Kittel, Rebekka, Brauhardt, Anne, & Hilbert, Anja

Leipzig University Medical Center, Integrated Research and Treatment Center AdiposityDiseases, Medical Psychology and Medical Sociology, Philipp-Rosenthal-Strasse 27, 04103 Leipzig (Germany)

Correspondence concerning this manuscript should be addressed to Rebekka Kittel, MSc, Leipzig University Medical Center, Integrated Research and Treatment Center AdiposityDiseases, Philipp-Rosenthal-Strasse 27, 04103 Leipzig (Germany).

Email: rebekka.kittel@medizin.uni-leipzig.de

Phone: +49 341 97 15366

Fax: +49 341 97 15359

COGNITIVE AND EMOTIONAL FUNCTIONING IN BED

ABSTRACT

Objective: Binge-eating disorder (BED) is characterized by recurrent episodes of binge eating and is associated with eating disorder and general psychopathology and overweight/obesity. Deficits in cognitive and emotional functioning for eating disorders or obesity have been reported. However, a systematic review on cognitive and emotional functioning for individuals with BED is lacking.

Method: A systematic literature search was conducted across three databases (Medline, PubMed, and PsycINFO). Overall, *n* = 57 studies were included in the present review.

Results: Regarding cognitive functioning, individuals with BED consistently demonstrated higher information processing biases compared to obese and normal-weight controls in the context of disorder-related stimuli (i.e., food and body cues), whereas cognitive functioning in the context of neutral stimuli appeared to be less affected. Thus, results suggest disorder-related rather than general difficulties in cognitive functioning in BED. With respect to emotional functioning, individuals with BED reported difficulties similar to individuals with other eating disorders, with a tendency to show less severe difficulties in some domains. In addition, individuals with BED reported greater emotional deficits when compared to obese and normal-weight controls. Findings suggest general difficulties in emotional functioning in BED. Thus far, however, investigations of emotional functioning in disorder-relevant situations are lacking.

Discussion: Overall, the cross-sectional findings indicate BED to be associated with difficulties in cognitive and emotional functioning. Future research should determine the nature of these difficulties, in regards to general and disorder-related stimuli, and consider interactions of both domains to foster the development and improvement of appropriate interventions in BED.

Keywords: binge-eating disorder, obesity, cognitive functioning, emotional functioning, emotion regulation, emotional awareness

COGNITIVE AND EMOTIONAL FUNCTIONING IN BINGE-EATING DISORDER: A SYSTEMATIC REVIEW

In the last two decades, substantial research led to the inclusion of binge-eating disorder (BED) in the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5; 1). BED is characterized by recurrent binge eating episodes that occur in the absence of recurrent inappropriate compensatory behaviors. Further, BED is associated with significant eating disorder and general psychopathology, impaired quality of life, and overweight/obesity (1). The recurrent binge eating episodes, as key symptoms of BED, are marked by a sense of lack of control over eating, implying pervasive difficulties in self-control processes. Problems regarding self-control in BED (i.e., the capacity to regulate thoughts, emotions, and behaviors; 2) suggest mechanisms of cognitive and emotional dysfunctioning to play an important role in the development and maintenance of BED. They have not, however, been systematically reviewed thus far.

Cognitive functioning and processing (CoF), involves “aspects of perception, thinking, reasoning, and remembering” (3; p. 412) in the context of neutral stimuli and information processing of disorder-related stimuli (i.e., food and body cues). Substantial research on CoF led to the publication of systematic reviews for anorexia nervosa (AN) and bulimia nervosa (BN). Overall, difficulties in executive functions (e.g., cognitive flexibility) and increased cognitive biases to disorder-related stimuli (i.e., attentional bias) were found in individuals with AN and BN (4-6). In addition, individuals with AN demonstrated deficits in visuo-spatial and visuo-constructive skills (4). However, recent investigations did not consistently replicate difficulties in, for example, cognitive flexibility in individuals with AN and BN (e.g., 7). Thus, firm conclusions on CoF deficits in individuals with AN and BN cannot yet be drawn (8; 9). Consistent with findings in individuals with AN and BN, systematic reviews identified deficits in overweight/obese individuals primarily in the domain of executive functions (e.g., difficulties in cognitive flexibility and decision making). Other aspects of CoF (e.g., language and memory) were less affected when compared to normal-weight controls, but were also investigated less (10, 11). Furthermore, an increased initial attention bias to food stimuli was found in overweight/obese individuals, but the studies did not consistently account for BED as a confounding factor (12).

Emotional functioning (EmF) comprises two rather distinct aspects of emotion regulation (ER) and emotional awareness (EA). While ER can be defined as the "process of initiating, avoiding, inhibiting, maintaining, or modulating the occurrence, form, intensity, or duration of internal feeling states, […]." (13; p. 338), EA encompasses difficulties in the differentiation of internal states (i.e., alexithymia, interoceptive awareness, and clarity; cf. 14). Thus far, a meta-analytical review found a dysfunctional use of various ER strategies in AN, BN, BED, and other types of disordered eating (15). Difficulties in ER and EA have also been reported in AN and BN when compared to healthy controls (16; 17). Just as for individuals with AN or BN, recent investigations and a narrative review reported difficulties in ER and EA in obese individuals when compared to normal-weight controls (18-20).

Research on self-control usually considered CoF and EmF to be isolated processes (21). However, this segregation appears rather artificial as several investigations point to the interdependence of these two processes (e.g., 22; 23). Summarizing the current state of research on BED, binge eating episodes are considered to be a multiply determined behavior linked to processes of CoF and EmF (24). In addition, several theories support the interrelation of cognitive and emotional processes in BED. The escape theory (25) postulates that cognitive processes are influenced by emotional states through a decrease of awareness when facing intolerable negative emotions. Comparatively, the ironic process theory (26) postulates that cognitive processes, in turn, influence emotional states (i.e., suppression of unwanted emotions) when confronted with stressors and distractors.

Previous narrative and systematic reviews underline the importance of CoF and EmF in eating disorders and overweight/obesity. As CoF and EmF are also considered to be relevant for processes of self-control in BED, an integrated review of the two is warranted, especially because previous reviews focused mainly on AN and BN, did not differentiate between eating disorder diagnoses (i.e., AN, BN, and BED), or included obese samples without explicitly focusing on the presence/absence of eating disorder symptoms (e.g., BED). Systematic investigations on EA in BED are lacking. Thus, this systematic review sought to critically summarize the current state of research on CoF and EmF (including ER and EA) in individuals with BED in comparison to (1) healthy controls (HC) and individuals with AN or BN, and (2) normal-weight (NW) and overweight/obese individuals without an eating disorder diagnosis (OW/OB).

METHOD

Search and Study Selection

A systematic review was conducted according to the PRISMA guidelines (27). Relevant studies published through April 2014 were identified in three electronic databases: Medline, PubMed, and PsycINFO. Search terms included "cognitive regulation, cognitive control, cognitive funct*, cognitive deficit*, neurocogn*, neuropsycholog*, executive funct*, flexib*, inhibit*, working memory, memory, verbal fluency, attention, decision-making, processing, cue, stimuli, emotion regulation, affect* regulation, emotion* control, affect* control, avoid*, ruminat*, accept*, reapprais*, suppress*, problem solving, alexithymia, interoceptive awareness, and emotional awareness" combined with "binge eating". In addition, cross-references from potentially relevant studies were examined and authors in the area of interest were contacted for articles in press. Titles and abstracts were screened, and for those considered relevant, full texts were checked for eligibility (see Figure 1 for an overview).

Eligibility Criteria and Data Collection

To be included in this review, studies had to: (1) include a sample of adult individuals diagnosed with BED according to the research criteria of the DSM-IV-TR (28) or binge eating in the absence of recurrent inappropriate compensatory behaviors; (2) provide statistical comparisons to HC, individuals with other eating disorders (i.e., AN or BN), NW or OW/OB groups on performance-based, (neuro-)physiological or self-report measures of CoF, ER or EA; and (3) be published in the English or German language. Studies reporting qualitative outcomes only were excluded.

Adult only samples were selected in order to increase the homogeneity of the studies. Consequently, this led to the exclusion of one study comprising a child/adolescent sample with BED (29).

Relevant data on study samples (e.g., age, body mass index, sample size), assessment methods of BED (e.g., self-report, clinical expert interview), assessment methods of CoF, ER, and EA including performance-based, (neuro-)physiological or self-report measures, and outcome variables were extracted from the studies and summarized in an a priori designed extraction form. To counter inadequate reporting of data or reviewers' uncertainty about data, the corresponding authors were contacted to ensure complete data collection. An overview of study characteristics is displayed in Table 1.

RESULTS

Study Characteristics

A total of *n* = 57 studies fulfilled the inclusion criteria covering CoF utilizing neutral stimuli (*n* = 12) and disorder-related stimuli (*n* = 16), ER (*n* = 10), and EA (*n* = 24) in BED. All but one study included individuals with BED with diagnoses based on DSM-IV/DSM-IV-TR/DSM-5 criteria. The remaining study diagnosed binge eating and excluded recurrent inappropriate compensatory behaviors, however, no diagnoses were provided. The majority of diagnoses were based on clinical interviews (*n* = 32), while *n* = 9 studies used self-report measures. Other studies did not specify the assessment of BED (*n* = 16). The mean BED group size was 40 (*SD* = 31.6) and ranged from 8 to 150. The majority of studies featured an all female sample (*n* = 42) and *n* = 15 studies had a predominantly female sample. Of all the studies included, *n* = 44 utilized obese control groups and *n* = 17 used control groups with other eating disorders[1]. The use of assessment methods (performance-based, (neuro-)physiological, or self-report measures) and outcome variables varied substantially across studies.

Information on assessment methods regarding CoF, ER, and EA will be given in detail separately in the results section. In line with other reviews in this area (9; 10), findings will be reported in their correspondence to the aspects of CoF, ER, and/or EA assessed. However, as some measures cover more than one aspect, allocation of instruments to only one aspect of CoF, ER, and/or EA was, to an extent, arbitrary and based on the consensus of all authors.

Cognitive Functioning and Processing utilizing Neutral Stimuli

Out of *n* = 12 studies on CoF utilizing neutral stimuli, *n* = 9 applied performance-based measures, *n* = 2 used functional magnetic resonance imaging (fMRI), and two studies utilized self-report instruments.

Performance-Based Measures

Inhibition. Inhibition was assessed in six studies. The studies applied different response inhibition paradigms including the Stroop Color-Word Test, a Stop Signal Task, a novel translation of the Rodent 5-Choice Serial Reaction Time Task, and the Conners' Continuous Performance Test to assess aspects of response inhibition (30-35). No differences were found between individuals with BED and OB or NW controls.

Flexibility. Four studies measured flexibility using neuropsychological tests. Administering a subtest of the Trail Making Test, requiring alternation between numbers and letters, resulted in ambiguous findings. Prolonged completion times were found for individuals with BED compared to OW/OB controls in one study (36), while no differences were found in two other investigations (33; 34). Studies assessing flexibility with the Rule Shift Cards Test and Wisconsin Card Sorting Test (WCST), operationalized as the ability to shift between rules, also yielded heterogeneous results (33; 35). While obese individuals with BED did not differ from OB controls on the Rule Shift Cards Test, obese individuals with BED were found to show greater shifting difficulties using the WCST (33). In contrast, individuals with BED and NW controls did not differ on the WCST in another investigation (35).

Working Memory. Working memory was investigated in two studies. Regarding verbal working memory, assessed with the Digit Span Test, findings were inconsistent. While one study found differences between obese individuals with BED and OB controls (33), another study did not find any group differences (34). Further, using a task similar to the Spatial Span Test of the Wechsler Memory Scales, obese individuals with BED did not differ from OB controls with regard to visual working memory (34).

