Published in final edited form as:

Behav Res Ther. 2013 September ; 51(9): . doi:10.1016/j.brat.2013.05.001.

Predicting group cognitive-behavioral therapy outcome of binge eating disorder using empirical classification

Peterson Carol B.^{a,*}, Ross D. Crosby^{b,c}, Stephen A. Wonderlich^{b,c}, James E. Mitchell^{b,c}, Scott J. Crow^a, and Scott Engel^{b,c}

^aDepartment of Psychiatry, University of Minnesota Medical School, F282/2A West, 2450 Riverside Avenue South, Minneapolis, MN, 55454, USA

^bDepartment of Clinical Research, Neuropsychiatric Research Institute, 700 First Avenue South, Fargo, ND 58103, USA

^cDepartment of Clinical Neuroscience, University of North Dakota School of Medicine and Health Sciences, 120 8th Street South, Fargo, ND, 58102, USA

Abstract

The purpose of this study was to use empirical classification based on Latent Profile Analysis to identify subgroups of binge eating disorder (BED) and to evaluate the extent to which these subgroups were predictive of treatment outcome in group cognitive-behavioral therapy (CBT). The Eating Disorder Examination (EDE), Structured Clinical Interview for DSM-IV, and Inventory of Depressive Symptomatology-Self-Report were administered to 259 participants at baseline in a 15-session CBT trial (190 of whom received active treatment). The best fitting model included three profiles: dietary restraint only (DRO; $n = 96$; 51%); low dietary restraint (LDR; $n = 52$; 27%); and dietary restraint plus psychopathology (DRP; $n = 42$; 22%). Regression analyses revealed that after controlling for baseline score and treatment condition, EDE Global scores were lower for the DRO compared to the LDR profile at one year follow-up ($p = .047$). Class assignment was not predictive of EDE binge eating frequency or abstinence at end of treatment or follow-up. These results suggest that meaningful empirical classes based on eating disorder symptoms, psychopathology, dietary restraint, and BMI can be identified in BED and that these classes may be useful in predicting long-term group CBT outcome.

Keywords

Binge eating; Cognitive-behavioral therapy; Empirical classification; Prognosis

Binge eating disorder (BED), an eating disorder characterized by the periodic consumption of large amounts of food accompanied by the subjective experience of loss of control, is associated with significant psychiatric and medical comorbidity (Hudson, Hiripi, Pope, & Kessler, 2007; Wonderlich, Gordon, Mitchell, Crosby, & Engel, 2009) as well as elevated mortality risk (Crow et al., 2009). Although psychological, pharmacological, and self-help interventions have shown some promise for the treatment of BED (Brownley, Berkman, Sedway, Lohr, & Bulik, 2007; NICE, 2004; Reas & Grilo, 2008; Wilson, Grilo, & Vitousek, 2007), treatment outcome data for BED have also been characterized by significant rates of attrition, relapse, and treatment non-response (Bulik, Brownley, & Shapiro, 2007; Wonderlich, de Zwaan, Mitchell, Peterson, & Crow, 2003). Because of these limitations,

strategies to improve available treatments as well to develop more effective interventions are needed to facilitate enduring recovery for patients with BED.

One strategy that can be used to potentially enhance treatment outcome is to identify clinically meaningful subtypes or subgroups within a broader category of psychopathology. Subgroupings can be utilized to improve treatment effectiveness in several ways. First, understanding patterns of heterogeneity within a diagnostic category can help determine whether a specific type of treatment is differentially effective for a specific subtype of patient. If a certain subgroup has relatively better or poorer outcome in response to a specific treatment, matching strategies can be utilized in which baseline predictors are used to select (or avoid) a specific treatment (Kraemer, Wilson, Fairburn, & Agras, 2002). In addition, subgroupings can be used to guide treatment development and specific modules within interventions can be designed to target specific patterns of symptoms. Finally, subgrouping and subtyping strategies can be utilized to identify etiological and maintenance mechanisms, which can lead to the development of more effective treatments (Rieger et al., 2010; Strauman & Merrill, 2004).

As reviewed recently by Grilo, Masheb, and Crosby (2012) and Sysko et al. (2010), several subgrouping strategies and their prognostic capacity have been examined in BED. For example, several studies using cluster analysis have differentiated individuals with BED who report high levels of dietary restraint combined with high levels of negative affect from those with high levels of dietary restraint and relatively lower levels of negative affect on a number of clinical and psychopathological variables (Grilo, Masheb & Wilson, 2001; Masheb & Grilo, 2008; Stice et al., 2001). The “pure” dietary restraint group with relatively lower levels of negative affect has also been found to have better treatment outcome on some measures than the negative affect/dietary restraint group in cognitive-behavioral therapy (CBT) delivered using guided self-help materials (Masheb & Grilo, 2008), behavioral weight loss (Masheb & Grilo, 2008), and dialectical behavior therapy (Stice et al., 2001). More recently, the negative affective/dietary restraint subtype was found to be a moderator of CBT outcome on several measures of eating disorder psychopathology and depression (Grilo et al., 2012). A second BED subtyping strategy, classification based on presence or absence of overvaluation of shape and weight, has yielded significant differences between these two groups on a several psychopathological and clinical measures (Grilo, Hrabosky, Allison, Stunkard, & Masheb, 2008; Grilo, Masheb & White, 2010; Grilo et al., 2009, 2012; Hrabosky, Masheb, White, & Grilo, 2007; Masheb & Grilo, 2000, 2008). For example, those endorsing overvaluation have poorer outcome on measures of eating disorder psychopathology in guided self-help CBT and behavioral weight loss (Masheb & Grilo, 2008). In addition, a more recent examination of moderators and predictors of treatment outcome for CBT and fluoxetine treatment found that overvaluation of shape and weight was a robust moderator and predictor of poorer outcome, particularly for participants who received medication only (Grilo et al., 2012).

