11.3), HC = 39.7 (11.6) | Clinical BED-obese and non-BED-obese; non-clinical HC | BED-obese = 42.8 (6.0), non-BED-obese = 45.4 (11.3), HC = 23.1 (2.5) | Interview: applying DSM-IV criteria | 20 (32%) | Desire to binge (bespoke) |

BE, binge eating; BED, binge eating disorder; BMI, body mass index; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, 4th Edition; s-BED, sub-threshold binge eating disorder; SD, standard deviation.
recruited from a clinical sample and five recruited from a non-clinical sample. The number of BED participants recruited ranged from 11 (39) to 350 (40), with those participants categorized as BED having mean BMI ranging from 32.9 kg m\(^{-2}\) (standard deviation [SD] = 6.9) (41) to 44.3 kg m\(^{-2}\) (SD = 6.8) (42). Regarding the age of participants, 13 studies reported on adults and two studies reported on children (39,43); the mean age ranged from 10.5 (SD = 1.9) (43) to 47.4 (SD = 13.7) (44) years. The percentage of female participants in studies ranged from 51% to 100%.

Data quality

The possible range of scores on the quality assessment was 0–2, with a higher score indicating better quality (38). The mean scores (SD) for individual indicators of quality across all included studies are presented in Table 2. The overall mean score for data quality was 1.52 (SD = 0.20, n = 15; range = 1.08 (45) to 1.75 (46)). Two studies scored more than one standard deviation below the sample mean (42,45) (Table 2). While the findings from these studies are included in the synthesis, they should be interpreted with caution.

Studies performed well on describing hypotheses and participants lost to follow-up. Studies performed poorly on controlling for confounding variables. For example, all but two (41,46) experimental studies, which measured food consumption, failed to account for BE being more prevalent towards the evening (47) when scheduling data collection (41,43,48–51,46). A further example was offering limited food types in experiments (43,48–51); not only is food craving culturally specific (52,53), but increasing the variety and amount of food presented in laboratory meals increases the amount eaten (54).

Overall, the included studies were of poor quality in relation to the sample size. Despite the BED focus of included studies, only four studies had 100% classified as having BED or sub-threshold BED (s-BED) (44,55,48,56), and seven papers had less than (or equal to) one-third of participants classified with BED (39–42,45,57,46). Data reporting in analyses was not consistent enough to allow for meta-analysis, and for the most part, effect sizes and estimates of variance were not reported.

Table 2  Indicators of quality for included studies

| Item | Indicator of quality | Mean (SD) |
|------|----------------------|-----------|
| 1    | Hypothesis description | 1.87 (0.35) |
| 7    | Describing those lost to follow-up | 1.80 (0.45) |
| 3    | Predictor and outcome measures description | 1.67 (0.49) |
| 14   | Methods of analysis | 1.67 (0.49) |
| 2    | Study is well described | 1.67 (0.49) |
| 20   | Conclusions | 1.61 (0.51) |
| 6    | Describing the sample | 1.60 (0.51) |
| 5    | Selection is unbiased | 1.60 (0.51) |
| 19   | Description of findings | 1.60 (0.51) |
| 13   | Quality of measures | 1.53 (0.52) |
| 4    | Follow-up | 1.5 (0.58) |
| 9    | Randomisation | 1.50 (0.58) |
| 15   | Inclusion of effect sizes | 1.33 (0.72) |
| 10   | Description of protocol | 1.33 (0.82) |
| 8    | Sample size | 1.27 (0.70) |
| 16   | Control for confounding variables | 1.13 (0.64) |

None of the included studies were Randomised control trials therefore the four items referring to RCTs are excluded from the reported data. SD, standard deviation.

Measurement

Emotion as an antecedent of eating was typically assessed using validated psychometric scales (39,40,42,44,55,45,48,56,51,46). Depression was most commonly examined (Table 1). Visual analogue scales were used to measure emotions in four studies (43,48–50), and three used a bespoke scale (41,42,51). Emotional eating was assessed using two validated psychometric measures across three of the included studies (44,57,46).

