

Mixture Modeling of Nonsuicidal Self-Injury and Binge Eating: Behaviors and Motives

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Nonsuicidal self-injury (NSSI) and binge eating frequently co-occur. These behaviors are often used to alleviate distress. Previous studies examining this co-occurrence have used a variable-centered approach. The current study used a person-centered approach (mixture modeling) to examine how individuals cluster in groups based on their past-month NSSI, past-month objective and subjective binge episodes (OBEs and SBEs, respectively), and endorsement of coping motives for NSSI and eating in two large samples of emerging adults. Validators included self-report measures of emotion regulation, impulsivity, and negative affect. In Study 1, additional validators included lifetime history of mental health treatment and suicide attempts. In Study 2, additional validators included child abuse history. In both Study 1 and Study 2, a three-class solution provided the most interpretable fit with classes characterized as (a) low psychopathology; (b) the presence of OBEs and NSSI, and endorsement of NSSI coping motives; and (c) the presence of SBEs and NSSI, and endorsement of high levels of NSSI coping motives. In both studies, eating motives were equivalent in Classes 2 and 3, but NSSI motives were most strongly endorsed by Class 3. In Study 1, Class 2 endorsed higher rates of lifetime suicide attempts than Class 3. In Study 2, both Class 2 and Class 3 endorsed higher rates of child abuse than Class 1, although they did not differ from each other. The class structure and validator analysis were consistent across samples and measures. Results suggest that binge eating and NSSI tend to cluster together in otherwise healthy emerging adults.

Keywords: nonsuicidal self-injury; binge eating; motives; mixture modeling

NONSUICIDAL SELF-INJURY (NSSI) refers to any socially unacceptable behavior causing intentional, direct destruction to one's own body tissue without suicidal intent (Claes & Muehlenkamp, 2014). Objective binge eating (OBE) is consuming what other people would describe as an objectively large amount of food with an accompanying sense of loss of control (LOC), while subjective binge eating (SBE) is the experience of LOC while eating smaller amounts of food (American Psychiatric Association, 2013). These behaviors frequently co-occur in clinical and emerging adult populations (Claes et al., 2015; Cucchi et al., 2016; Gollust et al., 2008). Estimates of NSSI in emerging adults range from 2 to 14%, and NSSI during the first year of college is associated with later suicide attempts (Hamza & Willoughby, 2016). Additionally, the period of emerging adulthood appears to be high risk for the development and persistence of binge eating (e.g., Goldschmidt et al., 2016).

Emerging adulthood is characterized by instability, identity exploration, self-focus, and multiple possibilities for romantic partners, careers, and other life choices (Arnett, 2007). It is also associated with poorer impulse control during a time when emerging adults are facing new stressors and decreased structure (Arnett, 2007). Two theoretical models relevant to the co-occurrence of NSSI and binge eating may be especially applicable to the development of maladaptive coping strategies for the increased stressors associated with this

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developmental period. According to an updated escape model, individuals engage in binge eating to escape from aversive self-awareness and negative affect, and thus, this behavior is reinforced (Pearson et al., 2015). Individual differences in negative urgency (NU), the tendency to act rashly when distressed, increase vulnerability to the use of binge eating as a coping mechanism (Pearson et al., 2015). Similarly, the experiential avoidance model (EAM) posits that NSSI is maintained by negative reinforcement through escape from undesirable emotional experiences (Chapman et al., 2006; Nock & Prinstein, 2004). In an extension of these models, Claes and Muehlenkamp (2014) hypothesized that when stressful life events interact with various risk factors, both NSSI and binge eating are used to regulate increases in internal distress, which in turn increases later dysregulation.

Data support the hypothesis that both NSSI and binge eating are motivated by affect regulation. Individuals who engage in NSSI and/or binge eating have similar risk and vulnerability factors, such as impulsivity, past abuse, and emotion dysregulation, as well as co-occurring mood and anxiety disorders (Claes & Muehlenkamp, 2014; Cucchi et al., 2016). Impulsivity and negative urgency are associated with NSSI and binge eating in emerging adult and clinical samples (Claes et al., 2015; Peckham et al., 2020; Peterson & Fischer, 2012; Riley et al., 2015), and predict the onset and maintenance of these behaviors during the first year of college (Peterson & Fischer, 2012; Riley et al., 2015).