An increasing number of studies have used empirical classification to examine subgroups within eating disorders by utilizing latent class analysis (LCA), latent profile analysis (LPA), and latent transition analysis (LTA; see reviews by Crow et al., 2011; Wonderlich, Joiner, Keel, Williamson & Crosby, 2007). More recently, empirical classification has also been used to determine subgroupings that are then used to predict eating disorder treatment outcome (e.g. Wildes et al., 2011) and mortality (Crow et al., 2012). Sysko and colleagues (2010) used empirical classification procedures with 205 BED participants who received interpersonal therapy (IPT), behavioral weight loss, or guided self-help CBT in a multisite randomized trial (Wilson, Wilfley, Agras, & Bryson, 2010) and found a four class solution: the first class was characterized by lower BMI, higher levels of physical activity, and the highest rate of past eating disorders in addition to BED; the second class had the highest

self-reported levels of binge eating, eating disorder psychopathology, and negative affect; the third class resembled the second class but had relatively lower levels of exercise and compensatory behaviors; the fourth class was characterized by the relatively highest level of BMI, overeating (but fewer binge eating episodes), an absence of compensatory behaviors, and the lowest rate of past co-occurring eating disorders. LTA indicated a higher probability of binge eating remission for IPT in the second class and guided self-help CBT in the third class. These findings support the use of empirical classification procedures in identifying meaningful subtypes within BED as well as the potential utility of these subgroupings in determining differential treatment response.

In summary, empirical subtyping or classifying within eating disorder diagnoses can help differentiate meaningful subtypes within symptom heterogeneity as well as determine the extent to which these empirically derived groups are predictive of treatment outcome. However, limited research has been conducted in which empirical classification strategies have been used to predict treatment outcome in BED. The prognostic capacity of subgroupings determined by empirical classification for group CBT has not been examined, a notable omission given that CBT is considered one of the most efficacious treatments of BED (NICE, 2004; Wilson et al., 2007) and that most CBT for BED has been conducted using group treatment (Brownley et al., 2007). The primary purpose of this study was to conduct empirical classification of baseline psychopathology and obesity severity using LPA in a treatment outcome sample of individuals with BED to examine the extent to which these subgroupings predict meaningful clinical outcomes in group CBT.

Method

Participants

Participants included 259 Adults (average age = 46.9, SD = 10.3, range = 18–66; average BMI = 38.8, SD = 7.8, range = 24.5–72.6; 96.1% Caucasian; 87.6% female; 54.9% college degree or higher) recruited from community and clinical settings from two USA sites: Fargo, North Dakota and Minneapolis, Minnesota (see Table 2). Participants met DSM-IV (American Psychiatric Association, 2000) criteria for BED as diagnosed by the Eating Disorder Examination (EDE; Fairburn & Cooper, 1993; see below) and were excluded if they were pregnant or nursing, had a past or present diagnosis of psychosis or bipolar disorder, had a current diagnosis of substance abuse or dependence, were receiving current psychotherapy, were enrolled in a commercial weight loss program, were medically unstable, or were at acute risk of self-injury. Participants on antidepressant medications were allowed to enroll if they had been on a stable dose for the past six weeks (79.5%; see Table 2).

Assessment and measures

The Eating Disorder Examination (EDE; Fairburn & Cooper, 1993) is an investigator-based interview to assess eating disorder symptoms. It includes four subscales (restraint, eating concern, shape concern, weight concern) and a global severity score. The EDE also includes frequency measures of several types of binge eating including objective bulimic (binge eating) episodes (OBEs), in which an investigator-rated large amount of food is consumed and accompanied by a sense of loss of control (corresponding with the binge eating criteria described in the DSM-IV), subjective bulimic (binge eating) episodes (SBEs) in which the participant believes that they have overeaten and reports a sense of loss of control but the amount of food is not considered objectively large by the assessment interviewer, and objective overeating episodes (OOEs), in which the amount consumed is considered objectively large but was not accompanied by a subjective experience of loss of control. The EDE has extensive psychometric data supporting its reliability and validity, including its use

with BED samples (Berg, Peterson, Frazier, & Crow, 2012; Fairburn, 2008; Grilo, Masheb, Lozano-Blanco, & Barry, 2004). Masters and doctoral level clinical interviewers were trained initially using didactics and role playing; teleconferencing and frequent communication on an e-mail listserv were used to prevent site drift. Inter-rater reliability based on a subsample of participants selected at random indicated reliability ratings of 0.95–0.98 on EDE subscales. The EDE was used to obtain baseline indicator measures of eating disorder psychopathology as well as for assessment of treatment outcome at end of treatment and two follow-up visits (6 and 12 months after treatment ended).

The Structured Clinical Interview for DSM-IV (SCID-I; First, Spitzer, Gibbon, & Williams, 1995) is a widely used semi-structured interview to assess current and past Axis I psychopathology diagnoses. Previous studies have found psychometric support for the reliability and validity of the SCID-I (e.g., Lobbetael, Leurgans, & Arntz 2010; Shear et al., 2000). The SCID-I was used for current assessment of comorbid anxiety and mood disorder diagnoses that were included as LPA indicators.

The Inventory of Depressive Symptomatology-Self Report (IDSSR; Rush et al., 1986) is a widely used 30-item self-report measure of depressive symptoms that yields an overall severity score. Previous studies have supported the reliability and validity of the IDSSR (Rush, Gullion, Basco, Jarret, & Trivedi, 1996). This measure was used to assess severity of depressive symptoms as a baseline LPA indicator.

The Rosenberg Self-Esteem Scale (RSE; Rosenberg, 1979) is a ten-item measure of self-esteem. This measure has been widely used in eating disorder studies as well as in previous BED treatment outcome investigations (e.g., Grilo et al., 2012).

Body mass index (BMI; kg/m²) was determined at baseline by a trained staff member. Weight was measured with an electronic digital scale that was calibrated for accuracy and height was assessed with a stadiometer. Participants were measured without shoes or outerwear. BMI was used as a measure of obesity severity as a baseline LPA indicator.

Treatment

Participants were randomized to one of three active CBT group treatments or a wait list control condition (see Peterson, Mitchell, Crow, Crosby & Wonderlich, 2009). All active treatments consisted of 15 group sessions of 80 min durations over 20 weeks (with weekly meetings for 10 weeks followed by biweekly meetings for 10 weeks) that included both a lecture and discussion component. Because the primary objective of the treatment study was therapist delivery, lecture, workbook, and discussion materials were identical (see Mitchell, Devlin, de Zwaan, Crow, & Peterson, 2008; Peterson & Mitchell, 1996; Peterson et al., 2009) in all three active treatment conditions. In the therapist-led condition ($n = 60$), a doctoral level therapist provided psychoeducational lecture materials and led each group discussion. In the therapist-assisted condition ($n = 63$), participants viewed a doctoral level therapist delivering a videotaped lecture of psychoeducational materials. A doctoral level therapist then joined the group after the videotape presentation and led each discussion. In the group self-help condition ($n = 67$), the participants watched a video of a doctoral level therapist delivering the psychoeducational information and led their own discussion based on written guidelines provided by the investigators. Wait-list participants received therapist-led treatment at the end of the 20-week waiting period. Doctoral level therapists were trained initially in a didactic session and participated in weekly supervision, including rated audiotape review (see Peterson et al., 2009).

