

# Application of a Latent Class Analysis to Empirically Define Eating Disorder Phenotypes

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**Context:** Diagnostic criteria for eating disorders influence how we recognize, research, and treat eating disorders, and empirically valid phenotypes are required for revealing their genetic bases.

**Objective:** To empirically define eating disorder phenotypes.

**Design:** Data regarding eating disorder symptoms and features from 1179 individuals with clinically significant eating disorders were submitted to a latent class analysis. The resulting latent classes were compared on non-eating disorder variables in a series of validation analyses.

**Setting:** Multinational, collaborative study with cases ascertained through diverse clinical settings (inpatient, outpatient, and community).

**Participants:** Members of affected relative pairs recruited for participation in genetic studies of eating disorders in which probands met *DSM-IV-TR* criteria for anorexia nervosa (AN) or bulimia nervosa and had at least 1 biological relative with a clinically significant eating disorder.

**Main Outcome Measure:** Number and clinical characterization of latent classes.

**Results:** A 4-class solution provided the best fit. Latent class 1 (LC1) resembled restricting AN; LC2, AN and bulimia nervosa with the use of multiple methods of purging; LC3, restricting AN without obsessive-compulsive features; and LC4, bulimia nervosa with self-induced vomiting as the sole form of purging. Biological relatives were significantly likely to belong to the same latent class. Across validation analyses, LC2 demonstrated the highest levels of psychological disturbance, and LC3 demonstrated the lowest.

**Conclusions:** The presence of obsessive-compulsive features differentiates among individuals with restricting AN. Similarly, the combination of low weight and multiple methods of purging distinguishes among individuals with binge eating and purging behaviors. These results support some of the distinctions drawn within the *DSM-IV-TR* among eating disorder subtypes, while introducing new features to define phenotypes.

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**T**HE TERM ANOREXIA NERVOSA (AN) was first used to describe a self-starvation syndrome predominantly affecting adolescent girls in the latter half of the 19th century.<sup>1</sup> Approximately 100 years later, Russell<sup>2</sup> introduced the term *bulimia nervosa* (BN) to describe women who exhibited recurrent bouts of binge eating and self-induced vomiting. Although most of these women had histories of AN, their binge-purge pattern was sustained at normal weight, leading Russell to conclude that BN represented an “ominous variant of anorexia nervosa.” Anorexia nervosa and BN now represent the formally recognized syndromes in the category of eating disorders in the *DSM-IV*, *Text Revision* (*DSM-IV-TR*)<sup>3</sup> and *International Classification of*

*Diseases and Related Health Disorders, 10th Revision* (*ICD-10*).<sup>4</sup>

Although data on psychological correlates<sup>5-7</sup> and the course of illness<sup>8-11</sup> support current nosologic schemes, other data suggest considerable overlap among AN, BN, and eating disorders not otherwise specified (EDNOS).<sup>12-15</sup> In as many as 50% of individuals with AN, BN develops, and among individuals with BN, approximately 30% report histories of AN.<sup>16</sup> Furthermore, the *DSM-IV-TR* and *ICD-10* definitions are not isomorphic regarding diagnosis of concurrent AN and BN. Considering the longitudinal instability of the distinction between disorders and shared characteristics, it is not surprising that family studies suggest substantial cross-transmission of AN, BN, and EDNOS.<sup>13,14</sup> Given evidence that eat-

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ing disorders are heritable,<sup>17,18</sup> it remains unclear whether familial cross-transmission reflects the existence of a broad eating disorder phenotype with shared genetic predispositions<sup>19</sup> or limitations in the systems we currently use to distinguish among eating disorders.<sup>20</sup> Moreover, the identification of genetic susceptibility loci for illnesses with complex inheritance requires the identification of valid and reliable phenotypes.<sup>21</sup>

Because diagnostic criteria influence how we recognize, research, and treat eating disorders, it is important to ensure their empirical validity. That is, beyond clinical experience in seeing patients who present with certain syndromal patterns, is there evidence that certain symptoms coaggregate at above-chance levels to form distinct disorders of eating? A recent investigation examined this question using latent class analysis (LCA).<sup>22</sup> Briefly, LCA posits that a heterogeneous group can be reduced to several homogeneous subgroups through evaluating and then minimizing associations among responses across multiple variables. For example, within a group of healthy control subjects and patients with BN and in whom patient status was unobserved, LCA would detect an association between the likelihood of endorsing binge eating and the likelihood of vomiting. By creating 2 latent classes (individuals denying vs individuals endorsing both symptoms), the association between these variables would be eliminated within classes, and the presence of controls vs patients would be revealed. Thus, LCA is capable of determining the number and composition of unobserved latent classes that produce observed data. Bulik et al<sup>22</sup> detected 6 latent classes, of which 3 represented clinically significant eating disorders resembling AN, BN, and binge-eating disorder. Limitations of this investigation included a low base rate of eating disorders in the population-based twin sample and restriction of eating disorder symptoms included in the LCA to DSM-IV-TR diagnostic criteria. In addition, the interview used “skip” rules based on DSM-IV-TR definitions to reduce the overall length of assessment. For example, individuals who did not binge were not asked about purging.<sup>22</sup> Thus, the potential utility of symptoms not included in the DSM-IV-TR was not evaluated, and evaluation of symptoms was shaped by current conceptualizations of eating disorder typology.