Memory. Verbal memory was measured in one study. When participants were asked to memorize a list of neutral stimuli, morbidly obese individuals with BED did not differ from OB individuals (34).

Decision Making. Decision making was investigated in five studies yielding inconsistent results. Using the Iowa Gambling Task (IGT), one study found obese individuals with BED and OB individuals to display greater difficulties in decision making when compared to NW controls, whereas individuals with BED and OB individuals did not differ (37). In contrast, another study did not find any group differences when controlling for level of education (38). Using an electronic version of the IGT (i.e., the Bechara Gambling Task) to investigate the impact of negative affect on decision making, negative affect did not change the choice behavior after rewards (i.e., winning money) in individuals with BED, BN, and HC (39). However, after punishment (i.e., losing money), increased negative affect led to more disadvantageous choice behavior in individuals with BED and BN when compared to HC. Conversely, decreased negative affect led to more disadvantageous choice behavior in HC. Assessing decision making using the Game of Dice Task, overweight/obese individuals with BED showed more risky choice behavior (i.e., disadvantageous choices in the long run) in comparison to OW/OB individuals in one study (36), while no differences were observed in another study (31).

Delay of Gratification. The ability to delay gratification (i.e., value of immediate rewards relative to delayed rewards) was assessed in one study. No differences were found between obese individuals with BED when compared to OB and NW controls when controlling for the level of education in one study (38).

Planning and Problem-Solving. Planning and problem-solving were assessed in only one study (33) using three subtests of the Behavioural Assessment of the Dysexecutive Syndrome. Obese individuals with BED achieved lower outcomes when compared to OB controls in the Action Program Test, involving novel problem-solving, and in the Modified Six Elements Test, requesting task scheduling and performance monitoring. In the Zoo Map Test, obese individuals with BED produced more errors in the high-demand condition requiring the formulation of a route, while no differences appeared for all other outcomes of the test.

Verbal Fluency. Verbal fluency was investigated in one study (34). Obese individuals with BED did not differ from OB individuals in a Letter Fluency Task, asking participants to generate as many words as possible in a specific time period with a specific first letter, nor in an Animal Fluency Task, requiring participants to name animals.

Spatial Imagination. Spatial imagination was investigated in one study. Using the Maze Task as a computerized adaptation of the Austin Maze, no differences in the detection of a path through an 8x8 grid of circles were found for obese individuals with BED and OB controls (34).

(Neuro-)Physiological Measures

Brain activation. When using fMRI in two studies to assess brain activation during task performance, individuals with BED demonstrated reduced prefrontal and insular processing in a Monetary Loss Task in comparison to OB and NW controls in one investigation (40). OB controls showed increased ventral striatal and prefrontal cortex activity compared to NW controls. Completing the Stroop Color-Word Test, individuals with BED demonstrated diminished activity in the prefrontal cortex, insula, and inferior frontal gyrus compared to OB and NW controls in the second investigation (32).

Self-Report Measures

Inhibition. Inhibition was the only aspect of CoF investigated that utilized self-report measures in $n = 2$ studies. Applying the Frontal Systems Behavior Scale to assess self-rated disinhibition (as well as apathy and executive dysfunction), morbidly obese individuals with BED or subthreshold BED reported greater difficulties than did OB controls (41). In addition, using the Self-Control Scale, obese individuals with BED reported greater difficulties in overriding or changing dominant inner responses and interrupting undesired behavioral tendencies compared to OB and NW controls (37).

Cognitive Functioning and Processing utilizing Disorder-Related Stimuli

Out of $n = 16$ studies on CoF utilizing disorder-related stimuli, $n = 6$ applied performance-based measures and $n = 10$ used (neuro-)physiological measures, including eye tracking paradigms (ET), brain imaging techniques such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG).

Performance-Based Measures

Attention. One study assessed attention applying a Go/No-go Task with food- and body-related stimuli (42). No differences were found between obese individuals with BED, OB, and NW controls regarding cognitive biases for food- and body-related targets.

Inhibition. Two studies investigated disorder-related inhibition. Compared to OB or NW controls, individuals with BED showed greater difficulties in inhibition when contrasting food/body and neutral stimuli in a Go/No-go Task (42) and in a Stop Signal Task (43), suggesting inhibition deficits in the context of disorder-related stimuli.

Flexibility. Flexibility in the context of disorder-related stimuli was assessed in one study applying a Go/No-go Task. No differences were found between individuals with BED and OB and NW controls regarding mental flexibility (42).

Working Memory. Working memory in the context of food-related stimuli was investigated in one study. Employing a N-Back Task with Lures, individuals with BED showed increased cognitive interference in working memory compared to OW controls for both food-related and neutral stimuli (44).

Memory. Disorder-related memory was assessed in two studies. While overweight/obese individuals with BED remembered fewer positive body-related words compared to OW/OB individuals, no differences were found for negative body-related words and control stimuli (45). This might suggest a bias for positive body-related associations in BED. Furthermore, the use of food-related and neutral stimuli in a Recent-Probes Task revealed a specific eating-related memory bias for individuals with BED (44).

Delay of Gratification. The ability to delay gratification utilizing disorder-related rewards (e.g., food), as well as disorder-unrelated rewards (e.g., money), was assessed in one study. Obese individuals with BED discounted all delayed and probabilistic rewards more steeply compared to OB and NW controls suggesting general difficulties in delay gratification rather than food-specific alterations (46).

Spatial Imagination. Spatial imagination was investigated in one study using an Own-Body Transformation Task. Individuals with BED and HC yielded comparable results regarding the mental body transformation of a human figure or the transformation of external objects in a control condition (47). In contrast, individuals with BN showed a decreased ability relative to individuals with BED and HC when transforming body positions.

(Neuro-)Physiological Measures

Attention. A total of three studies conducted free exploration ET paradigms. Obese individuals with BED, OB, and NW controls showed more initial fixation on food stimuli compared to non-food stimuli. Additionally, obese individuals with BED demonstrated more ongoing and conscious attention allocation towards food stimuli than the OB and NW controls (48). When exposed to pictures of their own body and a control body, both individuals with BED and OW controls showed a bias towards self-rated ugly body parts (49), while individuals with BED showed a prolonged and more frequent fixation of these ugly body parts. However, the authors point to potential confounding effects as the BED group had a higher body mass index than the OB group. In a subsequent study (50), both groups showed a bias towards pictures of their own body when self and control body pictures were presented concurrently. Furthermore, individuals with BED showed more frequent fixations of their own body pictures and less frequent fixations of control body pictures compared to OW controls, while OW controls demonstrated prolonged fixations of control body pictures than did individuals with BED.

Inhibition. Only one study investigated inhibition in a modified ET Antisaccade paradigm where food or non-food stimulus were randomly presented and participants were instructed to look away from the stimuli as fast as possible. Individuals with BED showed more general, as well as food-related, difficulties in inhibition compared to OB and NW controls (48).

Brain Activation. The processing of food cues was assessed in seven studies. Utilizing an EEG paradigm, higher frontal beta activity was found in response to food stimuli compared to control landscape stimuli for both individuals with BED and OW controls (51); the frontal beta activity was greater in individuals with BED in a resting state and independent of the stimulus. In contrast, individuals with BED showed larger long latency event-related potentials for high caloric food pictures compared to OW controls, but no differences were observed for low caloric food pictures (52).

Investigating neural processing of food cues using fMRI in BED, BN, OB, and NW, a basic appetitive response pattern in all groups was found in brain areas such as the orbitofrontal cortex (OFC), anterior cingulate cortex (ACC), and insula (53; 54). Activation was found to differ between groups in the prefrontal cortex, OFC, premotor cortex, insula, ACC, ventral striatum, and amygdala (32; 40; 53-56). Greater activation in the medial OFC was observed for the BED group compared to the other groups (53), suggesting increased reinforcement sensitivity in BED. In contrast, the BED group showed a reduced activity in the ventral striatum and ACC compared to the BN group, pointing to a higher motivation and attention in regard to food cues in BN.

Only one study assessed extracellular dopamine in the dorsal striatum in BED using Positron Emission Tomography. Overall, dopamine release was increased in response to food stimuli in obese individuals with BED, but not in OB controls (57), suggesting a hyper-responsive reward system in individuals with BED.

Summary of the Results on CoF

Overall, the number of studies investigating each aspect of CoF was small and the assessment methods varied substantially across studies. In addition, comparisons of BED to BN were rare, while comparisons to AN were lacking. In conclusion, the findings suggest that obese individuals with BED (1) obtained lower scores compared to OB and NW controls in performance-based tasks especially when disorder-related stimuli (e.g., food vs. non-food, body-related stimuli) were used[2] and (2) showed selective attentional processing and increased brain activation to disorder-related stimuli. Altogether, this suggests obese individuals with BED to have higher information processing biases than OB or NW controls rather than general difficulties in cognitive functioning.

Emotion Regulation

Out of the *n* = 10 studies investigating ER in BED, a majority of *n* = 8 used self-report instruments, with two studies additionally employing experimental designs. Only one study applied a performance-based measure. None of the included studies applied (neuro-) physiological measures. Likewise, no disorder-related stimuli or tasks (i.e., food- and body-related) were utilized.

Performance-Based Measures/ Experimental Designs

Suppression and Reappraisal of Feelings. Two subsequent studies assessed the role of ER as a mediator in the link between negative emotions and eating behavior in individuals with BED and OB/OW controls. Both studies applied experimental designs in which participants were asked to watch video clips inducing negative emotions and to suppress or reappraise these emotions (58; 59). While the suppression of emotions led to a desire to binge eat in individuals with BED, reappraisal did not (58). Furthermore, actual caloric intake was significantly higher in the suppression condition compared to the reappraisal condition (59).

In contrast to the authors' previous study (58), this effect appeared for both obese individuals with BED and OB/OW controls.

Other ER and Coping Strategies. Using the performance-based Means-Ends Problem-Solving Procedure to assess the interpersonal problem-solving ability, no differences were found for obese individuals with BED and OW/OB controls regarding the number of generated relevant solutions (60). However, the produced problem solutions of individuals with BED were significantly less effective and specific compared to OW/OB controls.

Self-Report Measures

Expression, Suppression, and Reappraisal of Feelings. Self-reports on expression, suppression, and reappraisal of feelings were administered in seven studies. Utilizing the Social Skills Inventory (SSI), a lower capacity for the expression of positive feelings was associated with a higher probability of BED in a sample of obese individuals with BED compared to OB and NW controls (61). Using the State-Trait Anger Expression Inventory (STAXI), obese individuals with BED were found to demonstrate a higher tendency to express anger when compared to OB and NW controls (62). However, individuals with BED did not differ from controls in the self-control of anger and aggression in provoking social situations (SSI) and attempts to control the expression of anger (STAXI) (61; 62). Furthermore, individuals with BED reported comparatively high levels of expression of anger and attempts to control the expression of anger (STAXI), as did individuals with bulimic features (BN and AN binge-eating/purging type) and HC (63). Regarding the suppression of feelings (STAXI), no differences were found between obese individuals with BED and OB and NW controls after controlling for depression (62). In contrast, two other studies found obese individuals with BED to report higher levels of emotion suppression (Emotion Regulation Questionnaire [ERQ]) compared to OW/OB controls (58; 59). In addition, both studies found individuals with BED to report lower reappraisal of emotions (ERQ) when compared to OW/OB controls. The pattern of high suppression and low reappraisal was similar for obese individuals with BED and individuals with BN and AN (63; 64). Furthermore, individuals with binge eating (BED, BN, and AN binge-eating/purging type) reported similar levels of elevated anger suppression when compared to HC (63).