Ecological momentary assessment (EMA) studies are also consistent with escape/avoidance theory models. Significant increases in negative affect and decreases in positive affect occur prior to NSSI among patients with bulimia nervosa (Muehlenkamp et al., 2009) and in non-eating disorder (ED) samples (Rodriguez-Blanco et al., 2018). Similarly, negative affect increases prior to binge eating and decreases following, with a concomitant decrease and increase in positive affect (Fischer et al., 2018; Smyth et al., 2007). Finally, affect regulation motives/beliefs are positively associated with the onset and maintenance of both NSSI and binge eating in this age group (Fischer et al., 2013; Wilcox et al., 2012).

Although it is clear that negative affect and coping motives are associated with NSSI and binge eating, it is less clear why an individual may engage in one behavior versus another versus both. In a series of studies, we used a person-centered approach to identify distinct patterns among individuals experiencing these clinical phenomena. We used mixture modeling, a statistical method that classifies individuals

into mutually exclusive groups (latent classes) based on their pattern of responses to a set of categorical and dimensional variables to examine the relationship of several common vulnerability factors, NSSI, and binge eating in two different large samples of emerging adults.

Prior research has primarily used a variable-centered approach to examine the co-occurrence of NSSI and binge eating. In this approach, each participant providing data is considered equally likely to be representative of the larger population (Von Eye & Bogat, 2006). In contrast, a person-centered analysis approach identifies distinct groups within a population (Von Eye & Bogat, 2006). Individuals with NSSI and/or binge eating are likely to be heterogeneous groups. Indeed, classification of subgroups in EDs using mixture modeling with emotion regulation, personality, or other variables yields different results than classification using diagnostic criteria (Forbush et al., 2017; Wonderlich et al., 2007). Specifically, the functions of behaviors may cause certain symptoms to cluster together (Fox et al., 2019; Muehlenkamp et al., 2019). Mixture modeling allowed us to group individuals based on their behaviors and motive endorsement to determine which characteristics, if any, differentiate those who just engage in NSSI compared to those who just engage in binge eating, or both.

In two studies, we used past-month NSSI, past-month OBEs and SBEs, and endorsement of coping motives for NSSI and eating as indicator variables. We used measures of coping motives as opposed to other types of motives as indicators because of the theories and data discussed above. And, typically, the most commonly cited reason that individuals engage in NSSI and binge eating is to reduce negative affect (e.g., Turner et al., 2016). We hypothesized that there may be four classes: (a) individuals who engage in both NSSI and binge eating, (b) people who engage in binge eating, (c) individuals who engage in NSSI, and (d) a group that did not endorse either behavior. We hypothesized that emerging adults who engage in both behaviors and endorsed respective coping motives would have higher levels of negative affect, impulsivity, and lower levels of emotion regulation and distress tolerance compared to the other classes. We used measures of negative affect, impulsivity, emotion dysregulation, ED symptoms, medication use, involvement in therapy, lifetime suicide attempts, distress tolerance, and thought suppression as validator variables. Furthermore, we conducted the same mixture-modeling analysis with two different samples in order to determine the strength of our results through replication.

Study 1

In Study 1, we used past-month frequency of NSSI, OBEs, and SBEs, as well as endorsement of coping motives for eating and NSSI, as indicators of latent classes. We used self-report measures of impulsivity, emotion dysregulation, thought suppression, negative affect, mental health treatment history, lifetime history of suicide attempts, and other ED-related variables as validators. We hypothesized that individuals who reported both behaviors and who endorsed coping motives for them would have significantly higher levels of negative affect, impulsivity, emotion dysregulation, and utilization of mental health services than those in other potential classes.

METHOD

Participants

Participants were 767 undergraduates recruited from a large public university in the southeastern United States. The sample consisted of 190 men (24.8%) and 568 women (74.1%); nine participants did not provide demographic information. The majority of the sample identified themselves as White (78.9%), with the remainder identifying themselves as Black (5.7%), Asian (8.1%), Hispanic or Latino/a (2.9%), or another ethnicity (1.2%). The participants' ages ranged from 17 to 25 years (mean = 19.13).