The present study is an empirical investigation of eating disorder phenotypes based on data from 2 international, multisite studies of genetic factors in the pathogenesis of AN and BN. Although inclusion as a proband required a DSM-IV-TR eating disorder, inclusion as an affected relative did not require conformation with current eating disorder diagnostic criteria. This allows assessment of how symptoms coaggregate within individuals when not required by definition.

## METHODS

Because of the size and scope of the studies from which data are drawn, separate reports describe the methods in detail.<sup>19,23</sup> Relevant methodological information is reviewed herein.

### PARTICIPANTS

Participants (N=1179) were recruited as members of an affected relative pair (ARP). An ARP consisted of 1 proband

**Table 1. Lifetime DSM-IV Diagnoses in Probands and Affected Relatives\***

DSM-IV-TR Diagnosis ( $\kappa$ )	No. of Participants		
	Probands (n = 547)	Affected Relatives (n = 632)	Total Study Group (N = 1179)
AN (0.99)	185	184	369
BN (0.997)	175	154	329
AN + BN (0.99)†	187	182	369
EDNOS (0.99)	0	112	112

Abbreviations: AN, anorexia nervosa; BN, bulimia nervosa; DSM-IV-TR, DSM-IV Text Revision; EDNOS, eating disorders not otherwise specified.

\*Excludes the amenorrhea criterion for AN. The  $\kappa$  reliabilities for diagnoses were calculated from 88 interviews;  $\kappa$  for assignment to 1 of 4 eating disorder categories was 0.996.

†Indicates the lifetime presence of full criteria for AN and BN, concurrently or sequentially.

and at least 1 affected biological relative. For the first study (AN-ARP),<sup>23</sup> probands were required to have a lifetime diagnosis of DSM-IV-TR AN (excluding the amenorrhea criterion), with AN onset before 25 years of age and at least 3 years before participation. For the second study (BN-ARP),<sup>19</sup> probands were required to have a lifetime diagnosis of DSM-IV-TR BN, self-induced vomiting as the primary method of purging, and minimum frequency/duration of binge eating and vomiting of twice per week for 6 months. For both studies, affected relatives were required to meet criteria for a clinically significant eating disorder. Clinical significance was defined by present distress, disability, or increased risk for suffering. However, the disorder did not need to conform to DSM-IV-TR criteria for AN or BN. Thus, clinical presentation among affected relatives could range from DSM-IV-TR criteria for AN, BN, or EDNOS characterized as (1) partial AN, (2) recurrent binge eating and inappropriate compensatory behavior below the minimum frequency for a DSM-IV-TR BN diagnosis, or (3) recurrent use of extreme measures to control weight (eg, self-induced vomiting, laxative abuse, fasting, excessive exercise) in the absence of binge-eating episodes. Binge-eating disorder could not be the sole eating disorder diagnosis for affected relatives. **Table 1** presents lifetime DSM-IV-TR eating disorder diagnoses for the study group. Most participants (n=1135 [96.3%]) were female. The mean (SD) age of participants was 28.2 (9.7) years.

### DATA COLLECTION CENTERS

Participants were recruited by 11 different centers selected for experience in assessment of eating disorders and geographic distribution. Centers (principal investigator[s]) included the University of Pittsburgh, Pittsburgh, Pa (W.H.K.); Cornell University, White Plains, NY (K.A.H.); University of California–Los Angeles (M.S.); University of Toronto, Toronto, Ontario (A.S.K. and D.B.W.); Roseneck Hospital for Behavioural Medicine, University of Munich, Prien, Germany (M.F. and N.Q.); University of London, London, England (J.T.); University of Pisa, Pisa, Italy (A.R., M.M., and G.C.); University of North Dakota, Fargo (J.E.M.); University of Minnesota, Minneapolis (S.J.C.); Harvard University, Cambridge, Mass (P.K.K.); and University of Pennsylvania, Philadelphia (W.H.B.). Each center obtained institutional review board approval from its own human subjects committee. All participants completed written informed consent before participation.

## MEASURES

All measures used in the AN-ARP and BN-ARP studies have demonstrated high reliability (interrater or internal) and reasonable convergent and discriminant validity.<sup>19,23</sup>

### CLINICAL INTERVIEWS

The Structured Interview for Anorexic and Bulimic Disorders<sup>24</sup> assesses the presence of eating disorder symptoms and characteristics when each was at its worst and also when symptoms co-occurred to assess lifetime prevalence of *DSM-IV-TR* eating disorders. Lifetime symptoms/diagnoses were examined owing to the longitudinal instability of current symptoms/diagnoses.

The Yale-Brown Obsessive Compulsive Scale<sup>25</sup> assesses the presence and severity of obsessions and compulsions found among individuals with obsessive-compulsive disorder. The mean score for patients with obsessive-compulsive disorder is 25.1.<sup>26</sup>

Among the measures conducted in the BN-ARP study alone, we collapsed the Structured Clinical Interview for Axis I *DSM-IV* Disorders<sup>27</sup> diagnoses into mood disorders (bipolar I, bipolar II, major depressive, or dysthymia), anxiety disorders (specific phobia, social phobia, panic, agoraphobia, or obsessive-compulsive, posttraumatic stress, or generalized anxiety disorder), and substance use disorders (abuse or dependence for alcohol, sedatives, cannabis, stimulants, opioids, cocaine, or hallucinogens) for analyses. With the Structured Clinical Interview for *DSM-IV* Axis II Personality Disorders,<sup>28</sup> diagnoses were collapsed into clusters B (borderline, antisocial, narcissistic, or histrionic) and C (obsessive-compulsive, avoidant, or dependent) personality disorders for analyses. Cluster A personality disorders were not assessed owing to their low prevalence among individuals with eating disorders and time constraints.