Other ER and Coping Strategies. Other ER strategies were investigated in two studies. Assessing adaptive ER strategies with the Inventory of Cognitive Affect Regulation Strategies (ICARUS), individuals with BED and AN, but not BN, reported fewer positive thoughts, reframing and growth, and mindful observation when compared to HC. No group differences were found for the use of downward comparison and reality testing (65). Furthermore, individuals with eating disorders reported less emotional acceptance when compared to NW and OW (65; 66).

Regarding maladaptive ER strategies, individuals with eating disorders (BED, BN, AN restricting type, and AN binge-eating/purging type) showed more self-criticism (ICARUS), difficulties in engaging in goal-directed behavior, impulse control difficulties, and limited access to strategies (Difficulties in Emotion Regulation Scale [DERS]) when compared to NW and OW controls (65; 66). However, individuals with BED reported fewer suicidal thoughts (ICARUS), difficulties in engaging in goal-directed behavior, impulse control difficulties, and limited access to strategies (DERS) when compared to individuals with AN and BN.

Emotional Awareness

EA was investigated in $n = 19$ studies. All studies applied self-report instruments.

Self-Report Measures

Alexithymia. Alexithymia was examined in six studies, all of them using either the original Toronto Alexithymia Scale-26 (TAS-26) or the revised Toronto Alexithymia Scale-

20 (TAS-20). Considering alexithymia as a categorical variable (i.e., defining alexithymia as TAS-26 scores ≥ 74 or TAS-20 scores ≥ 61), prevalence rates ranging from 24.1% to 62.5% were reported in individuals with BED (67-69). While higher prevalence rates in obese and normal-weight individuals with BED were reported when compared to OB and NW controls (67; 68), an earlier study found no differences in prevalences between obese individuals with BED and OB controls (69). Furthermore, prevalence rates of alexithymia did not differ in individuals suffering from binge eating (BED, subthreshold BED, and BN; 70).

When considering alexithymia as a continuous variable, higher alexithymia scores were reported for obese individuals with BED when compared to OW/OB individuals (58; 67; 68; 70; 71). In comparison to NW controls, normal-weight individuals with BED also displayed higher alexithymia scores (67). In contrast, another study found no differences between obese individuals with BED and OB controls (69). Regarding aspects of alexithymia (i.e., TAS subscales), obese and normal-weight individuals with BED reported greater difficulties in identifying and describing feelings (67; 68; 58). Only one study found obese individuals with BED to report more difficulties in identifying feelings but fewer difficulties in describing feelings (69). Furthermore, individuals with BED were also found to display more difficulties regarding externally oriented thinking (67), while other studies did not support this finding (68; 69; 58).

Interoceptive Awareness. Interoceptive awareness was assessed in 16 studies using the Interoceptive Awareness subscale of the Eating Disorder Inventory or the Eating Disorder Inventory-2. Obese individuals with BED reported greater difficulties (i.e., lower interoceptive awareness scores) when compared to individuals with sub-threshold BED (72-74), NW controls (62; 75; 76) or OB controls (62; 69; 72-74; 76-79). Only one study did not find obese individuals with BED and OB controls to differ (80). Comparisons to individuals with BN yielded lower interoceptive awareness scores in individuals with BED (73; 76; 81;

82), while other studies reported no differences (80; 83; 84), especially after controlling for age and depression (85).

Other EA aspects. Other aspects of EA were investigated in three studies. Individuals with eating disorders (BED, BN, or AN restricting type and AN binge-eating/purging type) reported a greater lack of emotional awareness and clarity (DERS) when compared to normal-weight and overweight HC (65; 66). Furthermore, less analysis of feelings and situation (ICARUS) was only reported for individuals with BED and AN (65). Overall, no group differences were found for individuals with eating disorders regarding their emotional awareness and level of analyzing feelings and situation. However, individuals with BED reported more emotional clarity than individuals with AN and BN (65; 66). Investigating the mindfulness trait as a concept associated with EA and ER (86), using the Five Facet Mindfulness Questionnaire, obese individuals with BED reported lower non-reactivity to internal experience, acting with awareness, describing internal experience with words, and observation of internal experience as facets of mindfulness when compared to OB and NW individuals (87). However, no group differences were found regarding non-judging of experience.

Summary of the Results on EmF

While aspects of ER were rarely examined, a large number of investigations focused on EA. Regarding ER, findings indicate that individuals with BED reported (1) similar difficulties as did individuals with AN and BN, with a tendency of individuals with BED to show less severe difficulties in some domains, but (2) greater difficulties than OB and NW controls. Concerning EA, results suggest that individuals with BED reported (1) fewer or equal difficulties as did individuals with BN, but (2) greater difficulties when compared to OB and NW controls.

DISCUSSION

The present review sought to systematically investigate CoF and EmF, including ER and EA, as self-regulation processes in adult individuals with BED. Overall, difficulties in CoF and EmF were found when individuals with BED were compared to individuals with other eating disorders including AN and BN, as well as healthy, normal-weight, and/or obese controls.

Regarding CoF, obese individuals with BED did not differ from obese and normal-weight controls in the majority of tasks utilizing neutral stimuli (i.e., disorder-unrelated cues). In contrast, when tasks utilizing disorder-related stimuli were applied, obese individuals with BED consistently obtained lower scores compared to obese and normal-weight controls. Overall, these results point to higher information processing biases rather than general difficulties in CoF in BED.

More precisely, in line with previous research (88), findings suggested an increased food-related reward sensitivity in BED, as individuals with BED displayed higher attention for food-related stimuli (48; 51), especially for high-caloric food (52), elevated reward responsiveness (e.g., 53), a tendency to discount food more steeply (46), and stronger responses to food stimuli in brain regions that are thought to be involved in reward processing (53; 55). In line with the latter results, alterations in brain structures related to reward sensitivity were also found in AN and BN (89; 90). However, investigations directly comparing BED to AN or BN are still lacking and further research is warranted. Overall, increased food-related reward sensitivity and deficits in delay of gratification could impede individuals with BED from sticking to plans to resist certain foods or to exercise in order to lose weight and, thus, could contribute to the maintenance of the disorder. With respect to body-related stimuli and corresponding with previous findings (91), a bias towards the own body and towards ugly body parts (49; 50) was found to be stronger in individuals with BED than in obese controls. This bias could account for the commonly found overvaluation of shape and weight found in BED (92). Furthermore, body dissatisfaction might be additionally increased by difficulties in attending to positively valenced, body-related information (45), while first evidence suggests that, contrary to BN, a maladaptive mental representation of the bodily self could be ruled out in BED (47).

In addition to attentional alterations, individuals with BED showed pronounced difficulties in food-related response inhibition compared to obese and normal-weight controls (43; 42; 48) as well as altered activation patterns in prefrontal and orbitofrontal brain regions (e.g., 53; 55) that are thought to be play a role in inhibitory control (93). Greater inhibitory impairments were also found in BN when confronted with food-related stimuli (31). So far, only two studies suggested generalized inhibitory control difficulties in BED (32; 48). These difficulties, especially when facing food-stimuli, could contribute to the rash-spontaneous behavior fostering loss of control during binge eating episodes. As comparisons between individuals with BED and BN are yet lacking, more research is needed to differentiate between the two disorders.

Several studies using ET and response inhibition paradigms have assessed early attentional stages of information processing, involving the selection of relevant information, as well as late inhibitory stages, involving the selection of relevant responses. However, the intermediate stage, once information has entered working memory, has rarely been assessed in BED (for detailed information on inhibition-related processing stages, see Ref. 94). Only one recent study investigated intermediate cognitive processes and found generally increased and selectively increased eating-related cognitive interference in BED (44). Altogether, these results suggest alterations in BED concerning the processing of disorder-related stimuli at different stages of information processing. Regarding other aspects of CoF (e.g., decision making, flexibility, spatial imagination), results were mixed and/or the number of studies was considered insufficient to draw conclusions.

With respect to EmF, studies included in the present review found similarities in the levels of ER difficulties (e.g., higher levels of emotion suppression and lower levels of reappraisal) in individuals with BED, AN or BN. Individuals with BED, however, tended to show a slightly more adaptive ER pattern than individuals with AN and BN. Regarding EA, individuals with BED reported equal or fewer difficulties than individuals with BN, while comparisons to individuals with AN are lacking. Thus, more research is needed. These results are further supported by the identification of a continuum of clinical severity across bulimic eating disorders ranging from BED being less severe to BN being more severe (95). In contrast to the findings in individuals with eating disorders, obese individuals showed fewer difficulties in ER and EA underlining the distinctiveness of obesity and BED (96). Therefore, deficits in EmF do not appear to be associated with obesity, but rather with eating disorder symptoms and eating disorder psychopathology (e.g., 65). Overall, difficulties in ER could lead to eating and binge eating in response to negative affect when effective skills are not available (97). In addition, lower levels of EA could also induce emotional eating and binge eating as individuals with BED might have deficits in differentiating between feelings (i.e., negative affects) and sensations of hunger/satiety (cf. 98). Furthermore, difficulties in identifying own emotional states and regulating them appropriately might cause interpersonal problems (61), based on troubles in expressing and communicating feelings to others in an adequate way.

Summarizing the present results, the interaction of CoF and EmF was assessed in only one study, finding more disadvantageous decision making after increased negative affect in individuals with BED and BN compared to healthy controls (39). Furthermore, difficulties in behavioral response inhibition were found to be related to self-reported emotional eating in another recent investigation (43). However, all studies assessing CoF using disorder-related stimuli might, to a certain extent, indirectly measure interactive effects between CoF and

EmF, as disorder-related stimuli could possibly trigger motivational and emotional reactions in individuals with BED interfering with CoF.

Strengths and Limitations

Several strengths and limitations of the present review should be taken into account when interpreting the findings. Strengths include the use of a systematic search strategy and a priori defined inclusion criteria. No restrictions of sample size were used as an exclusion criterion. However, it should be noted that an appropriate sample size of *n* = 26 individuals per group[3] was only met by *n* = 34 of the 57 included studies (59.6 %). Thus, several results should be treated with caution. As another limitation, eating in response to negative affect in BED (i.e., emotional eating; 99) was not further investigated in this review, although, it could be understood as a dysfunctional strategy of ER. Rather, this review aimed to shed light on the dealing with emotional states apart from eating, i.e. ER strategies and EA, to better understand why eating and binge eating occur in response to various emotional states.

In addition to the limitations of the review itself, several general limitations of the included studies should be mentioned. First, studies assessed full-syndrome and/or sub-threshold BED according to DSM-IV criteria, but the diagnostic assessment methods varied widely from self-reports to structured clinical expert interviews. Second, findings from performance-based measures and self-reports were previously shown to be weakly correlated (e.g., 100). Hence, the comparability of results was rather limited. CoF was often measured using neuropsychological tests, while self-report questionnaires were utilized to assess EmF in the majority of studies and, thus, might be more affected by a self-report bias. Furthermore, the utilization of self-report questionnaires to assess EA appears rather contradictory when asking ‘unaware’ individuals to rate their emotions (14). Third, the included studies dealt very differently with the issue of confounding variables including psychiatric comorbidities. For example, depression was found to be associated with CoF and EmF (15; 101) and, therefore, might have been controlled for. On the other hand, comorbidity rates of affective disorders including depression and BED are high (102). However, as most of the studies did not control for comorbidities and some studies excluded comorbidities in control individuals only, it could not be ruled out that differences in these variables may have affected difficulties of CoF and EmF in BED. Fourth, a majority of studies investigated CoF and EmF in only women with BED, limiting the research on gender effects in BED. Fifth and last, all studies included in this review investigated CoF and EmF cross-sectionally, thus, impeding the identification of potential causal relationships and trajectories of CoF and EmF in the development and maintenance of BED.