Indicator selection and statistical analysis

Indicators selection was informed by previous empirical classification studies of BED (e.g., Sysko et al., 2010) as well as prediction of outcome investigations (e.g., Grilo et al., 2012). In order to examine consistency with this previous research, similar indicators were selected whenever possible. In general, indicators were selected to reflect behavioral severity (e.g., binge eating), eating disorder symptoms including the overvaluation of shape and weight, obesity severity, and comorbid psychopathology with an emphasis on mood and anxiety. Based on these rationale, the initial indicators included the following baseline variables: the sum of OBE and SBE frequencies from the EDE, OOE frequency from the EDE, the four EDE subscales (restraint, eating concern, shape concern, weight concern), EDE Overvaluation of Shape/Weight (as measured by a score of 4 or above on the Importance of Weight or Importance of Shape item), presence of a current anxiety disorder diagnosis on the SCID-I, presence of a current mood disorder diagnosis on the SCID-I, depression severity based on the IDS-SR, self-esteem as measured by the RSE, and body mass index (BMI). LPA was conducted on the full sample ($N = 259$) and was iterative involving the exclusion of variables due to conditional dependence (see Crow et al., 2011) to find the best fitting model. Through this iterative process, several indicators were dropped due to concerns about conditional dependence including the EDE Shape Concern subscale, the EDE Weight Concern subscale, and the RSE. Model fit was evaluated using the Bayesian information criterion (BIC; Schwartz, 1978), the sample adjusted BIC (aBIC; Sclove, 1987), and the consistent Akaike information criterion (cAIC; Akaike, 1987; Bozdogman, 1987). All of the information criterion indices were used for comparing plausible models with the lowest values indicating the best fitting model. In addition, the entropy index (Ramaswamy, DeSarbo, Reibstein, & Robinson, 1993), which represents average classification accuracy, was used for evaluating competing models. The assumption of conditional independence was evaluated using pair-wise residuals for LPA indicators with values greater than 4.0 suggesting conditional dependence. In order to evaluate the stability of the LPA solution, a bootstrap procedure was performed selecting 100 consecutive random samples consisting of 95% ($n = 246$) of the original sample. Assignment of individuals to classes was made on the basis of posterior probabilities. A separate LPA was performed on each sample. Stability was evaluated in terms of the number of clusters identified and correspondence between cluster membership in the original and bootstrap samples (see Wonderlich et al., 2005).

To maximize the similarity of treatment received among the participants in these analyses as well as to examine outcome at follow-up time points, the wait list control group (who received active treatment but not until they had waited for 20 weeks) was excluded from predictor analyses, resulting in a sample of 190. Statistical comparisons revealed no differences between the subsample of 190 and the full sample of 259 on any demographic or psychopathology measures.

Treatment outcome at end of treatment, 6-month follow-up, and 1-year follow-up was defined in three ways including frequency of OBE episodes (past 28 days), abstinence from OBE episodes (past 28 days), and EDE global score. Analysis of covariance (EDE global), generalized estimating equations models with negative binomial response function (OBE episodes), or logistic regression analysis (abstinence) controlling for baseline severity and treatment condition, were used to determine whether LPAs were predictive of outcome at end of treatment and both follow-up assessments. Analysis was based upon all available data at a given time point.

Results

Attrition

Of the 190 who started, 136 (71.6%) participants completed treatment ($n = 53$, 88.3% of therapist-led; $n = 43$, 68.3% of therapist-assisted; $n = 40$, 59.7% of self-help conditions). At 6-month follow-up, 117 (61.5%) were assessed ($n = 40$, 66.7% of therapist-led; $n = 38$, 47.6% of therapist-assisted; $n = 39$, 58.2% of self-help conditions). At 1-year follow-up, 91 (47.9%) were assessed ($n = 25$, 41.7% of therapist-led; $n = 30$, 47.6% of therapist-assisted; $n = 36$, 53.7% of self-help conditions). As reported previously (Peterson et al., 2009), no differences were found between the non-completers and completers except that non-completers were younger.

Empirical classification

The best fitting LPA model in the full sample yielded three latent profiles (see Tables 1 and 2 and Fig. 1) which was confirmed in all 100 bootstrap samples. The overall rate of individual classification discrepancy was 2.9%. As shown in Table 2, after excluding the wait list control group which resulted in a sample of 190, the first latent profile, dietary restraint only (DRO; $n = 96$; 51%), was associated with relatively lower scores on baseline measures of eating disorder psychopathology, depression, and anxiety and relatively higher restraint scores. The second latent profile, low dietary restraint (LDR; $n = 52$; 27%), was associated with relatively lower levels of eating disorder and associated psychopathology and higher BMI than the other two latent profiles (see Table 2). The third latent profile, dietary restraint plus psychopathology (DRP; $n = 42$; 22%), was characterized by relatively higher levels of eating disorder psychopathology (including the highest level of dietary restraint, significantly more OBEs than the DRO latent profile and more SBEs than both other latent profiles), mood, and anxiety symptoms. For potential clinical utility in applying LPA findings to clinical practice, Table 3 provides patterns of cut-points for patterns of indicator variables within each latent profile. Within the DRO profile, two most common clinical patterns are high levels of dietary restraint (based upon a median score of 1.2 in the current sample) with or without high levels of eating concerns in the absence of a current mood or anxiety disorder. The most common clinical pattern within the LDR profile is high BMI (based upon median value of 38.0) and low dietary restraint in the absence of a current mood or anxiety disorder. The most common clinical patterns within the DRP profile are high levels of weight and shape concerns with or without a current mood or anxiety disorder, along with high depression scores (based upon a median IDS score of 23.0).