A wide range of measures were utilized to assess BED (Table 1), which presents challenges in drawing comparisons across the published literature. In eight studies, a trained practitioner administered a structured clinical interview, including the structured clinical interview for the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV) (49,56,50,51), the Eating Disorders Examination (57,48,56,51) and the Child Eating Disorder Examination (39,43) (adapted from the adult version (58)). Eight of the included studies assessed presentation of BE against DSM-IV criteria using either a bespoke interview (40–42,55,45,57,48,46) or self-report data (40). All included studies assessed BE retrospectively, presenting a limitation, as some individuals who explicitly deny BE when assessed prospectively, demonstrate behaviours that meet BED criteria when assessed in the moment (59,60).

Application of DSM BED diagnostic criteria in included studies

Twelve of the included studies classified participants according to DSM-IV (4) diagnostic criteria. The variability in classification of BED may be accounted for by a recent change in frequency of BE episodes required for diagnosis of BED (61) (from twice weekly (4) to once (3)). Two studies cited a cut-off of two binge episodes per week (42,45); two studies used a cut-off of one BE episode per week (40,57). Four studies stated that the DSM-IV (4) criteria had been applied, implying that a cut-off of two binge episodes per week was used (41,56,51,46). As a further complexity in the classification of BED, four studies classified participants with a sub-threshold variant of BED (s-BED). This is defined
as having a minimum of one binge episode per week (62), while fulfilling all other DSM-IV criteria (4). One study analysed the s-BED group separately (55), and three merged them with the BED group (48–50).

Finally, BED was not classified according to the DSM (3,4) criteria in three of the included studies, which used the Binge Eating Scale (44) or the Child Eating Disorder Examination (39,43). Goldschmidt et al. (43) reported frequency of bingeing episodes; participants classified as BED reported a mean of 12 (SD = 13.5) BE episodes over the past 3 months, placing them within the range of one episode per week in line with Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (3). There is a need for researchers to consistently apply diagnostic criteria to improve the clinical utility of research findings.

**Narrative synthesis of findings and discussion**

**Associations between emotions and binge eating**

In a community sample of obese individuals with BED (44), depression was both positively and significantly correlated with self-reported BE as measured by a psychometric tool, the Binge Eating Scale (63). Higher depressive symptoms were also independently related to higher odds of reporting with BED (40). Finally, meeting diagnostic criteria for BED-obese was associated with receiving treatment for depression (40) when compared with non-BED-obese and normal weight controls.

Zeeck et al. (46) invited participants to recall their last experience of a particular emotion during a one-to-one standardized interview. They then rated ‘urge to eat’. A list of emotions, provided as a prompt, was taken from the Differential Affect Scale (64) and the Emotional Eating Scale (65). An urge to eat was significantly higher in BED-obese patients experiencing anger or feelings of being hurt, guilty or disappointed, in comparison with non-BED-obese and healthy controls. There was also a statistical difference concerning the positive emotion ‘satisfied’, with BED-obese showing the lowest urge to eat when experiencing this emotion (46).

Allen et al. interviewed children (aged 8–13 years) to establish the presence or absence of BE in the month prior to assessment. Clinicians assessed children’s BE during interviews at baseline and 1-year follow-up. Emotions were associated with onset and cessation of BE. Specifically, ceasing BE was associated with a decrease in depression and emotional eating. The onset of BE was associated with a slight increase in these variables or they remained stable over time (39).

Finally, BE (as measured by the Binge Eating Scale (63)) was significantly correlated with hypomania (55). The authors conclude that ‘affective instability, which characterizes bipolar spectrum disorders, might be a particularly potent predictor of BE’ (p. 582). Further evidence of the importance of the stability of emotions was found in experimental research (see succeeding text (56)).

There are limitations to measuring the association between emotions and BE using self-report as the previous studies have done. These include under-reporting (59,60) and reliance on the participant’s accurate recall of events/emotions. In an attempt to overcome the limitations of retrospective recall, other studies (41,56) attempted to capture BE as it occurs, within the natural environment.