Research Implications

While some difficulties in CoF and EmF in individuals with BED are evident, less is known about which specific aspects of CoF and EmF are altered in BED as well as in other eating disorders (e.g., 8). Thus, implications for future research include the development of guidelines and standard assessment batteries to assess various CoF aspects, e.g., the Ravello Profile (103), in order to identify specific difficulties across diagnoses or within patients with one diagnosis. Moreover, developing more instruments using disorder-related stimuli and neutral stimuli would provide further insight into specific impairment profiles in individuals with eating disorders (9). Concerning EmF, previous research mostly assessed ER strategies independently of the situational context. More research is needed in affect-evoking and/or disorder-relevant situations as they were found to interact with individuals' ER strategies (58; 59; 104). Further, a majority of studies in this review used the Interoceptive Awareness subscale of the EDI to assess EA. However, this does not allow for the discrimination of specific aspects of EA. Therefore, future research should focus in more detail on instruments differentiating between aspects of EA (e.g., applying the DERS with its various subscales; 105). In addition, utilizing assessment measures that distinguish between the ability to identify own emotional states and the emotional states of others could foster insight into the context of social problems (e.g., Level of Emotional Awareness Scale; 106). Furthermore, it remains difficult to determine whether alterations in CoF and EmF are attributable to the comorbid obesity or the increased eating disorder psychopathology in BED as only 18 out of 57 studies included in this review comprised both obese and normal-weight controls. Thus, more research including obese individuals with BED and both obese and normal-weight controls is warranted.

Above all, future research should focus on the interaction between CoF and EmF in BED. Potential research avenues could include, for example, the investigation of the impact of positive and negative affect on the delay of gratification in BED using mood-inducing paradigms in combination with standardized neuropsychological tests.

Clinical Implications

Overall, several clinical implications derive from the present findings on difficulties in CoF and EmF for individuals with BED. A consideration of these difficulties within psychological treatments of BED could result in an improvement of CoF and EmF as a secondary outcome. In addition to the well-established cognitive-behavioral therapy (e.g., 107), interventions directly focusing on CoF (i.e., cognitive remediation therapy) have already been successfully implemented for AN (108) and appear to be promising for individuals with BED. Furthermore, treatments based on attentional bias modification (109) could help to retrain attention away from food-related cues, especially high-caloric food, in order to reduce the consumption of these foods (12). Regarding ER difficulties, established psychological treatments for BED, e.g., dialectical behavior therapy (DBT; 110), have already encompassed the need for alternative adaptive ER strategies to cope with negative affect as an antecedent of binge eating episodes (111). In addition to DBT, first evidence from a case study suggests that individuals with BED could benefit from acceptance and commitment therapy (ACT; 112), applying acceptance and mindfulness-based strategies to effectively deal with aversive internal experience and become more aware of own emotions (113). Above all, both difficulties in CoF and EmF could draw on the limited resource of self-control capacity (cf. 114) that, if depleted, could lead to binge eating episodes. Thus, both domains should be simultaneously considered to treat individuals with BED in a more integrated way. Future research will show if interventions are efficacious, not only in improving key symptoms of BED and the associated eating disorder psychopathology, but also in improving CoF and EmF.

Footnotes

[1] A total of three studies were not accounted for in the description of control groups. One additional study (30) also included OB individuals, but the authors did not investigate differences between BED and OB groups. Further, two studies (31; 75) also included individuals with other eating disorders, but did not compare them to individuals with BED.

[2] When looking at the distribution of significant results based on the utilized stimuli or tasks, all tasks using disorder-related stimuli generated significant differences between individuals with BED and comparison groups (eight out of eight tasks; 100%). The percentage of significant results in neutral tasks was much lower (9 out of 28 tasks; 32%).

[3] A total of n = 26 individuals per group was required to detect potential group differences given an expected large effect size (Cohen's d = 0.8) and a power of 80% when using two group t-tests at a two-tailed α = .05 (115).

REFERENCES

1. American Psychiatric Association (APA). Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5). Washington, DC: APA; 2013.

2. Finkenauer C, Engels R, Baumeister R. Parenting behaviour and adolescent behavioural and emotional problems: The role of self-control. Int J Behav Dev 2005;29:58-69.

3. Mosby. Mosby's medical dictionary (7th ed.). St. Louis, MO: Elsevier Health; 2006.

4. Duchesne M, Mattos P, Fontenelle LF, Veiga H, Rizo L, Appolinario JC. Neuropsychology of eating disorders: A systematic review of the literature. Rev Bras Psiquiatr 2004;26:107-177.

5. Roberts ME, Tchanturia K, Treasure JL. Exploring the neurocognitive signature of poor set-shifting in anorexia and bulimia nervosa. J Psychiatr Res 2010;44:964-970.

6. Brooks S, Prince A, Stahl D, Campbell IC, Treasure J. A systematic review and meta-analysis of cognitive bias to food stimuli in people with disordered eating behaviour. Clin Psychol Rev 2011;31:37-51.

7. Galimberti E, Martoni RM, Cavallini MC, Erzegovesi S, Bellodi L. Motor inhibition and cognitive flexibility in eating disorder subtypes. Prog Neuropsychopharmacol Biol Psychiatry 2012;36:307-312.

8. Jauregui-Lobera I. Neuropsychology of eating disorders: 1995-2012. Neuropsychiatr Dis Treat 2013;9:415-430.

9. Van den Eynde F, Guillaume S, Broadbent H, Stahl D, Campbell IC, Schmidt U, et al. Neurocognition in bulimic eating disorders: A systematic review. Acta Psychiatr Scand 2011;124:120-140.

10. Fitzpatrick S, Gilbert S, Serpell L. Systematic review: Are overweight and obese individuals impaired on behavioural tasks of executive functioning? Neuropsychol Rev 2013;23:138-156.

11. Smith E, Hay P, Campbell L, Trollor J. A review of the association between obesity and cognitive function across the lifespan: implications for novel approaches to prevention and treatment. Obes Rev 2011;12:740-755.

12. Nijs IM, Franken IH. Attentional Processing of Food Cues in Overweight and Obese Individuals. Curr Obes Rep 2012;1:106-113.

13. Eisenberg N, Spinrad TL. Emotion-related regulation: Sharpening the definition. Child Dev 2004;75:334-339.

14. Rommel D, Nandrino JL, Ducro C, Andrieux S, Delecourt F, Antoine P. Impact of emotional awareness and parental bonding on emotional eating in obese women. Appetite 2012;59:21-26.

15. Aldao A, Nolen-Hoeksema S, Schweizer S. Emotion-regulation strategies across psychopathology: A meta-analytic review. Clin Psychol Rev 2010;30:217-237.

16. Brockmeyer T, Bents H, Holtforth MG, Pfeiffer N, Herzog W, Friederich H-C. Specific emotion regulation impairments in major depression and anorexia nervosa. Psychiat Res 2012;200:550-553.

17. Harrison A, Sullivan S, Tchanturia K, Treasure J. Emotional functioning in eating disorders: Attentional bias, emotion recognition and emotion regulation. Psychol Med 2010;40:1887-1897.

18. Da Ros A, Vinai P, Gentile N, Forza G.,Cardetti S. Evaluation of alexithymia and depression in severe obese patients not affected by eating disorders. Eat Weight Disord 2011;16:e24-e29.

19. Fischer S, Munsch S. Self-regulation in eating disorders and obesity - Implications for the treatment. Verhaltenstherapie 2012;22:158-164.

20. Zijlstra H, van Middendorp H, Devaere L, Larsen JK, van Ramshorst B, Geenen R. Emotion processing and regulation in women with morbid obesity who apply for bariatric surgery. Psychol Health 2012;27:1375-1387.

21. Sokol BW, Müller U. The development of self-regulation: Toward the integration of cognition and emotion. Cognitive Dev 2007;22:401-405.

22. McRae K, Jacobs SE, Ray RD, John OP, Gross JJ. Individual differences in reappraisal ability: Links to reappraisal frequency, well-being, and cognitive control. J Res Pers 2012;46:2-7.

23. Mueller SC. The influence of emotion on cognitive control: Relevance for development and adolescent psychopathology. Front Psychol 2011;2:327.

24. Engelberg MJ, Steiger H, Gauvin L, Wonderlich SA. Binge antecedents in bulimic syndromes: An examination of dissociation and negative affect. Int J Eat Disord 2007;40:531-536.

25. Heatherton TF, Baumeister RF. Binge eating as escape from self-awareness. Psychol Bull 1991;110:86-108.

26. Wegner DM. Ironic Processes of Mental Control. Psychol Rev 1994;101:34-52.

27. Moher D, Liberati A, Tetzlaff J, Altman DG, Group TP. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLOS Med 2009;6:1-6.

28. American Psychiatric Association (APA). Diagnostic and Statistical Manual of Mental Disorders (4th ed., text rev., DSM-IV TR). Washington, DC: APA; 2000.

29. Warschburger P, Kröller K. Adipositas im Kindes- und Jugendalter: Was sind Risikofaktoren für die Entstehung einer Binge Eating Disorder? [Obesity in childhood and adolescence: What are the risk factors for the development of a binge eating disorder?]. Z Gesundh 2005;13:69-78.

30. Voon V, Irvine MA, Derbyshire K, Worbe Y, Lange I, Abbott S, et al. Measuring "waiting" impulsivity in substance addictions and binge eating disorder in a novel analogue of rodent serial reaction time task. Biol Psychiatry 2014;75:148-155.

31. Wu M, Giel KE, Skunde M, Schag K, Rudofsky G, de Zwaan M, et al. Inhibitory control and decision making under risk in bulimia nervosa and binge-eating disorder. Int J Eat Disord 2013;46:721-728.

32. Balodis IM, Molina ND, Kober H, Worhunsky PD, White MA, Rajita S, et al. Divergent neural substrates of inhibitory control in binge eating disorder relative to other manifestations of obesity. Obesity (Silver Spring) 2013;21:367-377.

33. Duchesne M, Mattos P, Appolinario JC, de Freitas SR, Coutinho G, Santos C, et al. Assessment of executive functions in obese individuals with binge eating disorder. Rev Bras Psiquiatr 2010;32:381-388.

34. Galioto R, Spitznagel MB, Strain G, Devlin M, Cohen R, Paul R, et al. Cognitive function in morbidly obese individuals with and without binge eating disorder. Compr Psychiatry 2012;53:490-495.

35. Kelly NR, Bulik CM, Mazzeo SE. Executive functioning and behavioral impulsivity of young women who binge eat. Int J Eat Disord 2013;46:127-139.

36 . Svaldi J, Brand M, Tuschen-Caffier B. Decision-making impairments in women with binge eating disorder. Appetite 2010;54:84-92.

37. Danner UN, Ouwehand C, Haastert NL, Hornsveld H, Ridder DTD. Decision-making impairments in women with binge eating disorder in comparison with obese and normal weight women. Eur Eat Disord Rev 2012;20:e56-e62.

38. Davis C, Patte K, Curtis C, Reid C. Immediate pleasures and future consequences: A neuropsychological study of binge eating and obesity. Appetite 2010;54:208-213.

39. Danner UN, Evers C, Sternheim L, van Meer F, van Elburg AA, Geerets TA, et al. Influence of negative affect on choice behavior in individuals with binge eating pathology. Psychiatry Res 2012;207:100-106.

40. Balodis IM, Kober H, Worhunsky PD, White MA, Stevens MC, Pearlson GD, et al. Monetary reward processing in obese individuals with and without binge eating disorder. Biol Psychiatry 2013;73:877-886.