### INTERVIEW ASSESSMENT TRAINING

Across the 2 studies and 11 centers, there were 38 clinical interviewers. All had clinical experience in eating disorder treatment or research. Highest degrees ranged from doctorates (17 interviewers [45%]) to masters' (15 [39%]) and bachelors' (6 [16%]) degrees in psychology. Each clinical interviewer completed a training program that involved (1) viewing trained raters performing assessments (minimum of 3), (2) scoring 3 videotaped interviews with an accepted level of accuracy, and (3) taping practice interviews reviewed by the head of assessment until the criterion was met (mean of 3). Subsequent to this training, every 10th interview was audiotaped for review by the head of assessment to prevent interviewer drift. The  $\kappa$  reliabilities for *DSM-IV-TR* diagnoses are reported in the tables.

### SELF-REPORT MEASURES

The Temperament and Character Inventory<sup>29</sup> assesses 7 dimensions of temperament (novelty seeking, harm avoidance, reward dependence, and persistence) and character (self-directedness, cooperativeness, and self-transcendence).

The Multidimensional Perfectionism Scale<sup>30</sup> evaluates overall perfectionism along with 6 specific dimensions of perfectionism (concern over mistakes, high personal standards, high perceived parental expectations, high perceived parental criticism, doubt about quality of performance, and need for organization, order, and precision). For this self-report measure alone, participants were asked to make ratings for when their eating disorder was most severe.

The State-Trait Anxiety Inventory<sup>31</sup> assesses anxiety "at this moment" (state) and general levels of anxiety (trait).

The following self-report assessments were conducted in the BN-ARP study alone: the Beck Depression Inventory,<sup>32</sup> which measures levels of depression, and the Revised NEO Personality Inventory,<sup>33</sup> which evaluates 5 personality factors (neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness).

### LATENT CLASS ANALYSES

We used LCA<sup>34</sup> to determine the number and composition of groups in which participants aggregated on the basis of their eating disorder symptoms and characteristics. We used log-linear and event history analysis with missing data using the EM algorithm<sup>35</sup> to conduct LCA and formulas presented by McCutcheon<sup>34</sup> to assign participants to their most likely latent class.

We included the *DSM-IV-TR* diagnostic criteria and features commonly associated with but not required for a diagnosis of an eating disorder in the LCA from the Structured Interview of Anorexic and Bulimic Disorders (**Table 2**). Amenorrhea was not included because of missing data for AN-ARP participants. Data concerning frequency/duration of symptoms were not included to prevent violation of the conditional independence assumption within LCA. Finally, data concerning undue influence of shape and weight on self-evaluation, fear of becoming fat, and the importance of being thin were not included because each was endorsed by more than 98% of participants (reflecting study inclusion criteria).

An LCA was conducted with the affected relatives alone ( $n=632$ ) to reduce the influence of proband inclusion criteria on the resulting solution, with probands alone ( $n=547$ ) to examine latent classes underlying cases in which *DSM-IV-TR* criteria were met, and with the full sample ( $N=1179$ ). The following 4 criteria were used to evaluate the best solution: (1) a nonsignificant  $\chi^2$  statistic, suggesting no significant difference between predicted and observed data distributions; (2) a significant improvement in fit from the previous solution (the difference between the log-likelihood statistics and degrees of freedom was evaluated along a  $\chi^2$  distribution); (3) insignificant improvement in fit between the solution and subsequent solution; and (4) stability of the latent class solution across multiple runs to avoid the problem of local maxima. All 3 LCAs produced the same solution characterized by similar symptom profiles supporting the reliability of the solution. Results of the full LCA are presented, and validation analyses were conducted with the full data set.

### VALIDATION ANALYSES

Validation analyses served the following 2 purposes: examination of correlates that may reflect "more fundamental abnormality" supporting clinical validity of categories<sup>36</sup> and description of latent classes. For example, temperament is a posited risk factor for the emergence of distinct eating disorders, whereas highest body mass index (BMI; calculated as self-reported weight in kilograms divided by the square of height in meters) was included for descriptive purposes. Measures were selected on the bases of prior empirical support for their associations with eating disorder subtypes as well as expert opinion among coinvestigators of clinical relevance.

Validation analyses were conducted using generalized estimating equations<sup>37-39</sup> to control for inclusion of biological relatives in the sample. For continuous dependent variables (such as Multidimensional Perfectionism Scale scores), we calculated the correlation within pairs of female probands and their sisters and then entered this estimated association within an exchangeable correlation matrix as a conservative correction for similarity in response patterns within families. For nominal dependent variables (such as mood disorder diagnosis), only