Prediction of treatment outcome

Regression analyses indicated that LPA classification was not predictive of treatment outcome as measured by OBE frequency (end of treatment: Wald $\chi^2 = 0.97$, $df = 2$, $p = .616$; 6-month follow-up: Wald $\chi^2 = 2.48$, $df = 2$, $p = .289$; 12-month follow-up: Wald $\chi^2 = 3.85$, $df = 2$, $p = .146$) or abstinence (end of treatment: Wald $\chi^2 = 0.36$, $df = 2$, $p = .835$; 6-month follow-up: Wald $\chi^2 = 4.32$, $df = 2$, $p = .116$; 12-month follow-up: Wald $\chi^2 = 1.07$, $df = 2$, $p = .584$) (see Table 4). Based on the EDE global score, LPA classification was not predictive of outcome at end of treatment ($F = 1.41$, $df = 2$, 129, $p = .248$, partial $\eta^2 = 0.02$) or 6-month follow-up ($F = 1.02$, $df = 2$, 111, $p = .363$, partial $\eta^2 = 0.02$) but was significant with a moderate effect size (Cohen, 1988) for 12-month follow-up ($F = 3.16$, $df = 2$, 83, $p = .047$, partial $\eta^2 = 0.07$), with the LDR profile showing significantly poorer outcome than DRO profile based upon covariate-adjusted post hoc contrasts (neither were significantly different from DRP). Treatment outcome by LPA classification is shown in Fig. 2.

Discussion

The results of this investigation support previous research suggesting that empirical classification is a potentially useful method for identifying meaningful BED subgroupings based on eating disorder symptoms, obesity severity, and associated psychopathology. Specifically, this study found three latent profiles using baseline indicators of eating disorder psychopathology, mood and anxiety disorder symptoms and diagnoses, and BMI. These three latent profiles included a DRO profile (the largest subsample with slightly over half the participants), an LDR profile (27% of the sample), and a DRP profile (22% of the sample). Of note, the LDR group was associated with relatively higher BMI, suggesting that this group was characterized by more obesity compared to the other two profiles. The DRP profile was associated with significantly more OBEs at baseline than the LDR profile. The results of this investigation also support previous studies of BED indicating that classification based on levels of dietary restraint and associated psychopathology including depressive symptoms creates meaningful subgroupings (Grilo et al., 2001; Masheb & Grilo, 2008; Stice et al., 2001). In contrast to previous findings, this study found support for three instead of two groupings, namely dietary restraint only, low dietary restraint, and dietary restraint with psychopathology. Empirical classification procedures used in this study also provide further evidence for the value of examining the overvaluation of shape and weight (e.g., Masheb & Grilo, 2008) given the relatively high rates of this symptom in the DRP profile.

Although previous research has found that groupings based on empirical classification were predictive of BED treatment outcome in IPT and guided self-help treatment (Sysko et al., 2010), the current study of group CBT observed only one significant finding: the LDR profile was predictive of higher global eating disorder symptoms at 12-month follow-up. Profile status was not predictive of global eating disorder symptoms at end of treatment or 6-month follow-up or of binge eating frequency or abstinence at any time point. However, the fact that the LDR profile had relatively higher eating disorder psychopathology scores at one year follow-up suggests that group CBT, at least as it was administered in the current study, was not as effective at targeting these symptoms in this group of participants at one year follow-up.

Reasons for these findings are unclear but may be the result of several factors. First, a priori LPA indicator choice was based on previous research suggesting that depression, dietary restraint, overvaluation of shape and weight, and other measures of psychopathology may be valid predictors of BED outcome (Grilo et al., 2012; Sysko et al., 2010). The fact that most baseline indicators were measures of general eating disorder and psychiatric symptoms may have increased the likelihood that the resulting LPA groupings that included eating disorder symptoms were predictive of eating disorder global severity. An additional possibility is that attrition, especially at follow-up assessments, may have limited the power needed to detect predictive relationships between latent profile groups and binge eating outcome measures. The contrast in findings between the current study and that of Sysko and colleagues' may be due to the fact that although many of the indicators overlapped, the previous study used additional indicators such as physical activity, compensatory behaviors, and past eating disorder history. Alternatively, the findings may be treatment-specific given that the previous study did not include group CBT.

This study is characterized by several strengths, including a relatively large multisite BED sample, the use of semi-structured interview assessment, and attention to conditional dependence in the LPA procedures. However, several limitations are important to note in interpreting the findings of this investigation. First, although statistical analysis controlled for type of CBT treatment (and, as described in Peterson et al., 2009, no significant

differences among treatment conditions were observed at follow-up), the fact that this study compared therapy delivery models including technology-delivered psychoeducation and structured self-led group discussions meant that some of the participants received CBT delivered unconventionally. These variations in treatment delivery may limit the extent to which these findings can be more broadly generalized more generally to group CBT for BED. In addition, sample size made it impossible to examine treatment condition specific outcomes (e.g., whether latent profiles were predictive of outcome in specific types of CBT delivery models including self-help, therapist-assisted and therapist led conditions) and it is possible that treatment specific effects would have been observed if statistical power had permitted such analyses. Although the CBT manual used in the treatment study was modified from previous use with bulimia nervosa (Mitchell et al., 1993), this version of group CBT for BED has not been as widely used as other manuals (e.g., Wilfley et al., 2002). In addition, whether these results would generalize to other evidence-based BED treatments including interpersonal therapy (IPT; Fairburn, Marcus, & Wilson, 1993; Wilfley et al., 2002) or dialectical behavior therapy (DBT; Safer, Robinson, & Jo, 2010) as well as to other CBT manuals (e.g., Fairburn, 2008) is unclear. Although cut-points are provided in Table 3 to enhance the clinical relevance of these results, these measures are not typically administered in clinical practice which may limit the practical implications of these findings. As described above, attrition may have limited statistical power and may have restricted the generalizability of the sample at end of treatment and follow-up assessments. Additionally, although the LPA indicators used in this study were selected based on previous BED research, they were limited in scope. Alternative indicators including personality measures (e.g., Wildes et al., 2011; Wonderlich et al., 2005) may yield latent classes and profiles in empirical classification that have better predictive validity than the ones used in this investigation. Finally, this sample was primarily Caucasian and as a result is not well representative of the ethnic diversity of BED community samples (see Franko et al., 2012).