41. Boeka AG, Lokken KL. Prefrontal systems involvement in binge eating. Eat Weight Disord 2011;16:e121-e126.

42. Mobbs O, Iglesias K, Golay A, Van der Linden M. Cognitive deficits in obese persons with and without binge eating disorder: Investigation using a mental flexibility task. Appetite 2011;57:263-271.

43. Svaldi J, Naumann E, Trentowska M, Schmitz F. General and food-specific inhibitory deficits in binge eating disorder. Int J Eat Disord 2014;47:534-542.

44. Svaldi J, Schmitz F, Trentowska M, Tuschen-Caffier B, Berking M, Naumann E. Cognitive interference and a food-related memory bias in binge eating disorder. Appetite 2014;72:28-36.

45. Svaldi J, Bender C, Tuschen-Caffier B. Explicit memory bias for positively valenced body-related cues in women with binge eating disorder. J Behav Ther Exp Psychiatry 2010;41:251-257.

46. Manwaring JL, Green L, Myerson J, Strube MJ, Wilfley DE. Discounting of various types of rewards by women with and without binge eating disorder: Evidence for general rather than specific differences. Psychol Rec 2011;61:561-582.

47. Urgesi C, Fornasari L, De Faccio S, Perini L, Mattiussi E, Ciano R, et al. Body schema and self-representation in patients with bulimia nervosa. Int J Eat Disord 2011;44:238-248.

48. Schag K, Teufel M, Junne F, Preissl H, Hautzinger M, Zipfel S, et al. Impulsivity in binge eating disorder: Food cues elicit increased reward responses and disinhibition. PLoS ONE 2013;8.

49. Svaldi J, Caffier D, Tuschen-Caffier B. Attention to ugly body parts is increased in women with binge eating disorder. Psychother Psychosom 2011;80:186-188.

50. Svaldi J, Caffier D, Tuschen-Caffier B. Automatic and intentional processing of body pictures in binge eating disorder. Psychother Psychosom 2012;81:52-53.

51. Tammela LI, Paakkonen A, Karhunen LJ, Karhu J, Uusitupa MI, Kuikka JT. Brain electrical activity during food presentation in obese binge-eating women. Clin Physiol Funct Imaging 2010;30:135-140.

52. Svaldi J, Tuschen-Caffier B, Peyk P, Blechert J. Information processing of food pictures in binge eating disorder. Appetite 2010;55:685-694.

53. Schienle A, Schafer A, Hermann A, Vaitl D. Binge-eating disorder: Reward sensitivity and brain activation to images of food. Biol Psychiatry 2009;65:654-661.

54. Weygandt M, Schaefer A, Schienle A, Haynes JD. Diagnosing different binge-eating disorders based on reward-related brain activation patterns. Hum Brain Mapp 2012;33:2135-2146.

55. Karhunen LJ, Vanninen EJ, Kuikka JT, Lappalainen RI, Tiihonen J, Uusitupa MIJ. Regional cerebral blood flow during exposure to food in obese binge eating women. Psychiatry Res 2000;99:29-42.

56. Geliebter A, Ladell T, Logan M, Schneider T, Sharafi M, Hirsch J. Responsivity to food stimuli in obese and lean binge eaters using functional MRI. Appetite 2006;46:31-35.

57. Wang GJ, Geliebter A, Volkow ND, Telang FW, Logan J, Jayne MC, et al. Enhanced striatal dopamine release during food stimulation in binge eating disorder. Obesity (Silver Spring) 2011;19:1601-1608.

58. Svaldi J, Caffier D, Tuschen-Caffier B. Emotion suppression but not reappraisal increases desire to binge in women with binge eating disorder. Psychother Psychosom 2010;79:188-190.

59. Svaldi J, Tuschen-Caffier B, Trentowska M, Caffier D, Naumann E. Differential caloric intake in overweight females with and without binge eating: Effects of a laboratory-based emotion-regulation training. Behav Res Ther 2014;56C:39-46.

60. Svaldi J, Dorn C, Trentowska M. Effectiveness for interpersonal problem-solving is reduced in women with binge eating disorder. Eur Eat Disord Rev 2011;19:331-341.

61. Duchesne M, de Oliveira Falcone EM, de Freitas SR, D'Augustin JF, Marinho V, Appolinario JC. Assessment of interpersonal skills in obese women with binge eating disorder. J Health Psychol 2012;17:1065-1075.

62. Fassino S, Leombruni P, Piero A, Abbate-Daga G, Giacomo Rovera G. Mood, eating attitudes, and anger in obese women with and without Binge Eating Disorder. J Psychosom Res 2003;54:559-566.

63. Waller G. Schema-level cognitions in patients with binge eating disorder: A case control study. Int J Eat Disord 2003;33:458-464.

64. Danner UN, Sternheim L, Evers C. The importance of distinguishing between the different eating disorders (sub)types when assessing emotion regulation strategies. Psychiatry Res 2014;215:727-732.

65. Svaldi J, Griepenstroh J, Tuschen-Caffier B, Ehring T. Emotion regulation deficits in eating disorders: A marker of eating pathology or general psychopathology? Psychiatry Res 2012;197:103-111.

66. Brockmeyer T, Skunde M, Wu M, Bresslein E, Rudofsky G, Herzog W, et al. Difficulties in emotion regulation across the spectrum of eating disorders. Compr Psychiatry 2014;55:565-571.

67. Pinna F, Lai L, Pirarba S, Orru W, Velluzzi F, Loviselli A, et al. Obesity, alexithymia and psychopathology: A case-control study. Eat Weight Disord 2011;16:e164-170.

68. Pinaquy S, Chabrol H, Simon C, Louvet JP, Barbe P. Emotional eating, alexithymia, and binge-eating disorder in obese women. Obes Res 2003;11:195-201.

69. de Zwaan M, Bach M, Mitchell JE, Ackard D. Alexithymia, obesity, and binge eating disorder. Int J Eat Disord 1995;17:135-140.

70. Borges MB, Jorge MR, Morgan CM, Da Silveira DX, Custodio O. Binge-eating disorder in Brazilian women on a weight-loss program. Obes Res 2002;10:1127-1134.

71. Zeeck A, Stelzer N, Linster HW, Joos A, Hartmann A. Emotion and eating in binge eating disorder and obesity. Eur Eat Disord Rev 2011;19:426-437.

72. de Zwaan M, Mitchell JE, Seim HC, Specker SM. Eating related and general psychopathology in obese females with binge eating disorder. Int J Eat Disord 1994;15:43-52.

73. Fitzgibbon ML, Sanchez-Johnsen LA, Martinovich Z. A test of the continuity perspective across bulimic and binge eating pathology. Int J Eat Disord 2003;34:83-97.

74. Kuehnel RH, Wadden TA. Binge eating disorder, weight cycling, and psychopathology. Int J Eat Disord 1994;15:321-329.

75. Thiel A, Jacobi C, Horstmann S, Paul T, Nutzinger DO, Schüßler G. Eine deutschsprachige Version des Eating Disorder Inventory EDI-2 [A German version of the Eating Disorder Inventory EDI-2]. Psychother Psychosom Med Psychol 1997;47:365-376.

76. Villarejo C, Jimenez-Murcia S, Alvarez-Moya E, Granero R, Penelo E, Treasure J, et al. Loss of control over eating: A description of the eating disorder/obesity spectrum in women. Eur Eat Disord Rev 2014;22:25-31.

77. Bonfà F, Marchetta L, Avanzi M, Baldini E, Raselli R, Uber E, et al. Exploratory evaluation of an obese population seeking bariatric surgery in an Italian public service. Eat Weight Disord 2010;15:e119-e126

78. Dalle Grave R, Todisco P, Oliosi M, Marchi S. Binge eating disorder and weight cycling in obese women. Eat Disord 1996;4:67-73.

79. Ramacciotti CE, Coli E, Bondi E, Burgalassi A, Massimetti G, Dell'Osso L. Shared psychopathology in obese subjects with and without binge-eating disorder. Int J Eat Disord 2008;41:643-649.

80. Fassino S, Piero A, Gramaglia C, Abbate-Daga G. Clinical, psychopathological and personality correlates of interoceptive awareness in anorexia nervosa, bulimia nervosa and obesity. Psychopathol 2004;37:168-174.

81. Raymond NC, Mussell MP, Mitchell JE, Crosby RD, de Zwaan M. An age-matched comparison of subjects with binge eating disorder and bulimia nervosa. Int J Eat Disord 1995;18:135-143.

82. Tobin DL, Molteni AL, Elin MR. Early trauma, dissociation, and late onset in the eating disorders. Int J Eat Disord 1995;17:305-308.

83. Ramacciotti CE, Coli E, Paoli R, Gabriellini G, Schulte F, Castrogiovanni S, et al. The relationship between binge eating disorder and non-purging bulimia nervosa. Eat Weight Disord 2005;10:8-12.

84. Tasca GA, Illing V, Lybanon-Daigle V, Bissada H, Balfour L. Psychometric properties of the Eating Disorders Inventory-2 among women seeking treatment for binge eating disorder. Assessment 2003;10:228-236.

85. Barry DT, Grilo CM, Masheb RM. Comparison of patients with bulimia nervosa, obese patients with binge eating disorder, and nonobese patients with binge eating disorder. J Nerv Ment Dis 2003;191:589-594.

86. Hill CL, Updegraff JA. Mindfulness and its relationship to emotional regulation. Emotion 2012;12:81-90.

87. Compare A, Callus E, Grossi E. Mindfulness trait, eating behaviours and body uneasiness: A case-control study of binge eating disorder. Eat Weight Disord 2012;17:e244-251.

88. Schag K, Schonleber J, Teufel M, Zipfel S, Giel KE. Food-related impulsivity in obesity and Binge Eating Disorder - a systematic review. Obesity Reviews 2013;14:477-495.

89. Frank S, Kullmann S, Veit R. Food related processes in the insular cortex. Front Hum Neurosci 2013;7:499.

90. Friederich HC, Wu M, Simon JJ, Herzog W. Neurocircuit function in eating disorders. Int J Eat Disord 2013;46:425-432.

91. Arias Horcajadas F, Sánchez Romero S, Gorgojo Martínez JJ, Almódovar Ruiz F, Fernández Rojo S, Llorente Martin F. Clinical differences between morbid obese patients with and without binge eating. Actas Esp Psiquiatr 2006;34:362-370.

92. Grilo CM. Why no cognitive body image feature such as overvaluation of shape/weight in the binge eating disorder diagnosis? Int J Eat Disord 2013;46:208-211.

93. Dillon DG, Pizzagalli DA. Inhibition of action, thought, and emotion: A selective neurobiological review. Appl Prev Psychol 2007;12:99-114.

94. Friedman NP, Miyake A. The relations among inhibition and interference control functions: A latent-variable analysis. J Exp Psychol Gen 2004;133:101-135.

95. Hay P, Fairburn C. The validity of the DSM-IV scheme for classifying bulimic eating disorders. Int J Eat Disord 1998;23:7-15.

96. Wonderlich SA, Gordon KH, Mitchell JE, Crosby RD, Engel SG. The validity and clinical utility of binge eating disorder. Int J Eat Disord 2009;42:687-705.

97. Wiser S, Telch CF. Dialectical behavior therapy for binge-eating disorder. J Clin Psychol 1999;55:755-768.

98. Van Strien T, Engels R, Van Leeuwe J, Snoek HA. The Stice model of overeating: Tests in clinical and non-clinical samples. Appetite 2005;45:205-213.