**Table 2. Frequency of Eating Disorder Symptoms and Characteristics in Latent Classes\***

Symptoms	No. (%) of Subjects			
	LC1 (n = 369)	LC2 (n = 565)	LC3 (n = 46)	LC4 (n = 199)
Weight <85% expected for height and age	<b>318 (86.2)</b>	332 (58.8)	31 (67.4)	68 (34.2)
Objective binge episodes	<i>2 (0.5)</i>	<b>533 (94.3)</b>	4 (8.7)	<b>195 (98.0)</b>
Subjective binge episodes	<i>66 (17.9)</i>	<b>520 (92.0)</b>	11 (23.9)	<b>185 (93.0)</b>
Atypical binge episodes (grazing)	<i>10 (2.7)</i>	<i>192 (34.0)</i>	7 (15.2)	47 (23.6)
Increased eating due to emotional stress	<i>88 (23.8)</i>	<b>449 (79.5)</b>	8 (17.4)	136 (68.3)
Chew/spit out food	<i>68 (18.4)</i>	<i>208 (36.8)</i>	2 (4.3)	24 (12.1)
Self-induced vomiting	<i>50 (13.6)</i>	<b>459 (81.2)</b>	2 (4.3)	<b>161 (80.9)</b>
Other purge (laxative/diuretic abuse, appetite suppressants)	<i>103 (27.9)</i>	362 (64.1)	1 (2.2)	49 (24.6)
Urge to eat normally avoided foods	191 (51.8)	<b>519 (91.9)</b>	7 (15.2)	<b>170 (85.4)</b>
Extreme calorie limit	<b>332 (90.0)</b>	<b>560 (99.1)</b>	20 (43.5)	118 (59.3)
Qualitative dietary restriction (avoiding specific foods)	<b>348 (94.3)</b>	<b>565 (100.0)</b>	31 (67.4)	133 (66.8)
Excessive exercise	<b>296 (80.2)</b>	<b>503 (89.0)</b>	29 (63.0)	114 (57.3)
Compulsive behaviors around food/eating	<b>341 (92.4)</b>	<b>544 (96.3)</b>	6 (13.0)	99 (49.7)
Preoccupation with eating	<b>369 (100.0)</b>	<b>564 (99.8)</b>	5 (10.9)	<b>180 (90.5)</b>
Preoccupation with weight/shape	<b>369 (100.0)</b>	<b>559 (98.9)</b>	19 (41.3)	<b>189 (95.0)</b>

Abbreviations: LC, latent class; LC1, restricting anorexia nervosa (RAN); LC2, anorexia bulimia nervosa (BN) with multiple purging methods; LC3, RAN with obsessive-compulsive features; LC4, BN with self-induced vomiting.

\*Boldface indicates frequency greater than 75%; italics, frequency less than 50%.

the independent correlation matrix is possible. Application of the exchangeable vs independent correlation matrix for analyses of continuous dependent variables did not influence the results in terms of effect sizes or statistical significance. Therefore, we do not believe that this variation in controlling for related data would have any impact on interpretation of results.

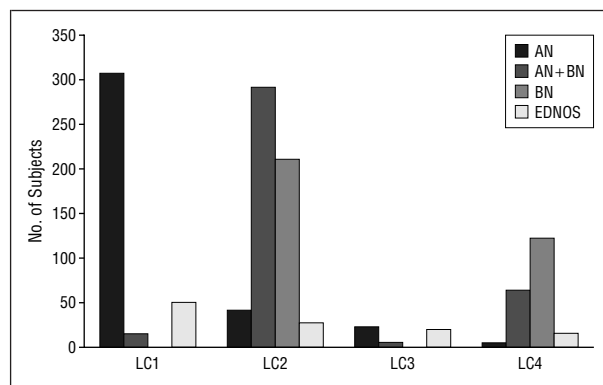
As already stated, data came from 2 studies and across 11 centers. Differences in validation variables due to center were found within latent class nested within study; however, differences due to study were not found within latent class nested within center. Therefore, only center was included as an additional clustering variable in analyses. Type 3 tests (score [ $\chi^2$ ] statistics) were used for testing the significance of latent class for each variable. Means and frequencies adjusted for cluster relationships (family and center) were generated by means of generalized estimating equations, and post hoc contrasts using score statistics were conducted on these adjusted values to examine differences between latent classes on the dependent variables. Because of the large sample size relative to the number of cases within families or centers, the adjusted and unadjusted values are quite similar, and unadjusted values are reported for descriptive purposes.

A Bonferroni-corrected  $\alpha$  level of .0016 was used to evaluate associations between latent class and validation variables (representing 32 independent analyses), whereas an  $\alpha$  level of .0083 was used to evaluate post hoc contrast analyses (representing 6 independent contrasts for each overall effect). Statistical analyses were conducted using the GENMOD procedure of SAS 8.0.2.<sup>40</sup>

## RESULTS

### LATENT CLASS ANALYSIS

After fitting a single-class model, the addition of further classes improved the fit of the model up to a 4-class solution reliably (model  $\chi^2_{167, 862} = 117,185$  [ $P > .99$ ]; improvement of fit  $\chi^2_{16} = 349$  [ $P < .001$ ]). Of the total sample, 369 (31.3%) were members of latent class 1 (LC1); 565 (47.9%), latent class 2 (LC2); 46 (3.9%), latent class 3 (LC3); and 199 (16.9%), latent class 4 (LC4). Biological



Distribution of DSM-IV diagnostic categories across latent classes (LCs). AN indicates anorexia nervosa; BN, bulimia nervosa; and EDNOS, eating disorders not otherwise specified. Latent classes are described in the "Latent Class Analysis" subsection of the "Results" section.

relatives were significantly likely to share a latent class ( $\chi^2_3 = 17.96$  [ $P < .001$ ]), supporting the role of familial factors in the etiology of these empirically derived phenotypes. Table 2 presents the distribution of the eating disorder symptoms/features across the 4 latent classes.