MEASURES

Demographics and History Questionnaire

A demographics questionnaire assessed participant age, year in school, gender, and self-reported ethnicity. Dichotomous questions were asked about psychotherapy (e.g., "Have you ever attended psychotherapy?") and psychiatric medication use. We also asked a dichotomous question "Have you ever attempted suicide?" The item description clarified that a suicide attempt indicated behavior designed to harm oneself with the intent to die. We then asked two follow-up questions: "How many times have you attempted suicide in your lifetime?" and "How many times have you attempted suicide in the last 2 years?" Due to concerns about the anonymous nature of the data collection, and in conjunction with the Institutional Review Board (IRB), we did not ask any other questions about current suicidal ideation or more recent attempts.

Indicator Variables

Eating Disorder Examination Questionnaire (EDE-Q). The EDE-Q is a self-report measure that assesses ED symptoms over the past 28 days (Fairburn & Beglin, 1994). OBEs and SBEs are

assessed via questions about amount of food eaten, LOC, and frequency of episodes. OBEs and SBEs were dichotomized indicating the presence or absence of binge-eating episodes in the past 28 days. Binge episodes (past month) were used as indicators. The global score ($\alpha = .95$) and purging were used as validators.

Deliberate Self-Harm Inventory (DSHI). The DSHI (Gratz, 2001) measures behavior described as the deliberate, direct destruction of body tissue without conscious suicidal intent. Participants were asked to quantify the amount of times they engaged in 15 different types of NSSI over the past month. We used a dichotomous variable in our analyses to indicate the presence or absence of NSSI in the past month.

Functional Assessment of Self-Mutilation (FASM). The FASM is a self-report measure assessing the type, frequency, and function of NSSI (Nock & Prinstein, 2004). The motive items were used for this study. The survey assesses motives for NSSI on a 22-item scale from 0 (*never*) to 3 (*often*). The items are associated with one of four subscales proposed by Nock and Prinstein: (a) Automatic Negative Reinforcement, (b) Automatic Positive Reinforcement, (c) Social Negative Reinforcement, and (d) Social Positive Reinforcement. Automatic negative reinforcement is the use of NSSI to reduce aversive internal experiences, while automatic positive reinforcement is the use of NSSI to increase a wanted emotion. The structure was replicated in psychiatric samples (Nock et al., 2009). We summed the automatic negative and positive reinforcement items to create an overall score of NSSI coping motives as an indicator ($\alpha = .87$).

Motivations to Eat Scale. The Motivations to Eat Scale (Jackson et al., 2003) is a 20-item measure examining a range of psychological motivations for eating based upon the four-category model of the Drinking Motives Questionnaire (DMQ; Cooper, 1994). Subscales are Coping Motives, Social Motives, Compliance Motives, and Pleasure Motives. Coping motives were used as an indicator ($\alpha = .78$).

Validator Variables

Patient-Reported Outcomes Measurement Information System (PROMIS). The PROMIS scales assess patient functioning across various domains of well-being (Pilkonis et al., 2011). Respondents report their emotions over the past 7 days utilizing a 5-point Likert scale from 1 (*never*) to 5 (*always*). Cronbach's alpha in our sample for depression,

anxiety, and anger were .94, .92, and .89, respectively.

White Bear Suppression Inventory (WBSI). The WBSI ($\alpha = .88$) is a 15-item self-report questionnaire that measures the tendency to suppress unwanted negative thoughts (Muris et al., 1996). Items are rated on a 5-point Likert scale, with higher scores indicating greater thought suppression.

UPPS Impulsive Behavior Scale—Positive Urgency (UPPS-P). The UPPS-P is a 44-item self-report questionnaire rated on a 4-point scale ranging from 1 (*agree strongly*) to 4 (*disagree strongly*; Whiteside & Lynam, 2001). The UPPS-P consists of the following subscales: (lack of) Premeditation ($\alpha = .85$), Urgency ($\alpha = .88$), Sensation Seeking ($\alpha = .91$), and (lack of) Perseverance ($\alpha = .84$).

Positive and Negative Affect Schedule (PANAS). The PANAS is a 20-item inventory that assesses positive ($\alpha = .87$) and negative ($\alpha = .83$) affect (Watson et al., 1988). Participants rated the extent to which they experienced each emotion over the past week on a 5-point Likert scale from 1 (*very slightly/not at all*) to 5 (*very much*).