99. Ricca V, Castellini G, Lo Sauro C, Ravaldi C, Lapi F, Mannucci E, et al. Correlations between binge eating and emotional eating in a sample of overweight subjects. Appetite 2009;53:418-421.

100. Chaytor N, Schmitter-Edgecombe M, Burr R. Improving the ecological validity of executive functioning assessment. Arch Clin Neuropsychol 2006;21:217-227.

101. Austin MP, Mitchell P, Goodwin GM. Cognitive deficits in depression: Possible implications for functional neuropathology. Brit J Psychiat 2001;178:200-206.

102. Hilbert A, Pike KM, Wilfley DE, Fairburn CG, Dohm FA, Striegel-Moore RH. Clarifying boundaries of binge eating disorder and psychiatric comorbidity: A latent structure analysis. Behav Res Ther 2011;49:202-211.

103. Rose M, Davis J, Frampton I, Lask B. The Ravello Profile: Development of a global standard neuropsychological assessment for young people with anorexia nervosa. Clin Child Psychol Psychiatry 2011;16:195-202.

104. Dingemans AE, Martijn C, Jansen AT, van Furth EF. The effect of suppressing negative emotions on eating behavior in binge eating disorder. Appetite 2009;52:51-57.

105. Gratz KL, Roemer L. Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. J Psychopathol Behav Assess 2004;26:41-54.

106. Lane RD, Quinlan DM, Schwartz GE, Walker PA, Zeitlin S. The levels of emotional awareness scale: A cognitive-developmental measure of emotion. J Pers Assess 1990;55:124-134.

107. Hilbert A, Tuschen-Caffier B, Essanfälle und Adipostas: Ein Manual zur kognitiv-behavioralen Therapie der Binge-Eating-Störung [Binge eating and obesity: Cognitive-behavioral therapy manual for binge eating disorder]. Goettingen: Hogrefe; 2010.

108. Tchanturia K, Lloyd S, Lang K. Cognitive remediation therapy for anorexia nervosa: Current evidence and future research directions. Int J Eat Disord 2013;46:492-495.

109. Renwick B, Campbell IC, Schmidt U. Review of attentional bias modification: A brain-directed treatment for eating disorders. Eur Eat Disord Rev 2013;21:464-474.

110. Safer DL, Robinson AH, Jo B. Outcome from a randomized controlled trial of group therapy for binge eating disorder: Comparing dialectical behavior therapy adapted for binge eating to an active comparison group therapy. Behav Ther 2010;41:106-120.

111. Haedt-Matt AA, Keel PK. Revisiting the affect regulation model of binge eating: A meta-analysis of studies using ecological momentary assessment. Psychol Bull 2011;137:660-681.

112. Baer RA, Fischer S, Huss DB. Mindfulness-based cognitive therapy applied to binge eating: A case study. Cogn Behav Prac 2005;12:351-358.

113. Merwin RM, Zucker NL, Lacy JL, Elliott CA. Interoceptive awareness in eating disorders: Distinguishing lack of clarity from non-acceptance of internal experience. Cognition Emotion 2010;24:892-902.

114. Muraven M, Baumeister RF. Self-regulation and depletion of limited resources: Does self-control resemble a muscle? Psychol Bull 2000;126:247-259.

115. Bezeau S, Graves R. Statistical power and effect sizes of clinical neuropsychology research. J Clin Exp Neuropsychol 2001;23:399-406.

Table 1. Characteristics of included studies regarding cognitive functioning, emotion regulation and emotional awareness

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Cognitive Functioning and Processing utilizing Neutral Stimuli						
Balodis, Kober et al. (2013) (40)	BED OB NW	19 19 19	36.7 (4.1) 34.6 (3.5) 23.3 (1.1)	fMRI: Monetary Reward/Loss Task	Brain activation during reward/loss processing: - insula - ventral striatum - prefrontal cortex	 BED < OB, NW BED < OB; OB > NW BED < OB, NW; OB > NW
Balodis, Molina et al. (2013) (32)	BED OB NW	11 13 11	37.1 (3.9) 34.6 (4.1) 23.2 (1.1)	fMRI: Stroop Color-Word Interference Task	Behavioral Stroop performance: - congruent trials - incongruent trials Brain activation during Stroop task: - ventromedial prefrontal cortex, inferior frontal gyrus - insula	 ns ns BED < OB BED < OB, NW

Study	**Sample**	**N**	**BMI**	**Measures**	**Outcome variables**	**Key findings**[a,b,c]
Boeka & Lokken (2011) (41)	BED BED_{sub} OB	22 47 82	47.9 (7.6) 50.1 (7.2) 49.1 (9.8)	Frontal Systems Behavior Scale	Disinhibition, executive dysfunction, apathy, total	BED, BED_{sub} > OB
Danner, Ouwehand et al. (2012) (37)	BED OB NW	20 21 34	38.7 (6.3) 30.8 (3.0) 22.3 (2.0)	Iowa Gambling Task Self-Control Scale	Total score, learning effect Sum score	BED, OB > NW BED > OB, NW
Danner, Evers et al. (2012) (39)	BN BED NW	30 31 34	23.4 (3.3) 37.5 (5.1) 21.8 (2.3)	Experiment: influence of sadness on choice behavior (Bechara Gambling Task)	Choice behavior after reward Choice behavior after punishment: - and after increase in sadness - and after decrease in sadness	ns BED, BN > NW BED, BN < NW
Davis et al. (2010) (38)	BED OB NW	65 73 71	35.7 (9.0) 38.6 (7.1) 21.7 (1.9)	Iowa Gambling Task Delay Discounting Task	Total score, learning effect Indifference point for different delay periods	BED, OB > NW[d] BED, OB > NW[d]

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Duchesne et al. (2010) (33)	BED	38	35.9 (2.9)	BADS: Action Program,	Stages completed	BED > OB
	OB	38	36.6 (3.8)	Modified Six Elements,	Tasks completed minus tasks with broken rule	BED > OB
				Zoo Map	Errors (Trial 1)	BED > OB
					Errors (Trial 2), planning time, completion time	ns
				Rule Shift Cards	Errors, completion time	ns
				Wisconsin Card Sorting Task	Total errors	ns
					Perseverative errors, failure to maintain set	BED > OB
				Trail Making Test	Part A, Part B: completion time	ns
				Stroop Color-Word Test	Color-Word trial: correct answers, completion time	ns
				Digit Span	Forward: correct responses	ns
					Backward: correct responses	BED > OB

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Galioto et al. (2012) (34)	BED OB	41 90	45.4 (6.1) 44.9 (6.6)	Verbal List Learning	Total learning, short- and long-delay recall, recognition accuracy	ns
				Digit Span	Backward: correct responses	ns
				Spatial Span	Correct trials	ns
				Computerized Trail Making Test	Part A, Part B: completion time	ns
				Stroop Color-Word Test	Word trial, Color-Word trial: correct answers	ns
				Computerized Austin Maze	Errors, overruns	ns
				Letter Fluency Task	Correct words	ns
				Animal Fluency Task	Correct animal names	ns
Kelly et al. (2013) (35)	BE+ BE-	50 66	24.5 (5.1) 23.4 (5.2)	Conners' Continuous Performance Task	Errors of commission	ns

Study	**Sample**	**N**	**BMI**	**Measures**	**Outcome variables**	**Key findings**[a,b,c]
				Wisconsin Card Sorting Task	Total errors, perseverative responses	ns
Svaldi, Brand et al. (2010) (36)	BED	17	32.8 (3.5)	Game of Dice Task	Advantageous – disadvantageous choices (net score), final balance	BED > OB/OW
	OB/OW	18	30.7 (3.9)			
				Trail Making Test	Part A: completion time	ns
					Part B: completion time	BED > OB/OW
					Proportional score	BED > OB/OW
Voon et al. (2014) (30)	BED	30	34.7 (5.5)	Premature Responding Task	Premature responses	ns (BED = HC_{NW-BED} ; OB = HC_{NW-OB})
	OB	30	32.7 (3.4)			
	HC_{NW-BED}	30	23.9 (2.7)		Motivation index	ns (BED = HC_{NW-BED} ; OB = HC_{NW-OB})
	HC_{NW-OB}	30	24.1 (2.9)			
Wu et al. (2013) (31)	BED	54	34.0 (5.0)	Stop Signal Task	Stop signal reaction times	BN > HC_{NW-BN}; BED = HC_{OB-BED}
	BN	19	22.2 (2.9)			
	HC_{OB-BED}	43	35.1 (5.1)		Reaction times for no-signal trials	ns
	HC_{NW-BN}	31	22.2 (2.9)			

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
				Game of Dice Task	Frequency of risky decisions	BN = HC_{NW-BN}; BED = HC_{OB-BED}
Cognitive Functioning and Processing utilizing Disorder-Related Stimuli						
Geliebter et al. (2006) (56)	BED_{subOB}	5	32.3 (4.6)	fMRI (binge type food, non-binge type food, and non-food stimuli)	Strict conserved activation[e] in response to:	
	BED_{subNW}	5	22.4 (1.0)			
	OB	5	33.5 (6.5)		- binge type food stimuli	BED_{subOB} > BED_{subNW}, OB, NW
	NW	5	21.9 (1.3)			
					- non-binge type food stimuli	ns
					- non-food stimuli	ns
Karhunen et al. (2000) (55)	BED	8	35.2 (5.0)	SPECT (food vs. picture of a landscape)	Regional cerebral blood flow in response to food exposure:	
	OB	11	32.7 (4.0)			
	NW	12	22.2 (1.6)		- frontal and pre-frontal regions of the left hemisphere	BED > OB, NW

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Manwaring et al. (2011) (46)	BED OB NW	30 30 30	42.0 (9.8) 42.6 (7.8) 23.3 (2.4)	Delay Discounting Task	Relative subjective value of all delayed rewards combined	BED > OB, NW
				Probability Discounting Task	Relative subjective value of all probabilistic rewards combined	BED > OB, NW
Mobbs et al. (2011) (42)	BED OB NW	16 16 16	34.6 (3.5) 33.6 (6.4) 21.3 (1.8)	Mental Flexibility Task (Go/No-go Task with food-related and body-related stimuli)	Errors, food and body sections	BED + OB > NW; BED > OB
					Omissions, food section	BED + OB = NW; BED > OB
					Omissions, body section	BED + OB > NW; BED = OB
					Mental flexibility and cognitive biases, food and body sections	ns

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Schag et al.	BED	25	35.4 (5.6)	Free Exploration	Initial fixation position	ns
(2013) (48)	OB/OW	26	35.4 (5.4)	Paradigm (eye-tracking	Total gaze duration:	
	NW	25	22.5 (1.6)	with food and non-food	- non-food stimuli	ns
				stimuli)	- food stimuli	BED > OB, NW
				Modified Antisaccade	First saccades errors:	
				Paradigm	- non-food stimuli	BED > OB, NW
					- food stimuli	BED > OB, NW
					Second saccades errors:	
					- non-food stimuli	ns
					- food stimuli	BED > OB, NW
					Sequential errors:	
					- non-food stimuli	BED > OB, NW
					- food stimuli	BED > OB, NW

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Schienle et al. (2009) (53)	BED	17	32.2 (4.0)	fMRI	Brain activation to food stimuli:	
	BN	14	22.1 (2.5)		- medial and lateral orbitofrontal cortex	BED > BN
	HC_{NW}	19	21.7 (1.4)			
	HC_{OW}	17	31.6 (4.7)		- medial orbitofrontal cortex	BED > HC_{NW}, HC_{OW}
					- insula and the anterior cingulate cortex	BED, HC_{NW}, HC_{OW} < BN
					Brain activation to disgust-inducing stimuli	ns
					Ratings of food pictures concerning appetite and valence	ns
					Arousal	BED, HC_{NW}, HC_{OW} < BN
Svaldi, Bender et al. (2010) (45)	BED	18	32.8 (3.5)	Recall Task	Positive body-related/control words	BED > OB/OW
	OB/OW	18	30.7 (3.9)		Negative body-related/control words	ns