**Ecological momentary assessment**

Munsch et al. (56) used ecological momentary assessment (EMA) to explore emotions and BE. Participants were supplied with a palmtop computer, which was used to ask direct questions about eating and emotions (e.g. Did you experience binge eating since your last entry?) or to respond to a computerized Likert or visual analogue scale.

Participants completed the questionnaires in response to an alarm that was set at five time-contingent intervals throughout the day, over 7 d. In addition, event-contingent data were gathered whereby participants completed the questionnaires whenever BE occurred. Using this method allows for subtle variations in emotion to be mapped against BE episodes. With a sample of BED-obese participants, immediately before a BE episode, a significant curvilinear increase in tension was observed, coupled with a significant curvilinear decrease in positive mood; this was most pronounced shortly before the first binge (56). There was a slight improvement in mood up until 30 min before a binge episode, followed by an abrupt deterioration immediately before the binge. Together with findings relating BE to hypomania (55), this suggests that the stability of, and interplay between, emotions may be of interest in examining antecedents of BE.

Using a similar protocol, Hilbert (41) asked participants to rate their mood (on a seven-point rating scale where 0 = very bad and 6 = very good) on 32 randomized occasions per day, over 2 d, and before, during and after each episode of eating. Mood was significantly more negative prior to BE episodes, when compared with normal eating episodes among participants diagnosed with BED; this pattern did not occur in healthy controls. However, as the paper examines the role of general negative mood in BE episodes, it offers no insight into the role of discrete emotions.

With regards to the protocol used to capture emotions and BE behaviour, an EMA protocol, as exemplified here (41,56), offers several advantages. Given that EMA occurs in the natural environment, this increases ecological validity by allowing for more naturalistic observations of eating behaviour, and other variables of interest (66). Furthermore, the use of this methodology offers greater insight into the trajectory of emotions over time, the associations between
emotions and their significance for binge behaviours. This presents the potential to determine if relationships between emotions and food are systematically associated over time.

It is important to note that EMA methods may not be without limitations. Assessments are completed repeatedly and in close proximity to the behaviours, thoughts and emotions of interest. As such, this presents the possibility that the research methods themselves may affect the variables under investigation (66,67); this is known as reactivity. In completing an assessment, a participant may become more aware of rising anxiety or have an opportunity to reconsider their behaviour (67) and thus take steps to lessen this emotion, or change the behaviour, should it be perceived as unwanted. For example, an individual may resolve not to binge-eat as they consciously think through the potential consequences of a binge episode.

To account for this possibility, Munsch et al. (56) measured reactivity to EMA using items such as ‘Did the frequency of binge eating change during the diary period?’ and ‘Did you focus more on your psychological well-being?’ They found patients to be highly compliant with no evident reactivity to EMA. Furthermore, estimated treatment effects for BE were found to be comparable for EMA and questionnaire-based methods, suggesting that BE can be equally accurately assessed by these methods (68).

Emotional induction experiments

Five studies presented experimental data on eating behaviour in response to emotion induction. Two (49,50) tested the effect of lab-based stress induction on the consumption of chocolate pudding. The studies compared BED-obese with non-BED-obese participants who were drawn from a community sample. Stress was induced through the Trier Social Stress Test (69). Overall and independent of the stress induction, those with BED ate larger-sized spoonfuls during the laboratory ‘meal’ (50). Those with BED had a greater increase in average eating rate during the stress condition when compared with a no-stress condition and a corresponding greater increase in frequency of spoonfuls of chocolate pudding were eaten (49). In participants with BED, stress was associated with an increase in the initial eating rate, and they decelerated to a lesser extent than matched controls towards the end of the ‘meal’ (50).

Three studies induced sadness in a laboratory setting using film clips (43,48,51). In a sample of women with sub-threshold BED drawn from an eating disorders unit and the community, depressive mood at baseline was significantly associated with caloric intake during a taste test (48). There was also a significant interaction effect whereby the more depressed participants were at baseline, and the greater the sadness following the clip, then the more calories were consumed in the taste test (48).