Difficulties in Emotion Regulation Scale (DERS). The DERS (Gratz & Roemer, 2004) has 36 items assessing six aspects of difficulties in emotion regulation: (a) lack of emotional awareness, (b) lack of emotional clarity, (c) difficulty regulating behavior when distressed, (d) difficulty engaging in goal-directed cognition and behavior when distressed, (e) unwillingness to accept certain emotional responses, and (f) lack of access to strategies for feeling better when distressed. The DERS total score was used ($\alpha = .84$).

Distress Tolerance Scale (DTS). The DTS is a 15-item self-report measure of distress tolerance defined as the capacity to experience and withstand negative psychological states (Simons & Gaher, 2005). The total score was used ($\alpha = .91$).

PROCEDURE

Participants completed measures in groups of up to 30 individuals in classrooms at the university. All questionnaires were paper and pencil; the majority were completed with a scantron sheet for computer scoring. The DSHI and EDE-Q were entered by research assistants. Inclusion criteria were that participants had to be 18 or older (or have parental permission to participate in university research for class participation) and

speak and read English. All participants completed a written informed consent. The study was approved by the university's IRB. Research assistants provided participants with a debriefing document (about the study topic, how to contact study staff, and mental health) and reviewed it with participants as they left the room in which they completed questionnaires. The debriefing sheet contained information on where to obtain mental health services on campus.

ANALYTIC PLAN

We used OBEs in past month, SBEs in past month, and NSSI in past month as binary variable indicators, and coping motives for NSSI and eating as continuous variable indicators. We included OBEs and SBEs because both types of binges involve the sense of loss of control, which is associated with psychopathology. Due to the use of binary and continuous indicators, we used mixture modeling in Mplus version 7.0 to examine the latent class structure in this sample.

Using the aforementioned five indicators, the most parsimonious number of latent classes was determined by analyzing two-, three-, and four-class solutions, and comparing each model with the previous one. The final model was selected based on entropy values, Akaike information criterion (AIC), Bayesian information criterion (BIC), sample-size adjusted-BIC (ABIC), Vuong–Lo–Mendell–Rubin's (LMR) likelihood ratio test (LRT), bootstrap likelihood ratio test (BLRT), interpretability, and class sizes.

To validate class structure, we examined mean differences on ED- and NSSI-related variables among the classes using analysis of variance (ANOVA). For the first set of validators, we chose purging, other ED symptoms, and frequencies of NSSI and binge eating in the past month. Purging was not included as an indicator because it may not serve the same function as binge eating (e.g., Fox et al., 2019; Jeppson et al., 2003)—however, we selected purging as a validator due to its clinical association with binge eating. We anticipated that those in the binge-eating or NSSI class engaged in these behaviors more in the past month than those not in those classes. The first set of validators was chosen to establish the clinical meaningfulness of our classes.

For the second set of validators, we selected lifetime suicide attempts, psychiatric medication, history of psychotherapy, and scores on deficits in emotion regulation, distress tolerance, impulsivity, ED symptoms, thought suppression, affect, anxiety, depression, and anger. Lifetime suicide attempts were included due to the increased risk

for suicide among ED patients who engage in NSSI (Smith et al., 2018). These validators were chosen as they are indicative of impairment and distress.

Results

MIXTURE-MODELING ANALYSIS FINDINGS

A three-class solution demonstrated the most interpretable model fit based on past-month OBE and SBE, NSSI, and coping motives for both behaviors (see Tables 1 and 2). While the information criterion values (AIC, BIC, ABIC) for the three- and four-class solutions showed better fit compared to the two-class solution, the LMR LRT indicated significant model fit improvement from the two- to three-class solution ($p = .0008$). Model fit did not significantly improve in the subsequent model comparison ($p = .297$). Based on this combination of fit indices (e.g., Nylund et al., 2007), the three-class solution was retained as the most interpretable model with the following classifications: low psychopathology, OBE and NSSI, and SBE and NSSI. The results of the comparisons between all three classes on each of the motive scales and validators are summarized below and presented in Table 2.