Distributions of symptoms across latent classes suggested an association between our latent classes and DSM-IV-TR diagnostic categories, supported by regression analysis with generalized estimating equation corrections ( $\chi^2_3 = 190.58$  [ $P < .001$ ]). Post hoc contrast analyses suggested that this was largely attributable to the unique association between LC1 and women with lifetime histories of AN (Figure). The distribution of DSM-IV-TR diagnoses differed significantly between LC1 and the other latent classes, but no other significant differences existed among latent classes. The primary sources of disagreement between latent classes and diagnostic categories were the relatively even distribution of individuals with EDNOS across latent classes and the overrepresentation of participants with lifetime histories of BN in

**Table 3. Demographic Features Across Latent Classes (N = 1179)**

	Latent Class				$\chi^2$	P Value
	LC1 (n = 369)	LC2 (n = 565)	LC3 (n = 46)	LC4 (n = 199)		
Sex, No. (%) male	19 (5.1) <sup>a</sup>	5 (0.9) <sup>b</sup>	9 (19.6) <sup>c</sup>	11 (5.5) <sup>a</sup>	48.69	<.001
BMI, mean (SD)						
Current	18.98 (2.55) <sup>a</sup>	21.00 (3.23) <sup>b</sup>	19.60 (2.31) <sup>a</sup>	21.98 (3.43) <sup>c</sup>	111.07	<.001
Lowest	15.16 (2.38) <sup>a</sup>	16.76 (2.68) <sup>b</sup>	17.22 (2.00) <sup>b</sup>	18.52 (2.73) <sup>c</sup>	133.52	<.001
Highest	21.47 (2.78) <sup>a</sup>	24.04 (3.37) <sup>b</sup>	21.90 (3.15) <sup>a</sup>	24.49 (3.39) <sup>b</sup>	119.63	<.001
Age of eating disorder onset, mean (SD), y	16.05 (3.52) <sup>ac</sup>	15.54 (3.32) <sup>a</sup>	19.60 (5.42) <sup>b</sup>	17.20 (4.65) <sup>c</sup>	29.76	<.001

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); LC, latent class; LC1, restrictive anorexia nervosa (RAN); LC2, anorexia bulimia nervosa (BN) with multiple purging methods; LC3, RAN with obsessive-compulsive features; LC4, BN with self-induced vomiting.

\*Superscripts that differ represent significant differences between latent classes on that variable.

LC2 (Figure). In addition to low weight, compulsive rituals around eating and the use of multiple methods of purging further differentiated LC2 from LC4 (Table 2). Approximately 81% of individuals in LC2 and LC4 engaged in self-induced vomiting; however, 64.1% of individuals in LC2, compared with 24.6% of individuals in LC4, used laxatives, diuretics, or appetite suppressants to control their weight. Indeed, LC2 was the only group in which most members used multiple methods for purging. Although LC1 and LC3 resembled restricting AN, LC3 was distinguished by a relative absence of eating and body-related preoccupations and compulsions. Thus, we developed the following clinical descriptions for the 4 latent classes: for LC1, restricting AN (RAN); for LC2, AN and BN (ABN) with multiple methods of purging; for LC3, RAN without eating and body-related obsessive-compulsive features; and for LC4, BN with self-induced vomiting.

### VALIDATION ANALYSES

**Table 3** presents demographic data for the latent classes. Although men represented 3.7% of all participants, they were underrepresented in LC2 and overrepresented in LC3. The BMIs were lowest in LC1 and highest in LC4. Current and highest BMIs were also lower in LC3 compared with LC2, suggesting that binge eating is associated with increased weight. In contrast to similarities in BMI, LC2 reported a younger age of onset compared with LC4, and LC3 reported the oldest age of onset.

**Table 4** presents validation analyses of the latent classes on personality and attitudinal measures. Latent class 1 reported the highest need for organization, order, and precision and also reported high obsessions and compulsions. In addition, LC1 was distinguished from other classes by low novelty seeking, high persistence (tendency to maintain behavior that is no longer rewarded), and high conscientiousness. Overall, LC2 reported the greatest level of distress, with high scores for perfectionism, obsessions and compulsions, anxiety, harm avoidance, neuroticism, and depression. In addition, LC2 was distinguished by the lowest levels of self-directedness (ie, the tendency not to view the self as autonomous). In contrast, LC3 was associated with the lowest scores on perfectionism and obsessions and compulsions, confirm-

ing the relative absence of obsessive-compulsive features in this group. Finally, LC4 did not have the highest or lowest scores on any measure. For many comparisons, LC3 and LC4 reported similar scores that were less severe than those reported by LC1 and LC2.

**Table 5** presents validation analyses of the latent classes on lifetime history of Axis I and II disorders. Compared with the other classes, LC2 reported the highest lifetime prevalence of mood, substance use, and cluster B personality disorders.