Future research should aim to broaden the scope of empirical classification using a wider array of indicators in the context of traditionally-delivered group CBT and in IPT, DBT, individual therapy (e.g., CBT-Enhanced, Fairburn, 2008), and guided self-help (Wilson et al., 2010; Carter & Fairburn, 1998; Striegel-Moore et al., 2010), as well as clinical samples in naturalistic settings. In addition, empirical classification using LPA or LCA should be replicated in a nontreatment seeking sample of individuals with BED as well as obese individuals without BED to better understand the generalizability of these results. Expanding the clinical utility of empirical classification studies is especially imperative, for example, with cut points that can be utilized in clinical settings (e.g., Table 3). For example, these findings suggest that individuals with low levels of psychopathology and dietary restraint may need modified versions of CBT to target different mechanisms of eating disorder symptoms or require sequential treatment following CBT to more effectively reduce and eliminate eating disorder symptoms at longer term follow-up. Alternatively, this subgrouping of individuals may be better suited for alternative treatments including IPT and DBT. These findings also suggest that a subset of individuals with BED can be characterized by higher levels of eating disorder, mood, and anxiety symptoms. However, because this DRP profile was not predictive of poorer outcome, group CBT may be an appropriate treatment regardless of symptom severity in BED. Further research is needed to determine the extent to which empirical classification can be used as a treatment matching strategy as well as to refine and modify treatments to better target binge eating and associated symptoms. Empirical classification can potentially be used to guide the development of improved BED treatments by helping to identify causal and maintenance mechanisms that can be addressed in the context of innovative interventions. Finally, although prediction of treatment outcome using baseline indicators may be useful to understand patterns of prognosis, identifying treatment moderation effects may ultimately be more effective in identifying which treatments are most effective for different types of patients. Future studies

replicating this investigation are needed using more complex models of moderation effects to understand differential response to CBT among patients with BED.

Acknowledgments

This study was supported by grants R01DK61912, R01DK 61973, and P30 DK 60456 from the National Institute of Diabetes and Digestive and Kidney Diseases, grant K02 MH65919 from the National Institute of Mental Health, and the Neuropsychiatric Research Institute. The investigators wish to express gratitude to the research staff, clinical assessors, and therapists at the University of Minnesota and the University of North Dakota/Neuropsychiatric Research Institute including Drs. Helene Keery, Christianne Lysne, Kathryn Miller, Hal Pickett, Lorraine Swan, Molly Gill Willer, Aimee Arikian, Kelly Berg, and Tricia Myers as well as Li Cao, Christine Dittel, Nora Durkin, M.A., Heather Beach, M P H, Nancy Monson, Heather Simonich, M.A., Melissa Burgard, Kevin Rittenhouse, Macey Furstenuau, Lisa Chartier, Erin Venegoni, Andrew Selders, Kathy Lancaster, Shannon Bailey, Joy Johnson-Lind, M.S.W., Jodi Swanson, Traci Kalberer, Jason Hammes, Jennifer Redlin, Maria Frisch, Justin Boseck, and Deborah Roerig.

References

- Akaike H. Factor analysis and AIC. *Psychometrika*. 1987; 52:317–332.
- American Psychiatric Association. Diagnostic and statistical manual of mental disorders, text revision. 4th ed.. Washington, DC: American Psychiatric Association; 2000.
- Berg KC, Peterson CB, Frazier P, Crow SC. Psychometric evaluation of the Eating Disorder Examination and Eating Disorder Examination- Questionnaire: a systematic review of the literature. *International Journal of Eating Disorders*. 2012; 45:428–438. [PubMed: 21744375]
- Bozdogman H. Model selection and Akaike's information criterion: the general theory and its analytical extensions. *Psychometrika*. 1987; 52:345–370.
- Brownley KA, Berkman ND, Sedway JA, Lohr KN, Bulik CM. Binge eating disorder treatment: a systematic review of randomized controlled trials. *International Journal of Eating Disorders*. 2007; 40:310–320. [PubMed: 17370290]
- Bulik CM, Brownley KA, Shapiro JR. Diagnosis and management of binge eating disorder. *World Psychiatry*. 2007; 6:142–148. [PubMed: 18188431]
- Carter JC, Fairburn CG. Cognitive behavioral self-help for binge eating disorder: a controlled effectiveness study. *Journal of Consulting and Clinical Psychology*. 1998; 66:616–623. [PubMed: 9735577]
- Cohen, J. Statistical power analysis for the behavioral sciences. 2nd ed.. Hillsdale, NJ: Lawrence Erlbaum; 1988.
- Crow SJ, Peterson CB, Swanson SA, Raymond NC, Specker S, Eckert ED, et al. Increased mortality in bulimia nervosa and other eating disorders. *American Journal of Psychiatry*. 2009; 166:1342–1346. [PubMed: 19833789]
- Crow, S.; Swanson, SA.; Peterson, CB.; Crosby, RD.; Wonderlich, SA.; Mitchell, JE. Latent structure analyses of eating disorder diagnoses: critical review of results and methodological issues. In: Striegel-Moore, R.; Wonderlich, SA.; Walsh, BT.; Mitchell, JE., editors. Developing an evidence-based classification of eating disorders: scientific findings for DSM-5. Arlington, VA: American Psychiatric Association; 2011. p. 103-120.
- Crow SJ, Swanson SA, Peterson CB, Crosby RD, Wonderlich SA, Mitchell JE. Latent class analysis of eating disorders: relationship to mortality. *Journal of Abnormal Psychology*. 2012; 121:225–231. [PubMed: 21707126]
- Fairburn, CG. Cognitive behavior therapy and eating disorders. New York: Guilford; 2008.
- Fairburn, CG.; Cooper, Z. The eating disorder examination. In: Fairburn, CG.; Wilson, GT., editors. Binge eating: Nature, assessment, and treatment. 12th ed.. New York: Guilford Press; 1993. p. 317-360.
- Fairburn, CG.; Marcus, MD.; Wilson, GT. Cognitive-behavioral therapy for binge eating and bulimia nervosa: a comprehensive treatment manual. In: Fairburn, CG.; Wilson, GT., editors. Binge eating: nature, assessment and treatment. New York: Guilford Press; 1993. p. 361-404.
- First, MB.; Spitzer, RL.; Gibbon, M.; Williams, JBW. Structured clinical interview for DSM-IV axis I disorders patient-version (SCID-I/P). New York: NYSPI; 1995.