Svaldi et al. explored the causal role of emotional regulation in the association between emotion and BE. After inducing sadness, participants were asked either to regulate their emotions, either by suppressing the sad emotion or reappraising it. The induction of sadness using a film clip was found to increase desire to binge among female BED patients but not among healthy controls (51). Emotion suppression mediated the association between sadness and desire to binge. Specifically, desire to binge increased from baseline to post-film in BED-obese when asked to suppress their emotion, but not after the reappraise instruction. These specific differences were not observed in the healthy controls (51). Conversely, in girls (43), total energy intake among BED participants was no different when sadness was induced when compared with a neutral condition. In the neutral film condition, those classified as ‘binge eaters’ ate significantly more than the control group. However, these results did not meet significance in further analyses, which found the consumption of food was not predicted by BE status, nor by the interaction between BE status and condition. It may be that the association between emotions and BE behaviour differs across the lifespan, and emotions, other than sadness, are more salient as triggers for children.

Quasi-experimental studies

Quasi-experimental designs have explored how the association between BE and emotions differs when comparing BED-obese with a control group. Those classified as BED-obese report significantly more emotional eating (57) when compared with non-BED-obese and normal weight controls. BED-obese participants (45) report higher emotional distress related to feelings of loss of control over eating in comparison with matched non-BED-obese controls.

Colles et al. asked BED-obese and non-BED patients enrolled on a bariatric surgery programme what emotional factors predisposed them to consume food they knew not to be best for them. There was a significant difference in fatigue as a trigger for eating between the groups (42); however, the direction of this difference was not reported. They found no significant difference between groups in boredom or anger as an emotional trigger of eating. In contrast to experimental findings reported in the previous text, there was no difference in the frequency of stress as the self-reported trigger for eating when comparing BED-obese and non-BED-obese participants (42).

Conclusions

Findings from included studies evidence associations between emotions and BE. Meeting the diagnostic criteria for BED-obese is associated with reporting significantly more emotional eating (57) and reported emotional eating
fluctuated in line with expectations relative to the onset and decline of BE (39).

Depression was consistently associated with BE (44,46), with BED-obese patients more likely to present with depression or have been treated for it in the past (40). Depression predicted eating behaviour among BED-obese participants during experimental taste-tests (48), and was found to be higher prior to onset of BED, thereafter decreasing when BED ceased (39).

While general negative mood was found to be an antecedent of BE among BED-obese adults (41), findings regarding associations between other discrete negative emotions and BE were less consistent. When compared with healthy controls, individuals classified as BED-obese reported no difference in stress as a trigger of BE (42); however, experimental induction of stress resulted in them eating larger spoonfuls of food (50), and at a faster rate (49). Similarly, compared with non-BED-obese, and healthy controls, BED-obese patients reported a significantly higher urge to eat when experiencing anger (46); however, there was no difference between comparable groups recalling anger as a trigger for a previous binge episode (42).

The experimental induction of sadness (43,48,51) led to consumption of more food (48) or a higher reported desire to binge (51). However, this finding was not consistent in children (43). Other negative emotions associated with an urge to eat in BED-obese patients including feeling hurt, guilty or disappointed (46), whereas boredom did not associate with BE among BED-obese (42).

Only two studies (56,46) examined positive emotions in relation to BE, with inconclusive findings. Those who were BED-obese reported the lowest intensity of desire to eat in response feeling satisfied when compared with matched obese non-BED and healthy controls (46). However, EMA data indicated that a decrease in positive emotions and an increase in tension were predictive of BE (56). Associations with hypomania (55) suggest that emotional instability may have a role in emotion and BE relationships.

Real-time self-monitoring of thoughts, feelings and behaviours has long been used in clinical practice to either assess emotions and BE or present an intervention. Self-monitoring forms are a central aspect of enhanced cognitive behavioural therapy (CBT-E; 16) the aim being to increase self-awareness. However, this intervention is problematic as adherence can be poor due to the inconvenience of recording in real time (16), and it is common for BE and/or emotions to be denied or under-reported (41,72–74). Evidence supports the use of EMA as a suitable alternative on both counts (41,59,68).