Study	**Sample**	**N**	**BMI**	**Measures**	**Outcome variables**	**Key findings**[a,b,c]
Svaldi,	BED	26	38.7 (8.2)	Eye tracking	Ugliest self body parts:	
Caffier et al.	OW	18	30.0 (3.8)		- gaze duration (block 1, 2)	BED > OW
(2011) (49)					- gaze frequency (block 1, 2)	BED > OW
					Ugliest control body parts:	
					- gaze duration (block 1, 2)	BED > OW, ns
					- gaze frequency (block 1, 2)	ns, BED > OW
Svaldi,	BED	23	37.7 (6.9)	Eye tracking (picture	Gaze frequencies/durations higher	ns
Caffier et al.	OW	23	29.8 (3.9)	pairs of self body and	in self body picture than control	
(2012) (50)				control body)	body picture	
					Gaze frequency of 1st and 2nd	
					fixation on:	
					- self body picture	BE > OW
					- control body picture	BE < OW
					Gaze duration of 1st fixation	ns

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
					Gaze duration of 2nd fixation on:	
					- self body picture	ns
					- control body picture	BE < OW
Svaldi, Naumann et al. (2014) (43)	BED OB/OW	31 29	35.0 (5.1) 33.0 (6.0)	Stop-Signal-Task (food vs. neutral stimuli)	Stop signal reaction time	BED > OB/OW
					Commission errors:	
					- neutral stimuli	ns
					- food stimuli	BED > OB/OW
Svaldi, Schmitz et al. (2014) (44)	BED OW	31 36	35.1 (5.1) 33.3 (6.2)	N-Back Task with Lures	Lure trials relative to neutral trials:	
					- increase in response times	BED > OW
					- increase in errors rates	BED > OW
				Recent-Probes Task	Eating-related stimuli relative to neutral stimuli:	
					- increase in response times	BED > OW
					- increase in error rates	ns

Study	**Sample**	**N**	**BMI**	**Measures**	**Outcome variables**	**Key findings**[a,b,c]
Svaldi, Tuschen-Caffier et al. (2010) (52)	BED OW	22 22	36.5 (6.9) 30.5 (3.9)	EEG (high vs. low caloric food pictures)	Long latency event related potentials: - high caloric food pictures - low caloric food pictures	 BED > OW ns
Tammela et al. (2010) (51)	BE+ BE-	12 13	41.1 (9.0) 36.8 (6.0)	EEG (eyes-closed resting state vs. eyes-open during food and control stimuli presentation)	Brain electrical activity: - beta activity for all conditions - alpha, delta, theta activities	 BE+ > BE- ns
Wang et al. (2011) (57)	BED OB	10 8	43.4 (13.5) 36.5 (9.4)	PET (food vs. neutral stimuli after administra-tion of methylphenidate (MPH) vs. placebo; baseline condition = neutral stimuli after placebo)	Dopamine release in dorsal striatum: - comparison of food stimuli (MPH) vs. baseline - comparison of neutral stimuli (MPH) vs .baseline	 BED > OB ns

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
					- comparison of neutral stimuli (MPH) vs. baseline	ns
Weygandt et al. (2012) (54)	BED BN HC_{NW} HC_{OW}	17 14 19 17	32.2 (4.0) 22.1 (2.5) 21.7 (1.4) 31.6 (4.7)	fMRI (gustatory and reward-related brain activation patterns during food-cue processing)	Best separation accuracy by brain activation patterns in:	
					- right insular cortex	BED vs. HC_{NW} BN vs. HC_{NW}
					- right ventral striatum	BED vs. HC_{OW}
					- right lateral orbitofrontal cortex	BN vs. HC_{OW}
					- left ventral striatum	BED vs. BN
Urgesi et al. (2011) (47)	BED BN HC_{NW-BED} HC_{NW-BN}	15 15 15 15	38.6 (5.9) 21.6 (3.2) 21.6 (2.2) 21.1 (1.7)	Own-Body Transformation Task	Front-facing: reaction time on accuracy ratios	BED < BN; BED = HC_{NW-BED}; BN > HC_{NW-BN}
					Back-facing: reaction time on accuracy ratios	ns

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
				Letter Transformation Task	Turned, unturned	ns
Emotion Regulation						
Brockmeyer et al. (2013) (66)	BED	29	33.0 (4.7)	Difficulties in Emotion Regulation Scale	Total, all subscales	BED, BN, AN_r, AN_{bp} > HC_{ow}, HC_{nw}
	BN	34	21.7 (3.1)			
	AN_r	35	14.6 (1.9)		Additional significant group differences:	
	AN_{bp}	22	15.1 (1.7)			
	HC_{ow}	29	34.4 (4.2)		- total	BED < BN, AN_{bp}; BED = AN_r
	HC_{nw}	60	21.8 (1.9)			
					- difficulties in engaging in goal directed behavior	BED < BN; BED = AN_r, AN_{bp}
					- impulse control difficulties, limited access to strategies	BED < AN_{bp}; BED = BN, AN_r
Danner et al. (2014) (64)	BED	29	37.5 (5.1)	Emotion Regulation Questionnaire	Suppression	BED, BN, AN_r, AN_{bp} > HC
	BN	30	23.4 (3.3)			

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
	AN_r	32	17.2 (1.8)		Reappraisal	BED = BN = AN_r; BN, AN_r, > HC
	AN_{bp}	32	17.0 (1.9)			
	HC	64	22.0 (2.5)			
Duchesne et al. (2012) (61)	BED	60	38.1 (NR)	Social Skills Inventory	Assertiveness, self-exposure to strangers	BED > OB, NW
	OB	60	37.9 (NR)			
	NW	54	21.4 (1.6)		Expression of positive feelings, self-control of anger, conversational skills	ns
				Interpersonal Reactivity Index	Personal distress	BED > OB, NW
					Empathic concern, perspective taking, fantasy	ns
Fassino et al. (2003) (62)	BED	51	36.5 (6.3)	State-Trait Anger Expression Inventory	Anger-expression	BED > OB , NW
	OB	52	37.7 (5.7)		Anger-suppression	BED > NW[f]; BED = OB
	NW	93	22.9 (1.9)		Anger-control	ns

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Svaldi, Caffier et al. (2010) (58)	BED	27	36.7 (3.9)	Emotion Regulation Questionnaire	Suppression	BED > OB/OW
	OB/OW	25	33.8 (6.5)		Reappraisal	BED > OB/OW
				Experiment: emotion regulation as mediator between negative affect and desire to binge	Desire to binge after suppression	BED > OB/OW
					Desire to binge after reappraisal	ns
Svaldi, Dorn et al. (2011) (60)	BED	25	38.0 (8.2)	Means-Ends Problem-Solving Procedure (four scenarios)	Relevant means	ns
	OB/OW	30	29.5 (3.9)		Effectiveness, specificity	BED > OB/OW
Svaldi, Griepenstroh et al. (2012) (65)	BED	25	37.6 (6.7)	Affect Intensity Measure	Intensity of positive emotions	ns
	BN	18	22.3 (2.8)		Intensity of negative emotions	BED, AN > HC
	AN	20	16.3 (1.8)		Serenity	BED, BN, AN > HC
	HC	42	21.4 (2.5)	Difficulties in Emotion Regulation Scale	Non-acceptance, difficulties in engaging in goal directed behavior, impulse control difficulties	BED, BN, AN > HC

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
					Limited access to strategies	BED, BN, AN > HC; BED < BN, AN
				Emotion Regulation Questionnaire	Suppression	BED, BN, AN > HC
					Reappraisal	BED, BN, AN > HC
				Inventory of Cognitive Affect Regulation Strategies	Acceptance of feelings	BED, BN, AN > HC
					Acceptance of the situation	BED, HC > AN
					Positive thoughts, mindful observation	BED, AN > HC
					Reframing and growth	BED, AN > HC; BED, BN < AN
					Downward comparison and reality testing, thought suppression/mental distraction, blaming others	ns
					Self criticism/self-blame	BED, BN, AN > HC

Study	**Sample**	**N**	**BMI**	**Measures**	**Outcome variables**	**Key findings**[a,b,c]
					Thoughts of suicide	BED, HC < BN < AN
					Futile planning	ns
Svaldi, Tuschen-Caffier et al. (2014) (59)	BED	39		Emotion Regulation Questionnaire	Suppression	BED > OW
	OW	42			Reappraisal	BED > OW
				Experiment: effects of emotion regulation training on caloric intake	Caloric intake after suppression vs. after reappraisal	ns (both groups higher caloric intake in suppression than in reappraisal condition)
					Overall caloric intake	BED > OW
Waller et al. (2003) (63)	BED	13	NR	State-Trait Anger Expression Inventory	Anger-expression, anger-control	ns
	BN	68			Anger-suppression	BED, BN, AN_{bp} > HC
	AN_{r}	20				
	AN_{bp}	39				
	HC	50				

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Emotional Awareness						
Barry et al.	BED	79	39.2 (7.2)	Eating Disorder	Interoceptive awareness	BED < BN[g]; BED =
(2003) (85)	BED_{non-ob}	37	25.9 (3.2)	Inventory		BED_{non-ob}; BED_{non-ob} =
	BN	46	22.8 (9.5)			BN
Bonfà et al.	BED	30	45.1 (6.6)[h]	Eating Disorder	Interoceptive awareness	BED > OB
(2010) (77)	OB	75	45.7 (6.5)[h]	Inventory-2		
Borges et al.	BED	35	32.2 (5.4)	Toronto Alexithymia	Total score	BED, BN, BED_{sub}
(2002) (70)	BN	10	29.1 (3.1)	Scale-20		> OB/OW
	BED_{sub}	49	31.0 (5.2)			
	OB/OW	123	29.5 (3.9)			
Brockmeyer	BED	29	33.0 (4.7)	Difficulties in Emotion	Lack of emotional awareness	BED, BN, AN_r, AN_{bp} >
et al. (2013)	BN	34	21.7 (3.1)	Regulation Scale		HC_{ow}, HC_{nw}

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
(66)	AN_r	35	14.6 (1.9)		Lack of emotional clarity	BED, BN, AN_r, AN_{bp} >
	AN_{bp}	22	15.1 (1.7)			HC_{ow}, HC_{nw};
	HC_{ow}	29	34.4 (4.2)			BED < BN, AN_r, AN_{bp}
	HC_{nw}	60	21.8 (1.9)			
Compare et al. (2012) (87)	BED	150	33.1 (1.2)	The Five Facet Mindfulness Questionnaire	Global score, non-reactivity to experience, acting with awareness, describing with words, observation of experience	BED > OB, NW
	OB	150	33.2 (1.8)			
	NW	150	23.2 (1.3)			
					Non-judging of experience	ns
Dalle Grave et al. (1996) (78)	BED	35	37.3 (6.1)	Eating Disorder Inventory	Interoceptive awareness	BED > OB
	OB	60	37.6 (10.9)			
de Zwaan et al. (1994) (72)	BED	43	36.1 (3.7)	Eating Disorder Inventory	Interoceptive awareness	BED > BED_{sub}, OB
	BED_{sub}	20	37.7 (4.1)			
	OB	37	34.9 (3.3)[i]			