- Franko DL, Thompson-Brenner H, Thompson DR, Boisseau CL, Davis A, Forbush KT, et al. Racial/ethnic differences in adults in randomized clinical trials of binge eating disorder. *Journal of Consulting and Clinical Psychology*. 2012; 80:186–195. [PubMed: 22201327]
- Grilo CM, Crosby RD, Masheb RM, White MA, Peterson CB, Wonderlich SA, et al. Overvaluation of shape and weight in binge eating disorder, bulimia nervosa, and subthreshold bulimia nervosa. *Behaviour Research and Therapy*. 2009; 47:692–696. [PubMed: 19552897]
- Grilo CM, Hrabosky JI, Allison KC, Stunkard AJ, Masheb RM. Overvaluation of shape and weight in binge eating disorder and overweight controls: refinement of a diagnostic construct. *Journal of Abnormal Psychology*. 2008; 117:414–419. [PubMed: 18489217]
- Grilo CM, Masheb RM, Crosby RD. Predictors and moderators of response to cognitive behavioral therapy and medication for the treatment of binge eating disorder. *Journal of Consulting and Clinical Psychology*. 2012; 80:897–906. [PubMed: 22289130]
- Grilo CM, Masheb RM, Lozano-Blanco C, Barry DT. Reliability of the eating disorder examination in patients with binge eating disorder. *International Journal of Eating Disorders*. 2004; 35:80–85. [PubMed: 14705160]
- Grilo CM, Masheb RM, White MA. Significance of overvaluation of shape/weight in binge eating disorder: comparative study with overweight and bulimia nervosa. *Obesity*. 2010; 18:499–504. [PubMed: 19713949]
- Grilo CM, Masheb RM, Wilson GT. Subtyping binge eating disorder. *Journal of Consulting and Clinical Psychology*. 2001; 69:1066–1072. [PubMed: 11777111]
- Hrabosky JI, Masheb RM, White MA, Grilo CM. Overvaluation of shape and weight in BED. *Journal of Consulting and Clinical Psychology*. 2007; 75:175–180. [PubMed: 17295577]
- Hudson JI, Hiripi E, Pope HG Jr, Kessler RC. The prevalence and correlates of eating disorders in the National Comorbidity Survey Replication. *Biological Psychiatry*. 2007; 61:348–358. [PubMed: 16815322]
- Kraemer HC, Wilson GT, Agras WS, Fairburn CG. Mediators and moderators of treatment effects in randomized controlled trials. *Archives of General Psychiatry*. 2002; 59:877–883. [PubMed: 12365874]
- Lobbetael J, Leurgans M, Arntz A. Inter-rater reliability of the structured clinical interview for DSM-IV axis I disorders (SCID I) and axis II disorders (SCID II). *Clinical Psychology and Psychotherapy*. 2010; 18:75–79. [PubMed: 20309842]
- Masheb RM, Grilo CM. Binge eating disorder: a need for additional diagnostic criteria. *Comprehensive Psychiatry*. 2000; 41:159–162. [PubMed: 10834622]
- Masheb RM, Grilo CM. Prognostic significance of two sub-categorization methods for the treatment of binge eating disorder: negative affect and overvaluation predict, but do not moderate, specific outcomes. *Behaviour Research and Therapy*. 2008; 46:428–437. [PubMed: 18328464]
- Mitchell, JE.; Devlin, MJ.; de Zwaan, M.; Crow, SJ.; Peterson, CB. Binge-eating disorder: Clinical foundations and treatment. New York: Guilford; 2008.
- Mitchell JE, Pyle RL, Pomeroy C, Zollman M, Crosby R, Seim H, et al. Cognitive-behavioral group psychotherapy of bulimia nervosa: importance of logistical variables. *International Journal of Eating Disorders*. 1993; 14:277–287. [PubMed: 8275064]
- National Institute for Clinical Excellence (NICE). Eating disorders – core interventions in the treatment and management of anorexia nervosa, bulimia nervosa, related eating disorders. London: NICE; 2004. NICE clinical guideline No. 9.
- Peterson, CB.; Mitchell, JE. Treatment of binge-eating disorder in group cognitive- behavioral therapy. In: Werne, J., editor. Treating eating disorders. San Francisco: Jossey-Bass; 1996. p. 143–186.
- Peterson CB, Mitchell JE, Crow SJ, Crosby RS, Wonderlich SA. The efficacy of self-help group treatment and therapist-led group treatment for binge eating disorder. *American Journal of Psychiatry*. 2009; 166:1347–1354. [PubMed: 19884223]
- Ramaswamy V, DeSarbo W, Reibstein D, Robinson W. An empirical pooling approach for estimating marketing mix elasticities with PIMS data. *Marketing Science*. 1993; 12:103–124.
- Reas DL, Grilo CM. Review and meta-analysis of pharmacotherapy for binge eating disorder. *Obesity*. 2008; 16:2024–2038. [PubMed: 19186327]

