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Set-Shifting Among Adolescents With Bulimic Spectrum Eating Disorders

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Objective: Set-shifting difficulties are observed among adults with bulimia nervosa (BN). This study aimed to assess whether adolescents with BN and BN spectrum eating disorders exhibit set-shifting problems relative to healthy controls. **Methods:** Neurocognitive data from 23 adolescents with BN were compared with those from 31 adolescents with BN-type eating disorder not otherwise specified and 22 healthy controls on various measures of set-shifting (Trail Making Task [shift task], Color-Word Interference, Wisconsin Card Sorting Test, and Brixton Spatial Anticipation Task). **Results:** No significant differences in set-shifting tasks were found among groups ($p > .35$), and effect sizes were small (Cohen $f < 0.17$). **Conclusions:** Cognitive inflexibility may develop over time because of the eating disorder, although it is possible that there is a subset of individuals in whom early neurocognitive difficulty may result in a longer illness trajectory. Future research should investigate the existence of neurocognitive taxons in larger samples and use longitudinal designs to fully explore biomarkers and illness effects. **Trial Registration:** clinicaltrials.gov NCT00879151.
Key words: bulimia nervosa, set-shifting, neurocognition, eating disorders, cognitive inflexibility.

BN = bulimia nervosa; **EDNOS-BN** = BN-type eating disorder not otherwise specified; **HC** = healthy control; **EDE** = Eating Disorder Examination; **EDE-Q** = EDE Questionnaire; **MBW** = median body weight; **IQ** = intelligence quotient; **WCST** = Wisconsin Card Sorting Test.

INTRODUCTION

Bulimia nervosa (BN) is a serious psychiatric disorder that arises in adolescence and is characterized by recurrent episodes of binge eating and purging (1). Risk assessments for BN in adolescents identify a wide range of factors, but in many cases, these are not directly related to symptom expression and development. As such, a recent approach to etiological understanding and treatment development is the examination of neurocognitive correlates (2). Set-shifting difficulty is implicated as a potential risk marker, candidate endophenotype, and maintaining factor for eating disorders (3). Set-shifting is the ability to move between ideas, concepts, or tasks fluidly, such that those who have poor set-shifting are characterized by perseverative and rigid styles and behaviors. Poor set-shifting is reported in adults with BN (3,4); however, systematic review suggests that findings are mixed and that there are limited data on BN-type eating disorder not otherwise specified (EDNOS-BN). In general, there is a widely recognized deficit in the literature on the relationship between neurocognition and bulimic syndromes (5).

To our knowledge, no published study has evaluated set-shifting among adolescents with BN. This is important for several reasons: a) illness onset typically occurs during adolescence; b) identifying specific neurocognitive features among adolescents could suggest new avenues for treatment development; and c) the argument that cognitive inflexibility is a candidate endophenotype or risk marker for BN would be weaker if this neurocognitive signature is not observed in younger patients without chronic conditions. If set-shifting difficulties are not observed among adolescents, then it is more likely that the effects observed among adults are a result of the illness, as opposed to a preexisting or causative feature.

This study aimed to establish whether adolescents with BN and EDNOS-BN demonstrate a neurocognitive profile similar to that in adults. Measures were chosen to provide comparison to literature on adults. We hypothesized that adolescents with BN and EDNOS-BN would demonstrate more set-shifting difficulties than a comparison sample of healthy controls (HCs).

METHODS

Participants

Fifty-four adolescents were recruited from a two-site (University of Chicago and Stanford University) randomized clinical trial for adolescents aged 12 to 18 years with BN. All BN participants met DSM-IV-TR (1) criteria for BN or EDNOS-BN, defined as an average of one binge-eating episode (subjective or objective) and one purging episode per week for the past 3 months, with at least one binge-eating or purging episode occurring in the past month. Diagnoses were determined using the Eating Disorder Examination (EDE).

Other inclusion criteria were as follows: proficiency in the English language, with at least one parent speaking fluent English; sufficient medical stability for outpatient treatment; and, if under medication for a comorbid psychiatric disorder (e.g., depression), provision of a stable dosage of pharmacotherapy for at least 2 months, with the participant still meeting other inclusion criteria. Study participants were excluded for the following: diagnosis of psychotic syndrome and/or taking antipsychotics, and a history of head injury, seizure, or other medical comorbidities that may interfere with cognitive ability or weight maintenance.

A total of 22 HCs were recruited from the community around Stanford University and Palo Alto, CA, by advertisements placed on university notice boards and e-mail list serves. All controls were female, had no lifetime history of psychiatric disorder, were not taking any psychotropic medication, had no family member with a history of eating disorder, and were of normal weight (mean body weight >85%).