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
de Zwaan et al. (1995) (69)	BED	83	36.2 (3.9)	Toronto Alexithymia Scale-26	Total score, lack of daydreaming, externally oriented thinking	ns
	OB	99	36.3 (4.5)		Difficulty in identifying feelings	BED > OB
					Difficulty in describing feelings	BED < OB
				Eating Disorder Inventory	Interoceptive awareness	BED > OB
Fassino et al. (2003) (62)	BED	51	36.5 (6.3)	Eating Disorder Inventory-2	Interoceptive awareness	BED > OB; BED, OB > NW
	OB	52	37.7 (5.7)			
	NW	93	22.9 (1.9)			
Fassino et al. (2004) (80)	BED	49	35.9 (5.7)	Eating Disorder Inventory-2	Interoceptive awareness	BED = OB; BED = BN; BN > AN_{bp}, OB
	OB	47	38.6 (5.9)			
	BN	104	21.4 (3.4)			
	AN_{bp}	66	15.7 (1.6)			
	AN_r	61	16.0 (1.7)			

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Fitzgibbon et al. (2003) (73)	BED	64	38.4 (11.7)	Eating Disorder Inventory-2	Interoceptive awareness	BED, BN_{sub} < BN; BED > BED_{sub}, OB
	BED_{sub}	59	40.5 (11.1)			
	BN	123	24.8 (6.9)			
	BN_{sub}	105	30.3 (12.5)			
	OB	24	44.5 (12.2)			
Kuehnel & Wadden (1994) (74)	BED	11	39.4 (8.6)	Eating Disorder Inventory-2	Interoceptive awareness	BED > BED_{sub}, OB
	BED_{sub}	29	36.3 (4.4)			
	OB	30	35.5 (5.9)			
Pinaquy et al. (2003) (68)	BED	40	36.8 (NR)	Toronto Alexithymia Scale-20	Total score, difficulty in identifying feelings, difficulty in describing feelings	BED > OB
	OB	129	35.7 (NR)			
					Externally oriented thinking	ns

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Pinna et al. (2011) (67)	BED OB BED_{nw} NW	46 247 3 290	BED + OB: 35.6 (6.2) BED_{nw} + NW: 21.8 (2.1)	Toronto Alexithymia Scale-20	Total score, difficulty in identifying feelings, difficulty in describing feelings, externally oriented thinking	BED > OB; BED_{nw} > NW
Ramacciotti et al. (2005) (83)	BED BN_{np}	25 25	35.5 (NR) 23.8 (NR)	Eating Disorder Inventory-2	Interoceptive awareness	ns
Ramacciotti et al. (2008) (79)	BED OB	27 63	37.3 (14.3) 36.5 (13.0)	Eating Disorder Inventory-2	Interoceptive awareness	BED > OB
Raymond et al. (1995) (81)	BED BN	35 35	36.1 (3.7) 21.5 (2.7)	Eating Disorder Inventory	Interoceptive awareness	BED < BN

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Svaldi, Caffier et al. (2010) (58)	BED OB/OW	27 25	36.7 (3.9) 33.8 (6.5)	Toronto Alexithymia Scale-20	Total score, difficulty in identifying feelings, difficulty in describing feelings	BED > OB/OW
					Externally oriented thinking	ns
Svaldi, Griepenstroh et al. (2012) (65)	BED BN AN HC	25 18 20 42	37.6 (6.7) 22.3 (2.8) 16.3 (1.8) 21.4 (2.5)	Difficulties in Emotion Regulation Scale	Lack of emotional awareness	BED, BN, AN > HC
					Lack of emotional clarity	BED, BN, AN > HC; BED < BN
				Inventory of Cognitive Affect Regulation Strategies	Analysis of feelings and situation	BED, AN > HC
Tasca et al. (2003) (84)	BED BN	144 152	40.6 (10.2) 26.5 (6.8)	Eating Disorder Inventory-2	Interoceptive awareness	ns

Study	Sample	N	BMI	Measures	Outcome variables	Key findings[a,b,c]
Thiel et al. (1997) (75)	BED	30	42.0 (8.0)	Eating Disorder Inventory-2	Interoceptive awareness	BED > HC; BN > HC; AN > HC
	BN	38	22.0 (3.0)			
	AN	33	15.0 (1.0)			
	HC	186	22.0 (3.0)			
Tobin et al. (1997) (82)	BED	31	NR	Eating Disorder Inventory	Interoceptive awareness	BED < BN_p, BN_{np}, CED
	BN_p	188				
	BN_{np}	21				
	CED	27				
Villarejo et al. (2014) (76)	BED	50	37.0 (4.3)	Eating Disorder Inventory-2	Interoceptive awareness	BED < BN; BED > OB, NW
	BN	50	35.2 (4.4)			
	OB	50	44.7 (5.2)			
	NW	50	NR			
Zeeck et al. (2011) (71)	BED	20	42.8 (6.0)	Toronto Alexithymia Scale-20	Total score	BED > OB, NW
	OB	23	41.1 (6.7)			
	NW	20	23.1 (2.5)			

Notes: AN: Individuals with Anorexia Nervosa; AN_{bp}: Individuals with AN binge-eating/purging type; AN_r: Individuals with AN restrictive type; BE+/BE-: Individuals with (+)/without (-) binge eating in the absence of recurrent inappropriate compensatory behaviors; BED: Obese individuals with Binge-eating disorder; BED_{non-ob}: Non-obese individuals with Binge-eating disorder; BED_{nw}: Normal-weight individuals with Binge-eating disorder; BED_{sub}: Individuals with subthreshold BED; BED_{subNW}: Normal-weight individuals with subthreshold BED; BED_{subOB}: Obese individuals with subthreshold BED; BMI: Body mass index (kg/m²) reported as M (mean) and SD (standard deviation); BN: Individuals with Bulimia Nervosa; BN_{np}: Individuals with BN non-purging type; BN_p: Individuals with BN purging type; CED: Individuals with compensatory eating disorder (compensatory behavior, but no binge eating or weight criteria for anorexia); EEG: Electroencephalography; fMRI: Functional magnetic resonance imaging; HC: Healthy control individuals; HC_{NW}: Normal-weight healthy control individuals; HC_{NW-BED}: Normal-weight healthy control individuals matched for individuals with BED; HC_{NW-BN}: Normal-weight healthy control individuals matched for individuals with BN; HC_{NW-OB}: Normal-weight healthy control individuals matched for obese individuals; HC_{OW}: Overweight healthy control individuals; HC_{OB-BED}: Obese healthy control individuals matched for individuals with BED; N: Group size; NR: Not reported; ns: non-significant; NW: Normal-weight control individuals; OB: Obese control individuals ($BMI \geq 30$ kg/m^2); OW: Overweight control individuals ($BMI \geq 25$ kg/m^2); PET: Positron emission tomography; SPECT: Single photon emission computed tomography

[a] Key findings are presented as impaired cognitive functioning, or lower emotional functioning, i.e. high scores mean poor performance.

[b] In brain imaging studies, higher scores represent higher activation in the reported brain areas.

[c] In studies applying eye tracking, higher scores represent higher attention (e.g., longer gaze duration).

[d] Group differences disappeared after controlling for education level.

[e] Strict conserved activation is defined as activation of the same brain area in all individual subjects within a group.

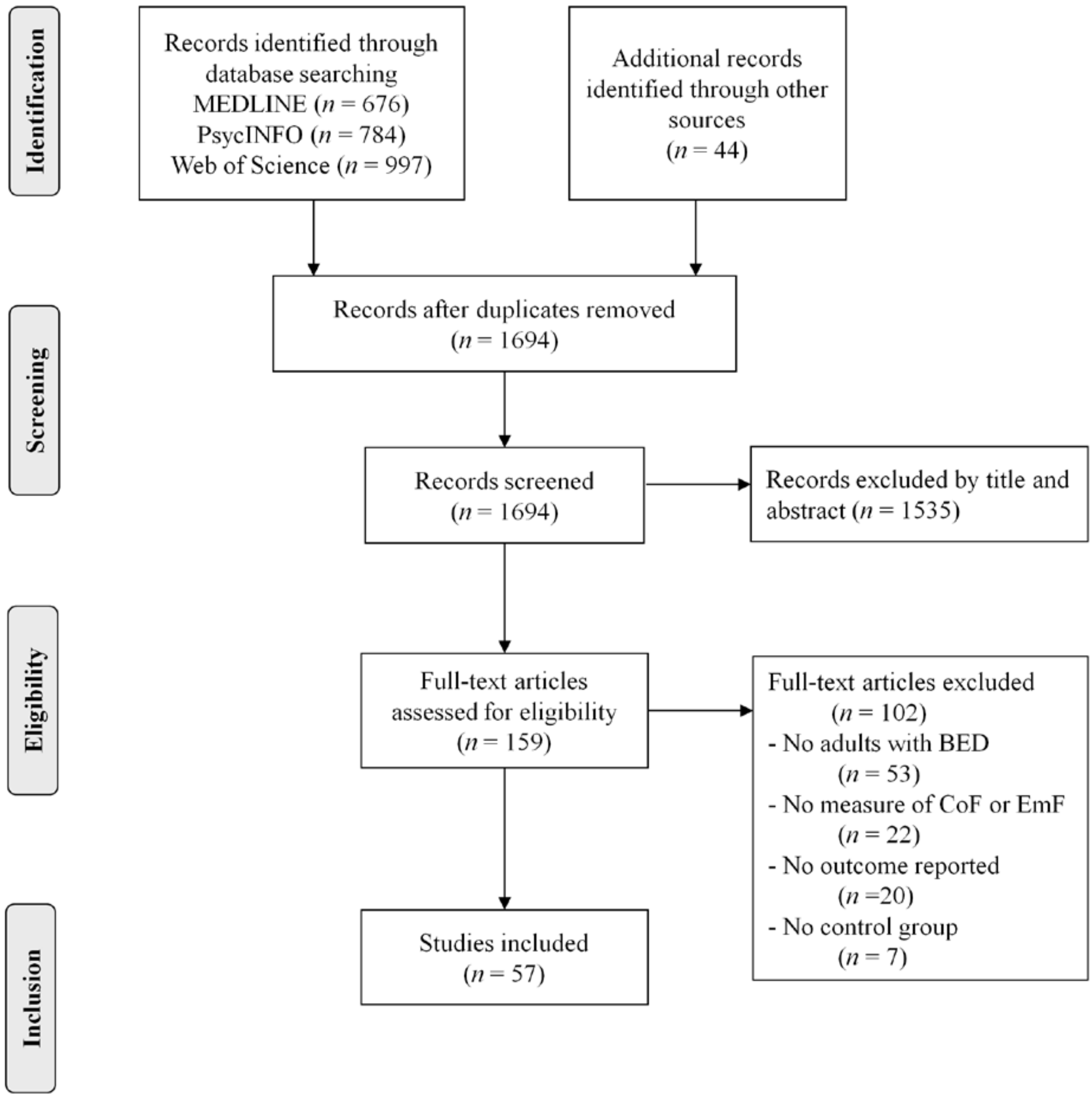
[f] Group differences disappeared after controlling for depression level.

[g] Group differences disappeared after controlling for depression level and age.

[h] BMI of male and female subgroups were averaged out.

[i] BMI of two subgroups including obese individuals reporting/not reporting overeating episodes were averaged out.

Figure 1. PRISMA flow chart of study inclusion.



ACKNOWLEDGMENTS / DISCLOSURE OF CONFLICTS

This work was supported by the Federal Ministry of Education and Research (BMBF), Germany, FKZ: 01GV0601 und 01EO1001. No author of this manuscript has any conflicts of interest, financial or otherwise, related to the submitted work.

We are grateful to Elizabeth Stainforth, MA, and Carolyn E. Edwards, BSc for their help with language and proof reading the manuscript.