- Rieger E, Van Buren DJ, Bishop M, Tanofsky-Kraff M, Welch R, Wilfley DE. An eating disorder-specific model of interpersonal psychotherapy (IPT-ED): casual pathways and treatment implications. *Clinical Psychology Review*. 2010; 30:400–401. [PubMed: 20227151]
- Rosenberg, M. *Conceiving the self*. New York: Basic Books; 1979.
- Rush AJ, Giles DE, Schlessner MA, Fulton CL, Weissenburger J, Burns C. The Inventory for depressive Symptomatology (IDS): preliminary findings. *Psychiatry Research*. 1986; 18:65–87. [PubMed: 3737788]
- Rush AJ, Gullion CM, Basco MR, Jarret RB, Trivedi MH. The Inventory of depressive Symptomatology (IDS): psychometric properties. *Psychological Medicine*. 1996; 26:477–486. [PubMed: 8733206]
- 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. *Behavior Therapy*. 2010; 41:106–120. [PubMed: 20171332]
- Schwartz G. Estimating the dimension of a model. *Annals of Statistics*. 1978; 6:461–464.
- Sclavos LS. Application of model-selection criteria to some problems in multivariate analysis. *Psychometrika*. 1987; 52:333–343.
- Shear MK, Greeno C, Kang J, Ludewig J, Frank E, Swartz HA, et al. Diagnosis of nonpsychotic patients in community clinics. *American Journal of Psychiatry*. 2000; 157:581–587. [PubMed: 10739417]
- Stice E, Agras WS, Telch CF, Halmi KA, Mitchell JE, Wilson GT. Subtyping binge eating-disordered women along dieting and negative affect dimensions. *International Journal of Eating Disorders*. 2001; 30:11–27. [PubMed: 11439405]
- Strauman TJ, Merrill KA. The basic science/clinical science interface and treatment development. *Clinical Psychology: Science and Practice*. 2004; 11:263–266.
- Striegel-Moore RH, Wilson GT, DeBar L, Perrin N, Lynch F, Rosselli F, et al. Cognitive-behavioral guided self-help for the treatment of recurrent binge eating. *Journal of Consulting and Clinical Psychology*. 2010; 78:312–321. [PubMed: 20515207]
- Sysko R, Hildebrandt T, Wilson GT, Wilfley DE, Agras WS. Heterogeneity moderates treatment response among patients with binge eating disorder. *Journal of Consulting and Clinical Psychology*. 2010; 78:681–690. [PubMed: 20873903]
- Wildes JE, Marcus MD, Crosby RD, Ringham RM, Dapello MM, Gaskill JA, et al. The clinical utility of personality subtypes in patients with anorexia nervosa. *Journal of Consulting and Clinical Psychology*. 2011; 79:665–674. [PubMed: 21767000]
- Wilfley DE, Welch RR, Stein RI, Spurrell EB, Cohen LR, Saelens BE, et al. A randomized comparison of group cognitive-behavioral therapy and group interpersonal psychotherapy for the treatment of overweight individuals with binge-eating disorder. *Archives of General Psychiatry*. 2002; 59:713–721. [PubMed: 12150647]
- Wilson GT, Grilo CM, Vitousek KM. Psychological treatments of eating disorders. *American Psychologist*. 2007; 62:199–216. [PubMed: 17469898]
- Wilson GT, Wilfley DE, Agras WS, Bryson SW. Psychological treatments of binge eating disorder. *Archives of General Psychiatry*. 2010; 67:94–101. [PubMed: 20048227]
- Wonderlich SA, Crosby RD, Joiner T, Peterson CB, Bardone-Cone A, Klein M, et al. Personality subtyping and bulimia nervosa: psychopathological and genetic correlates. *Psychological Medicine*. 2005; 35:649–657. [PubMed: 15918341]
- Wonderlich SA, de Zwaan M, Mitchell JE, Peterson CB, Crow SJ. Psychological and dietary treatments of binge eating disorder: conceptual implications. *International Journal of Eating Disorders*. 2003; 34(Supplement):S58–S73. [PubMed: 12900987]
- Wonderlich SA, Gordon KH, Mitchell JE, Crosby RD, Engel SG. The validity and clinical utility of binge eating disorder. *International Journal of Eating Disorders*. 2009; 42:687–705. [PubMed: 19621466]
- Wonderlich SA, Joiner TE, Keel PK, Williamson DA, Crosby RD. Eating disorder diagnoses: empirical approaches to classification. *American Psychologist*. 2007; 62:167–180. [PubMed: 17469896]

Fig. 1.

Baseline latent profile analysis. OBE/SBE = frequency of objective bulimic (binge eating) and subjective bulimic (binge eating) episodes (from the eating disorders examination); weight/shape = importance of weight and/or shape (score of 4, 5 or 6 on the eating disorder examination); IDS = inventory of depressive symptoms self report; mood Dx = current Axis I mood disorder; anxiety Dx = current Axis I anxiety disorder; BMI = body mass index; restraint = restraint subscale of the eating disorder examination; Eat concern = eating concern subscale of the eating disorder examination; OOE = objective overeating from the eating disorder examination; dietary restraint only, $n = 130$; 51%; low dietary restraint, $n = 71$; 27%; dietary restraint plus psychopathology, $n = 58$; 22%.

Table 1

Latent profile analysis model fit indices ($N = 259$).

Classes	Log likelihood	Para-meters	BIC	aBIC	cAIC	Entropy
1	-4360.66	26	8865.79	8783.37	8891.79	1
2	-4282.90	41	8793.63	8663.64	8834.63	0.5848
3	-4224.53	56	8760.23	8582.69	8816.23	0.7017
4	-4190.34	71	8775.21	8550.11	8846.21	0.7373
5	-4172.93	86	8823.74	8551.09	8909.74	0.7290
6	-4155.72	101	8872.68	8552.48	8973.68	0.7243
7	-4127.54	116	8899.67	8531.91	9015.67	0.7746
8	-4116.23	131	8960.40	8545.09	9091.40	0.7973

BIC = Bayesian information criterion; aBIC = the sample adjusted BIC; cAIC = consistent Akaike information criterion; AIC = Akaike information criterion.

Table 2

Baseline demographic, eating disorder, psychopathology, and body mass index measures for latent profiles ($N = 190$ active treatment participants).