All assessors were trained, certified, and supervised by a licensed clinical psychologist. All participants signed informed consent (signed by parents for participants aged <18 y) and/or assent (participants aged <18 y) forms before participation.

Measures

Primary outcome variables were decided a priori. All participants were administered a neuropsychological test battery at baseline. Raw scores were used to allow for analysis of between-group variation.

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General Intelligence

Wechsler Abbreviated Scale of Intelligence, Wechsler Intelligence Scale for Children, 4th edition, and Wechsler Adult Intelligence Scale, 3rd edition

For the purposes of this study, we used four subtests as proxy for the full test (Vocabulary, Similarities, Block Design, and Matrix Reasoning); thus, estimated intelligence quotient (IQ) scores, rather than full-scale IQ scores, are given.

Set-Shifting

Delis-Kaplan Executive Functioning System

The Delis-Kaplan Executive Functioning System (6) evaluates executive functioning and has been normed for individuals aged 8 to 89 years. In the current study, Trail Making Task, Color-Word Interference, and Verbal Fluency subtests were administered.

Trail Making Task comprises five paper-and-pen trials: identification tasks, two sequence switching tasks, and motor speed. The current study evaluated the time (seconds) taken to complete the switching task. We included motor speed as a descriptive variable. Results from a recent review concluded that evidence for impairment on the Trail Making Task is inconsistent (5).

The Color-Word Interference task is a Stroop task presented on flash cards, with color names written in dissonant color ink. This task assesses inhibition and switch task, with a change in rules for task completion.

Verbal Fluency consists of naming, category fluency, and category switching. All three trials were administered, but only category switching was evaluated.

Wisconsin Card Sorting Test (Computerized Version 4)

The Wisconsin Card Sorting Test (7) requires response to environmental feedback, ability to shift rules, and ability to inhibit previously appropriate responses. The primary outcome variable of interest is the number of perseverative errors (persisting with an incorrect rule). Nonperseverative errors and the number of categories completed were also assessed. Evidence for impairment on this task among individuals in other studies is mixed (5).

Brixton Spatial Anticipation Task

The Brixton Spatial Anticipation Task (8) is a concept attainment task. A blue circle is present in a sequence of 10 numbered circles. The position of the blue circle changes from trial to trial in a logical sequence, and the participant has to work out this sequence. The outcome variable is the total number of incorrect predictions.

Psychological Assessments

EDE and EDE-Questionnaire

The EDE (9) was administered to clinical participants. It is a standardized semistructured interview and a "gold standard" instrument, measuring the severity and frequency of the characteristic psychopathology and key behaviors of eating disorders during the past 4 weeks or, for diagnostic items, the previous 3 months. Interrater reliability between trained interviewers is high (κ coefficient of at least .9), and the measure has good internal consistency among eating disorder samples, with acceptable α coefficients for its subscales: dietary restraint (.75), eating concern (.78), shape concern (.68), and weight concern (.82).

The EDE Questionnaire (10) is a validated and reliable short-form, self-report version of the EDE and was administered to HCs. Among undergraduate women, internal consistencies range from .78 to .93 and from .57 to .70 for behavioral features such as binge eating and purging (11).

BN participants were also administered the Schedule for Affective Disorders and Schizophrenia for School-Aged Children, Present and Lifetime Version, to determine comorbidity and medication use.

Procedure

Study participants were assessed before the first treatment session. All participants received US$50. Data were collected during a 28-month period (from April 2009 to July 2011).

Ethical Approval

This study was approved by both the Stanford University and the University of Chicago Institutional Review Boards.

Statistical Analysis

One-way analyses of variance were conducted to ascertain whether significant differences existed between the three groups. Baseline characteristics that differed between the groups were entered as covariates, and eight analyses of covariance were conducted to identify differences in set-shifting. For the main outcome variables, α was adjusted with Bonferroni correction to .006 to guard against Type 1 error (.05/8). Cohen *f* was used for effect size calculation. Cohen suggests that *f* values of 0.1, 0.25, and 0.4 represent small, moderate, and large effect sizes, respectively.

RESULTS

The baseline characteristics for the three groups are presented in Table 1. The groups did not differ in any baseline characteristic, with the exception of IQ, where HCs had significantly higher estimated IQ scores than the BN and EDNOS-BN groups.

Analysis of covariance with IQ entered as a covariate failed to find any evidence of between-group difference in any variable under study (Table 2). Effect sizes were small.