### COMMENT

We found 4 latent classes among participants with clinically significant eating disorders. The primary distinctions that arose across classes confirmed some of the criteria used by the *DSM-IV-TR* to differentiate eating disorder diagnoses and introduced other criteria by which to make distinctions. In support of the *DSM-IV-TR* criteria, this study found substantial empirical support for differentiating a restricting subtype of AN. No individuals with a lifetime history of BN were found in LC1 or LC3. In addition, our analyses supported distinguishing among women who binge and purge on the basis of low weight, reflecting the diagnostic hierarchy presented in the *DSM-IV-TR* but not the *ICD-10*. However, our findings suggested that low weight alone was inadequate for differentiating these groups. Instead, the presence of multiple methods of purging appeared to identify a form of eating disorder that was associated with particularly high scores on measures of distress and high comorbidity. Similarly, our analyses suggested that a further subdivision may be merited among individuals with restricting AN on the basis of obsessive-compulsive features. Finally, our study did not support a distinction between individuals with lifetime histories of EDNOS and those with lifetime histories of AN or BN.

Our LCA supported 2 groups that could be broadly characterized as having RAN. The larger group (LC1) was characterized by greater perfectionism, obsessions, compulsions, rigidity, conscientiousness, lower levels of novelty seeking, and higher levels of harm avoidance, consistent with early clinical descriptions of patients with AN.<sup>41</sup> Comorbid obsessive-compulsive disorder cannot account for this clinical presentation because a substan-

**Table 4. Personality and Attitudinal Measures Among 1179 Individuals With Eating Disorders\***

	Scores, Mean (SD)				$\chi^2$	P Value
	LC1 (n = 369)	LC2 (n = 565)	LC3 (n = 46)	LC4 (n = 199)		
MPS overall perfectionism	94.19 (23.47) <sup>a</sup>	97.36 (22.48) <sup>a</sup>	71.87 (23.01) <sup>b</sup>	83.08 (22.67) <sup>c</sup>	63.11	<.001
Concern over mistakes	30.67 (9.55) <sup>a</sup>	31.79 (9.12) <sup>a</sup>	21.91 (9.39) <sup>b</sup>	26.57 (9.58) <sup>c</sup>	52.22	<.001
Personal standards	26.75 (6.22) <sup>a</sup>	26.25 (5.86) <sup>a</sup>	21.87 (7.71) <sup>b</sup>	23.28 (6.57) <sup>b</sup>	42.61	<.001
Perceived parental expectations	14.12 (5.71) <sup>ac</sup>	15.13 (5.76) <sup>a</sup>	10.89 (5.05) <sup>bc</sup>	13.02 (5.29) <sup>c</sup>	31.07	<.001
Perceived parental criticism	10.43 (4.71) <sup>a</sup>	11.62 (4.76) <sup>b</sup>	8.29 (3.77) <sup>a</sup>	10.16 (4.31) <sup>a</sup>	33.97	<.001
Doubt quality of performance	12.28 (4.12) <sup>a</sup>	13.15 (3.90) <sup>b</sup>	9.45 (3.64) <sup>c</sup>	11.04 (4.15) <sup>c</sup>	47.51	<.001
Organization, order, and precision	24.31 (5.42) <sup>a</sup>	23.01 (5.71) <sup>b</sup>	21.82 (5.72) <sup>ab</sup>	22.08 (5.76) <sup>b</sup>	23.32	<.001
Y-BOCS total	13.38 (11.56) <sup>a</sup>	13.35 (11.80) <sup>a</sup>	4.25 (9.31) <sup>b</sup>	6.85 (9.50) <sup>b</sup>	54.55	<.001
Obsessions	6.35 (5.91) <sup>a</sup>	6.38 (6.09) <sup>a</sup>	2.18 (4.89) <sup>b</sup>	3.13 (4.82) <sup>b</sup>	50.35	<.001
Compulsions	7.04 (6.35) <sup>a</sup>	6.97 (6.42) <sup>a</sup>	2.08 (4.64) <sup>b</sup>	3.72 (5.33) <sup>b</sup>	51.43	<.001
State-Trait Anxiety						
State	45.79 (14.31) <sup>ab</sup>	46.99 (13.65) <sup>a</sup>	40.88 (12.88) <sup>bc</sup>	41.60 (13.19) <sup>c</sup>	27.10	<.001
Trait	49.93 (14.02) <sup>ab</sup>	51.31 (13.33) <sup>a</sup>	44.89 (13.46) <sup>bc</sup>	45.53 (13.03) <sup>c</sup>	30.15	<.001
TCI						
Novelty seeking	17.02 (7.04) <sup>a</sup>	20.93 (6.69) <sup>b</sup>	20.51 (6.07) <sup>b</sup>	21.53 (6.50) <sup>b</sup>	67.90	<.001
Harm avoidance	20.55 (8.25) <sup>a</sup>	20.14 (7.57) <sup>a</sup>	16.72 (7.04) <sup>b</sup>	17.96 (7.71) <sup>b</sup>	18.55	<.001
Reward dependence	16.55 (3.96)	16.89 (3.84)	15.79 (3.96)	16.33 (4.30)	4.31	.23
Persistence	5.94 (2.08) <sup>a</sup>	5.38 (2.03) <sup>b</sup>	4.61 (2.13) <sup>bc</sup>	4.74 (2.03) <sup>c</sup>	41.54	<.001
Self-directedness	27.16 (9.45) <sup>a</sup>	24.43 (9.41) <sup>b</sup>	30.03 (8.27) <sup>a</sup>	27.12 (9.16) <sup>a</sup>	34.32	<.001
Cooperativeness	33.72 (6.07)	33.24 (6.43)	32.98 (4.38)	32.87 (6.07)	5.12	.16
Self-transcendence	14.29 (7.09)	15.88 (6.58)	13.84 (5.88)	14.09 (6.33)	14.13	.003
NEO						
Neuroticism†	99.97 (25.81) <sup>a</sup>	115.46 (24.28) <sup>b</sup>	99.81 (19.95) <sup>a</sup>	105.18 (24.54) <sup>a</sup>	44.92	.001
Extraversion†	109.92 (21.31)	109.85 (21.29)	106.59 (21.47)	110.23 (19.69)	0.38	.94
Openness to experience†	117.35 (18.64)	120.71 (20.01)	117.89 (21.91)	122.78 (18.73)	5.97	.11
Agreeableness†	123.13 (15.46)	119.02 (17.71)	121.04 (12.41)	117.43 (15.18)	10.57	.014
Conscientiousness†	117.54 (20.80) <sup>a</sup>	105.24 (22.13) <sup>b</sup>	111.19 (25.19) <sup>ab</sup>	108.29 (19.59) <sup>b</sup>	24.35	<.001
Beck Depression Inventory†	11.93 (9.60) <sup>a</sup>	15.01 (10.46) <sup>b</sup>	11.79 (10.27) <sup>ab</sup>	11.08 (7.86) <sup>a</sup>	23.54	<.001