	LPA 1: Dietary restraint only ($n = 96$)	LPA 2: Low dietary restraint ($n = 52$)	LPA 3: dietary restraint plus psychopathology ($n = 42$)	Total ($N = 190$)	Significance
Age (mean, SD)	46.7 (10.1)	47.3 (10.4)	45.7 (10.2)	46.7 (10.2)	$F_{(2,187)} = 0.29, p = .746$
Female ($n, \%$)	82 (85.9%)	48 (92.3%)	41 (97.6%)	171 (90.0%)	$\chi^2_{(2)} = 5.26, p = .072$
College education ($n, \%$)	71 (74.0%)	38 (73.1%)	30 (71.4%)	139 (73.20025%)	$\chi^2_{(2)} = 0.09, p = .953$
Antidepressant medication (%)	74 (77.1%)	42 (80.8%)	35 (83.3%)	151 (79.5%)	$\chi^2_{(2)} = 0.37, p = .831$
Body mass index (mean, SD)	37.9 (7.1) ^a	43.0 (9.0) ^b	38.2 (7.9) ^a	39.3 (8.1)	$F_{(2,187)} = 7.76, p = .001$
EDE OBE episodes (mean, SD)	19.8 (10.8) ^c	22.9 (15.1) ^a	30.0 (20.4) ^b	22.9 (15.0)	Wald $\chi^2_{(2)} = 12.69, p < .002$
EDE SBE episodes (mean, SD)	7.0 (10.5) ^a	9.3 (15.5) ^a	17.6 (20.4) ^c	10.0 (15.1)	Wald $\chi^2_{(2)} = 15.91, p < .001$
EDE restraint (mean, SD)	1.94 (0.96) ^a	0.15 (0.18) ^b	2.51 (1.47) ^c	1.58 (1.33)	$F_{(2,187)} = 81.79, p < .001$
EDE eating concern (mean, SD)	1.61 (1.06) ^a	1.78 (1.19) ^a	3.00 (1.02) ^b	1.97 (1.22)	$F_{(2,187)} = 24.87, p < .001$
EDE shape concern (mean, SD)	3.35 (0.98) ^a	3.34 (0.92) ^a	4.27 (0.88) ^b	3.55 (1.01)	$F_{(2,187)} = 15.91, p < .001$
EDE weight concern (mean, SD)	3.32 (1.04) ^a	2.88 (1.15) ^b	4.12 (0.87) ^c	3.37 (1.12)	$F_{(2,187)} = 17.13, p < .001$
EDE overvaluation of shape/weight ($n, \%$)	72 (75.0%) ^a	38 (73.1%) ^a	41 (97.6%) ^b	151 (79.5%)	$\chi^2_{(2)} = 10.96, p < .004$
EDE global (mean, SD)	2.55 (0.70) ^a	2.04 (0.68) ^b	3.48 (0.68) ^c	2.62 (0.86)	$F_{(2,187)} = 51.25, p < .001$
IDS-SR (mean, SD)	19.9 (7.9) ^a	21.7 (9.4) ^a	36.2 (9.7) ^b	24.1 (11.0)	$F_{(2,187)} = 52.77, p < .001$
Axis I current mood disorder ($n, \%$)	1 (1.0%) ^a	1 (2.0%) ^a	16 (38.1%) ^b	18 (9.5%)	$\chi^2_{(2)} = 51.87, p < .001$
Axis I current anxiety disorder ($n, \%$)	18 (18.9%) ^a	6 (11.5%) ^a	24 (57.1%) ^b	48 (25.4%)	$\chi^2_{(2)} = 29.70, p < .001$

EDE = Eating Disorder Examination; OBE = Objective bulimic (binge eating) episodes; SBE = subjective bulimic (binge eating) episodes; IDS-SR = Inventory of Depressive Symptoms Self Report; different letters in superscript indicate significant group differences ($p < .05$).

Table 3

Most common Indicator patterns within latent profiles based on cut-points.

Latent profile 1: dietary restraint only				
Percentage of participants within latent profile 1	Mood disorder diagnosis (SCID)	Anxiety disorder diagnosis (SCID)	Restraint (EDE Subscale)	Eating concern (EDE Subscale)
38	No	No	1.2	<1.8
28	No	No	1.2	1.8
Latent profile 2: low dietary restraint				
Percentage of participants within latent profile 2	Mood disorder diagnosis (SCID)	Anxiety disorder diagnosis (SCID)	BMI	Restraint (EDE subscale)
62	No	No	38	<1.0
Latent profile 3: dietary restraint plus psychopathology				
Percentage of participants within latent profile 3	Mood disorder diagnosis (SCID)	Anxiety disorder diagnosis (SCID)	Weight/Shape overvaluation (EDE items)	IDS-SR
31	No	Yes	Yes	23
22	Yes	No	Yes	23
19	Yes	Yes	Yes	23
19	No	No	Yes	23

SCID = Structured Clinical Interview for DSM-IV; EDE = Eating Disorder Examination; IDS = Inventory of Depressive Symptomatology-Self Report.

Table 4

Mean (standard deviation) binge eating and eating disorder severity for latent profiles at baseline, end of treatment and follow-up.

	EDE OBEs baseline	EDE OBEs end of treatment and % abstinent	EDE OBEs 6-month follow-up and % abstinent	EDE OBEs 12-month follow-up and % abstinent	EDE global baseline	EDE global end of treatment	EDE global 6-month follow-up	EDE global 12-month follow-up
LPA 1: dietary restraint only	19.84 (10.78), <i>n</i> = 96	3.43 (7.27), <i>n</i> = 71, 45.1%	3.03 (6.49), <i>n</i> = 61, 52.5%	2.22 (4.77), <i>n</i> = 45, 55.6%	2.56 (0.71), <i>n</i> = 96	1.72 (0.76), <i>n</i> = 71	1.56 (0.61), <i>n</i> = 61	1.34 (0.74), <i>n</i> = 44
LPA 2: low dietary restraint	22.92 (15.12), <i>n</i> = 52	6.37 (11.58), <i>n</i> = 38, 44.7%	6.82 (10.30), <i>n</i> = 33, 30.3%	4.67 (8.57), <i>n</i> = 30, 46.7%	2.04 (0.68), <i>n</i> = 52	1.73 (0.78), <i>n</i> = 37	1.64 (0.74), <i>n</i> = 33	1.61 (0.76), <i>n</i> = 30
LPA 3: dietary restraint + psychopathology	30.0 (20.36), <i>n</i> = 42	4.78 (8.11), <i>n</i> = 27, 51.9%	6.57 (12.34), <i>n</i> = 23, 47.8%	6.13 (8.57), <i>n</i> = 15, 40.0%	3.48 (0.68), <i>n</i> = 42	2.42 (1.17), <i>n</i> = 27	2.10 (1.04), <i>n</i> = 23	2.12 ± 0.90, <i>n</i> = 15
Overall sample	22.93 (15.03), <i>n</i> = 190	4.53 (8.87), <i>n</i> = 136, 46.3%	4.79 (9.12), <i>n</i> = 117, 45.3%	3.69 (7.01), <i>n</i> = 90, 50.0%	2.62 (0.86), <i>n</i> = 190	1.86 (0.90), <i>n</i> = 135	1.69 (0.77), <i>n</i> = 117	1.56 (0.82), <i>n</i> = 89

EDE = Eating Disorder Examination; OBE = Objective bulimic (binge eating) episodes (past 28 days); % Abstinent = percent abstinent from OBE episodes (past 28 days).