DISCUSSION

The study aimed to ascertain whether set-shifting difficulties identified among adult samples with BN are present among adolescents with BN and EDNOS-BN, thereby assessing the potential of this neurocognitive feature as a candidate endophenotype or risk marker for BN syndromes. We failed to find evidence of differences in set-shifting tasks between adolescents with BN, adolescents with EDNOS-BN, and HCs. Although there is no published literature on adolescents with BN with which to make a direct comparison, our findings are similar to a small number of studies that failed to find significant differences between adults with BN and HCs in the Trail Making Task, Wisconsin Card Sorting Test, or Brixton Spatial Anticipation Task (see Van den Eynde et al. (5) for a review).

Similar performance on set-shifting by all groups suggests the possibility that cognitive inflexibility may develop over time as a consequence of BN. Set-shifting problems could arise from either the symptoms of BN themselves (binge eating and purging), the effect of comorbidity, or a conscious attempt to become more rigid in the context of dietary restriction, which ultimately leads to a bulimic cycle, ultimately changing their neurocognitive signature over time. This hypothesis is in concert with most cognitive-behavioral models of BN symptoms; however, only a prospective longitudinal design can fully confirm the viability of such a hypothesis.

Although our sample was relatively small and findings need to be replicated, the failure to find impairment among adolescents casts doubt on the viability of cognitive inflexibility as an

TABLE 1. Demographic and Descriptive Variables (Mean [Standard Deviation]) for the Groups

	BN (n = 23)	EDNOS-BN (n = 31)	HC (n = 22)	Comparison
Age, y	16.33 (1.18)	15.37 (1.77)	15.41 (1.89)	$F(2,83) = 3.07$; $p = .052$
% MBW	109.14 (18.22)	108.31 (16.01)	105.69 (12.83)	$F(2,82) = 0.29$; $p = .75$
IQ	106.81 (8.67)	109.88 (10.87)	118.43 (11.88)	$F(2,79) = 7.5$; $p < .001$ (BN < HC; EDNOS-BN < HC)
Motor speed	27.13 (9.82)	26.06 (10.99)	24.00 (6.01)	$F(2,73) = 0.633$; $p = .534$
Verbal Fluency	43.00 (12.13)	40.97 (8.23)	38.41 (11.23)	$F(2,73) = 1.095$; $p = .340$
One comorbidity, n	12	16	–	
Multiple comorbidity, n	16	8	–	χ^2 (2) = 0.284; $p = .868$
Depression diagnosis, n	14	17	–	χ^2 (1) = 0.066; $p = .798$
Ill duration, months	21.08 (16.41)	15.01 (13.58)	NA	$t(47.81) = 1.534$; $p = .132$
Medication use, n	5	3	–	[a]
EDE-RES	3.64 (1.27)	3.11 (1.73)	NA	$t(59.87) = 1.389$; $p = .171$
EDE-EC	3.07 (1.30)	2.75 (1.45)	NA	$t(58.69) = 0.906$; $p = .369$
EDE-WC	3.80 (1.63)	3.75 (1.43)	NA	$t(51.97) = 0.124$; $p = .902$
EDE-SC	4.22 (1.41)	4.12 (1.34)	NA	$t(54.63) = 0.295$; $p = .769$
EDE-Q-RES	NA	NA	0.60 (0.63)	NA
EDE-Q-EC	NA	NA	0.38 (0.54)	NA
EDE-Q-WC	NA	NA	1.22 (0.81)	NA
EDE-Q-SC	NA	NA	1.44 (0.91)	NA
OBE episodes[b]	24.85 (16.43)	1.11 (1.87)	0.20 (0.63)	$F(2,69) = 46.710$; $p < .001$ (BN > EDNOS-BN; EDNOS-BN > HC)
Month 2	21.33 (20.33)	3.94 (6.60)	Not evaluated	$t(30.38) = 4.33$; $p < .001$
Month 3	19.18 (19.13)	3.91 (6.82)	Not evaluated	$t(31.12) = 3.95$; $p < .001$
Vomiting episodes[b]	31.33 (23.86)	18.20 (20.47)	0 (0.00)	$F(2,60) = 8.97$; $p = .000$ (BN > HC; EDNOS-BN > HC)
Month 2	25.11 (22.94)	22.57 (39.84)	Not evaluated	$t(60) = 0.29$; $p = .769$
Month 3	18.88 (18.42)	19.45 (40.17)	Not evaluated	$t(60) = 0.06$; $p = .946$
Laxatives episodes[b]	2.41 (6.51)	2.03 (9.69)	0 (0.00)	$F(2,68) = 0.353$; $p = .704$
Month 2	2.55 (6.32)	0.82 (2.90)	Not evaluated	$t(60) = 1.433$; $p = .157$
Month 3	1.77 (4.66)	2.82 (8.89)	Not evaluated	$t(60) = -0.557$; $p = .580$
Driven exercise[b]	12.33 (17.94)	16.09 (15.81)	0.10 (0.31)	$F(2,69) = 4.04$; $p = .022$ (BN > HC; EDNOS-BN > HC)
Month 2	10.70 (17.47)	14.88 (15.28)	Not evaluated	$t(60) = -1.00$; $p = .320$
Month 3	12.07 (17.57)	13.62 (16.61)	Not evaluated	$t(60) = -0.356$; $p = .723$