Abbreviations: LC, latent class; LC1, restricting anorexia nervosa (RAN); LC2, anorexia bulimia nervosa (BN) with multiple purging methods; LC3, RAN with obsessive-compulsive features; LC4, BN with self-induced vomiting; MPS, Multidimensional Perfectionism Scale; NEO, Revised NEO Personality Inventory; TCI, Temperament and Character Inventory; Y-BOCS, Yale-Brown Obsessive Compulsive Scale.

\*Superscripts that differ represent significant differences between latent classes.

†Indicates measures included only in the BN-affected relative pair study (LC1, n = 104; LC2, n = 460; LC3, n = 33; and LC4, n = 166).

tial proportion of LC1 had no lifetime history of anxiety disorders. In contrast, the smaller LC3 presented with the lowest levels of disturbance across validating analyses, and the combination of higher levels of novelty seeking and lower levels of harm avoidance provided good separation from LC1 on temperamental factors. The older age of onset for LC3 could reflect an increased premorbid period during which normal personality may develop. In the AN outcome literature, obsessive-compulsive personality features have been associated with worse outcome,<sup>42</sup> suggesting that these may serve as a marker for the presence of a particularly chronic form of RAN.

If obsessive-compulsive features in RAN serve as a potential marker of chronicity, then the presence of multiple methods of purging and low weight among women who binge serve as markers of severity. Across 32 validation analyses, LC2 reported the most severe psychological disturbance in 21, and they were unique in presenting with a combination of higher levels of novelty seeking and harm avoidance. The variables on which they did not report greatest severity included lowest, highest, and current BMI and the need for organization, order, and precision. Also, compared with the RAN groups (LC1 and LC3), LC2 reported lower levels of self-

directedness, persistence, and conscientiousness, potentially revealing the causes and consequences of binge-purge symptoms in this low-weight sample. Individuals in whom ABN with multiple methods of purging develops may be ill-suited to maintain a lowered body weight. This could result in higher BMIs relative to their counterparts with RAN and the emergence of binge eating after sustained food restriction. Furthermore, binge eating is likely to contribute to weight gain, as purging is largely ineffective in eliminating calories.<sup>43</sup> Women with ABN with multiple methods of purging appear to lack the extreme levels of rigidity and control reported by their counterparts with RAN, and this may make them temperamentally less suited to sustained food refusal. The combination of difficulties in maintaining a low weight and high levels of neuroticism and depression may make these individuals more likely to use multiple purging methods to control their weight. Use of multiple purging methods could also contribute to feelings of distress and shame. These individuals were also most likely to report doubts about their own performance and high parental criticism, suggesting an acute awareness of discrepancies between their highly perfectionistic goals and their ability to meet these standards. Moreover, our results support distinctions between the RAN and AN binge-

**Table 5. Lifetime Prevalence of Axis I and II Disorders Across Latent Classes Within the BN-ARP Study (N = 763)\***

Diagnosis, $\kappa$ †	No. (%) of Subjects				$\chi^2$	P Value
	LC1 (n = 104)	LC2 (n = 460)	LC3 (n = 33)	LC4 (n = 166)		
Mood disorders (0.89)	49 (53) <sup>a</sup>	359 (82) <sup>b</sup>	10 (37) <sup>a</sup>	97 (63) <sup>a</sup>	47.18	<.001
Anxiety disorders (0.86)	50 (54)	286 (64)	8 (31)	82 (53)	14.09	.003
Substance use disorders (0.95)	23 (26) <sup>a</sup>	233 (56) <sup>b</sup>	7 (26) <sup>a</sup>	55 (37) <sup>a</sup>	38.44	<.001
Cluster B personality disorders	3 (4) <sup>a</sup>	74 (17) <sup>b</sup>	1 (4) <sup>ab</sup>	8 (5) <sup>a</sup>	29.39	<.001
Cluster C personality disorders	17 (23)	139 (33)	5 (22)	34 (22)	9.08	.03

Abbreviations: BN-ARP, bulimia nervosa affected relative pair study; LC, latent class; LC1, restricting anorexia nervosa (RAN); LC2, anorexia BN with multiple purging methods; LC3, RAN with obsessive-compulsive features; LC4, BN with self-induced vomiting.