Clinical use of EMA may inform interventions for alternative emotion regulation strategies (51) and targeting a reduction of BE (43). Such interventions may address eating behaviour after emotional events (e.g. awareness-based interventions or interventions that focus on cognitive restructuring) and the capacity to cope with stressful situations. Presently, evidence for the effectiveness of EMA as an intervention is equivocal, but limited (75,76). The clinical utility of research findings regarding emotions and BE could be enhanced through the aligned use of EMA in clinical and research practices. This would help identify relatively consistent associations in the temporal dynamics of discrete antecedent, comitant and consequent emotions and cognitions in relation to food intake.

A final practical implication from this review stems from the consistent findings that BE was under-reported in included studies. Establishing trust and honesty in therapeutic relationships is a prerequisite for developing understanding and supporting behaviour change interventions (77). These attributes facilitate the expression of emotions-related and behaviours-related eating (77), which is vitally important in addressing under-reporting. Clinicians must emphasize the need for mutual trust and honesty in supporting a therapeutic alliance, reinforcing this need when undertaking diagnostic interview or utilizing patient self-monitoring.

In conclusion, the included studies offered support for the association between emotions and BE. However, theories that seek to explain emotions and BE associations largely discount the possible role of positive emotions. In order to progress theory and clinical practice, researcher and clinicians must address methodological limitations outlined within the present paper and consider the role of discrete positive and negative emotions prior, during and post BE behaviours.

Recommendations

Theories that seek to explain the association between emotions and BE contend that individuals may be using BE to regulate emotions, specifically negative emotions (13,14,17). With this theoretical steer, knowledge regarding associations between positive emotions and BE is limited, as research has largely focussed on examination of negative emotions (70). Capturing the true intensity and complexity of emotions requires differentiation between discrete positive and negative emotions (71). As such, consideration of distinct positive and negative emotions may offer theoretical advancements and greater utility in the design and delivery of clinical interventions for BED.
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**Appendix 1: Example Search Strategy (Medline)**

1. Control OR restrain*
2. Manage OR management
3. Regulation OR regulate OR regulatory
4. 1 OR 2 OR 3
5. Eat OR eating OR food OR meal* OR snack OR snack* OR feed OR feeding OR diet*
6. Afraid OR fearful OR fear OR scared
7. Aggressive OR aggression
8. Active OR energetic OR alert OR exhilarated OR lively OR vigorous
9. Anger OR angry OR annoy* OR furious OR mad
10. Anxious* OR nervous* OR concerned OR panic* OR apprehensive OR tense OR worried OR worry
11. Ashamed OR shame* OR embarrassed OR guilt*
12. Bitter OR bitterness
13. Boredom OR bored
14. Calm OR peaceful OR relaxed
15. Cheerful OR happy OR happiness OR joyful OR overjoy*
16. Content* OR pleased OR settled
17. Confused OR mixed-up OR muddled OR uncertain
18. Content* OR pleased OR settled
19. Dejected OR depressed OR downhearted OR miserable OR sad OR sadness
20. Disappointed OR disappointment OR disappoint OR dissatisfaction OR dissatisfied
21. Upset OR unhappy OR unhappiness
22. Delight OR delightful OR elated OR ecstatic OR excite OR excitement
23. Determine OR determined OR motivate OR motivated
24. Distress OR distressed OR pressured OR strained OR stress OR stressful OR stressed OR overwhelmed OR overwhelming OR overwhelmed
25. Exhaust or exhausted OR fatigue OR sleepy OR sluggish
26. Frustrate OR frustrated OR frustration OR irritable OR irritability OR irate OR irritated OR restless OR restlessness OR uneasy OR uneasiness OR uneasy
27. Fulfil OR fulfilment OR satisfied OR satisfy OR satisfaction
28. Inspired
29. Proud
30. Relief
31. 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30
32. 4 AND 5 AND 31

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