BN = bulimia nervosa; EDNOS-BN = BN-type eating disorder not otherwise specified; HC = healthy control; MBW = median body weight; IQ = intelligence quotient; NA = not applicable; EDE = Eating Disorder Examination; EDE-Q = EDE Questionnaire; RES = dietary restraint; EC = eating concern; WC = weight concern; SC = shape concern; OBE = objective binge-eating episodes in the past 28 days.

All participants were female.

[a] Too few participants in each group to conduct analysis.

[b] Means are derived from the EDE and EDE-Q for the clinical and HC groups, respectively.

identifiable risk marker for later development of BN. It does not preclude the possibility, however, that cognitive inflexibility could be a risk marker for a more enduring illness reflected in the adult data but lost in the group means here, which presumably include some individuals who will recover before reaching adulthood. It may be that there are differing profiles within the data that may yield more meaningful dichotomies and provide information about illness trajectory or other clinical variables and the development of tailored treatment approaches. This strategy was adopted by Roberts et al. (3), who found differences between those with superior set-shifting abilities and those with weak set-shifting abilities among adults. A larger sample would facilitate the examination of distinct profiles with BN samples, and this should be explored in future studies.

The major limitation of our study was the small sample size relative to published studies of adults. However, to our knowledge, this is the first study to report on the set-shifting abilities of adolescents with BN. Another advantage is the inclusion of an EDNOS-BN group, although it did not represent the full spectrum of EDNOS-BN. Nonetheless, the failure to find a difference between the BN groups suggests that set-shifting performance is not affected by the severity of BN symptoms. Other advantages include the use of a range of carefully chosen measures to assess differing dimensions of set-shifting. We also used measures that have been applied in eating

TABLE 2. Analysis of Covariance Between the Groups on the Primary Outcome Variables (Mean [Standard Deviation]) With Estimated IQ as Covariate

	BN (n = 23)	EDNOS-BN (n = 31)	HC (n = 22)	Comparison	F
Trails switching, seconds	64.91 (22.01)	67.26 (20.18)	64.05 (17.94)	$F(2,71) = 0.317$; $p = .792$	.09
Color-Word Interference (inhibition/switch)	56.78 (14.67)	57.74 (10.71)	52.95 (11.76)	$F(2,69) = 0.396$; $p = .675$	.10
Verbal Fluency category switching	12.30 (3.37)	12.68 (3.22)	12.26 (3.50)	$F(2,69) = 0.658$; $p = .521$	.13
WCST perseverative responses	7.48 (6.76)	6.42 (2.69)	6.58 (3.28)	$F(2,69) = 0.407$; $p = .667$	.11
WCST perseverative errors	7.00 (5.35)	6.16 (2.39)	6.37 (2.96)	$F(2,69) = 0.486$; $p = .617$	.11
WCST nonperseverative errors	6.39 (4.13)	5.77 (3.51)	5.74 (5.25)	$F(2,69) = 0.325$; $p = .827$	.09
WCST categories completed	5.96 (.209)	6.00 (00)	5.95 (.22)	$F(2,71) = 0.909$; $p = .408$	.16
Brixton raw score	12.22 (5.09)	10.45 (4.91)	8.39 (3.66)	$F(2,73) = 1.12$; $p = .331$	.17

IQ = intelligence quotient; BN = bulimia nervosa; EDNOS-BN = BN-type eating disorder not otherwise specified; HC = healthy control; WCST = Wisconsin Card Sorting Test.
All variables were raw scores.

disorder samples. In addition, this study adds to the limited literature on neurocognitive correlates of eating disorder symptoms and, in particular, BN, which, to date, has been understudied in comparison with anorexia nervosa (5). Although cognitive inflexibility is established among adults with anorexia nervosa and, to a lesser extent, BN, this study suggests that set-shifting problems may develop over time because of the illness, rather than being at the core of an endophenotype that signals it.

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