\*Superscripts that differ represent significant differences between latent classes. Due to missing data, the following numbers were used for latent classes across analyses: LC1, n = 75-92; LC2, n = 413-445; LC3, 23-27; and LC4, n = 149-157.

†Reliabilities of diagnoses were calculated from 88 interviews. Reliability was not available for personality disorders.

purge subtypes within the *DSM-IV-TR* and suggest further means for distinguishing the AN binge-purge subtype from BN.

Although LC4 was not the most or the least severe group across analyses, they were distinct from the first 2 latent classes on a number of measures, particularly those evaluating perfectionism, obsessive-compulsive features, anxiety, harm avoidance, and persistence. Like LC2, LC4 was less likely to attain or maintain a low body weight. However, this may represent a less salient goal for these individuals, as they were less likely to report extreme caloric restriction, qualitative restrictions in what they ate, or urges to eat forbidden foods. Similarly, LC4 reported less perfectionistic strivings for extreme goals along with less perfectionism and less rigidity. Thus, their reduced distress compared with LC2 may partially reflect a diminished discrepancy between goals and achievements in BN with vomiting relative to ABN with multiple methods of purging.

We did not produce any qualitatively distinct EDNOS categories. The relatively even distribution across latent classes of individuals with lifetime diagnoses of EDNOS who never met full criteria for AN or BN suggests that specific criteria currently used to distinguish AN and BN from EDNOS were not empirically supported. In some of these individuals, full-threshold eating disorders may develop,<sup>44</sup> particularly given the presence of AN or BN or both in their biological relatives. However, our results are consistent with those of other studies.<sup>6,7</sup>

Although our results could be interpreted as demonstrating 4 categories of eating disorders, LCA tends to identify spurious classes when an underlying continuum of severity causes associations among observed variables within each true latent class.<sup>45</sup> For example, it is possible that both RAN groups (LC1 and LC3) belong to 1 true latent class but represent different levels of severity within this class. This tendency, as well as differences in study group ascertainment, could contribute to the discrepancy in the number of classes found between this study and that by Bulik et al.<sup>22</sup> Moreover, LCA does not preclude dimensional associations among classes. Questions concerning the presence of discrete taxa vs continua underlying eating disorder diagnoses have been examined using taxometric analyses.<sup>46,47</sup> Results of such studies support the categorical distinctiveness of RAN vs binge-

eating/purging AN<sup>46</sup> and AN vs BN.<sup>47</sup> Thus, from different analytic approaches, there is excellent support for differentiating categories of restricting vs bulimic eating disorders. However, past taxometric analyses have relied on *DSM* definitions of eating disorders. Future application of taxometric analyses to the phenotypes presented herein can address the validity of 4 eating disorder categories.

This study had several strengths, including the careful assessment of lifetime eating disorders and use of highly reliable and valid assessment tools. This study also has one of the largest samples of individuals with clinically significant eating disorders. This enabled us to produce a rich characterization of the empirically derived phenotypes without encountering problems with power when controlling for multiple comparisons. By using conservative corrections for multiple comparisons and similarities in responses due to family membership and center, we increased the robustness of our findings and the likelihood that they will be replicated in future investigations.

This study may not have been sensitive to identification of eating disorder phenotypes that differ markedly from those in the *DSM-IV-TR* owing to restrictions on proband phenotypes and the familiarity of latent classes. Indeed, the failure to detect a distinct BN-nonpurging subtype may reflect proband inclusion criteria and heritability of vomiting.<sup>48,49</sup> As a consequence, our results may have limited relevance in developing a typology for eating disorders in children. Selection of affected relatives suitable for linkage analyses may limit generalizability of findings for defining eating disorders in individuals with no family history of eating disorders. We did not include variables concerning frequency or duration of behaviors or co-occurrence of symptoms owing to the requirement for conditional independence. Although these are important factors in making eating disorder diagnoses, the original and present studies were not designed to determine the threshold between eating disorders and normal eating. Comparisons of latent classes on personality or attitudinal measures should be interpreted as comparisons among groups with clinically significant eating disorders. Thus, for example, lower perfectionism in the BN with vomiting group (LC4) does not reflect that absence of perfectionism in this group. Finally, use of lifetime diagnoses involved retrospective recall that may introduce biases.

This study supports low weight and multiple purging methods as important indicators of distinct phenotypes among individuals who binge and purge. Furthermore, our findings suggest that obsessive-compulsive features may distinguish 2 groups within the category of RAN. Indeed, using the drive for thinness and obsessiveness as covariates in the AN-ARP study revealed several regions of suggestive linkage.<sup>50</sup> Evidence that the latent classes coaggregated within families increases their relevance in the search for genetic loci with moderate to large effects on disorder expression.<sup>21</sup> Phenotypes with longitudinal stability and specific biological and psychological risk factors are needed to identify susceptibility genes for eating disorders.<sup>51</sup> Future investigations can evaluate the predictive and etiologic validity of these phenotypes with longitudinal and genetic designs. Longitudinal studies may reveal distinctive course, treatment response, and outcome across phenotypes, and genetic studies can examine unique fundamental abnormalities contributing to the emergence of these phenotypes.<sup>36</sup>

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