Class 1: Low Psychopathology

Class 1 (704 participants; 91.79% of the sample) was characterized by low rates of ED behaviors and NSSI. A total of 3.1% reported self-harm in the past month and 16.6% endorsed lifetime self-harm. Regarding ED behaviors in the past month, 9.9% endorsed SBEs, 9.2% engaged in OBEs, and 5.3% reported purging behaviors. The low psychopathology class had significantly lower scores than all other classes on coping motives for NSSI and eating, and the lowest scores on all measures of ED symptoms, impulsivity, negative affect, emotion regulation, and thought suppression. Class 1 reported the lowest endorsement of life-

time medication use (8.9%), $\chi^2(2) = 10.62$, $p < .005$, Fisher's exact p value $< .01$; lifetime participation in psychotherapy (10.3%), $\chi^2(2) = 15.18$, $p < .001$, Fisher's exact p value $< .001$; lifetime NSSI, $\chi^2(2) = 84.42$, $p < .001$, Fisher's exact p value $< .001$; and lifetime suicide attempts (1.1%), $\chi^2(2) = 46.23$, $p < .001$, Fisher's exact p value $< .001$.

Class 2: Objective Binge Eating and NSSI

Class 2 was characterized by elevated rates of NSSI and ED behaviors with 45 students (5.87% of the sample). In this class, 26.7% engaged in NSSI in the last month and 68.9% endorsed lifetime NSSI. In the past month, 8.9% endorsed SBEs, 31.1% reported OBEs, and 17.8% engaged in purging behaviors (combined vomiting and laxative use). Class 2 had higher rates of endorsement of coping motives for NSSI than Class 1, and lower rates than Class 3. They reported similar rates of coping motives for eating compared to Class 3. Classes 2 and 3 did not significantly differ from each other on ED symptoms, impulsivity, affect related variables, distress, emotion regulation, and thought suppression. The OBE and NSSI class had the highest rates of lifetime suicide attempts (18.4%), and lifetime NSSI. Classes 2 and 3 were not significantly different from each other on psychiatric medication use (25.0% vs. 28.6%) and psychological treatment (25.0% vs. 50.0%).

Class 3: Subjective Binge Eating and NSSI

Class 3 (18 participants; 2.34% of the sample) was characterized by high endorsement of NSSI coping motives, high rates of SBEs, and past-month NSSI. A total of 27.8% reported NSSI in the last month and 55.6% endorsed lifetime NSSI. In the past month, 22.2% engaged in SBEs, 11.1% endorsed OBEs, and 16.7% reported purging behaviors. Class 3 had similar rates of eating coping motives compared to Class 2 and did not significantly differ on the validators. Unlike Classes 1 and 2, mem-

Table 1
Criteria Used to Assess Model Fit in Study 1 and Study 2

Study 1							
Models	Class n	Entropy	AIC	BIC	ABIC	LMR LRT value	LMR LRT p value
2 Class	715, 52	0.987	8073.287	8133.639	8092.358	914.183	0.395
3 Class	704, 18, 45	1.00	7318.121	7406.328	7345.995	748.388	0.0008**
4 Class	691, 23, 35, 18	1.00	7024.701	7140.763	7061.377	297.944	0.322
Study 2							
2 Class	436, 42	0.996	4856.367	4910.572	4869.312	588.271	0.001**
3 Class	419, 32, 27	1.00	4408.563	4487.785	4427.482	447.710	0.011*
4 Class	419, 25, 17, 17	0.998	4188.890	4293.131	4213.784	225.578	0.023*

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; ABIC = adjusted Bayesian information criterion; LMR LRT = Lo-Mendell-Rubin likelihood ratio test.

* $p < .05$, ** $p < .001$.

Table 2
Study 1 Group Differences in Motives, Psychopathology, Impulsivity, and Emotion Regulation

Measures	Low psychopathology (<i>n</i> = 704) <i>M</i> (<i>SD</i>)	OBE and NSSI (<i>n</i> = 45) <i>M</i> (<i>SD</i>)	SBE and NSSI (<i>n</i> = 18) <i>M</i> (<i>SD</i>)	ANOVA	
				<i>F</i>	<i>p</i>
Eating motives	9.06 (4.09) ^a	12.09 (6.12) ^b	12.56 (4.79) ^b	16.12	<.001**
NSSI motives	0.08 (0.33) ^a	4.78 (1.30) ^b	10.78 (1.48) ^c	1,419.80	<.001**
EDE global	1.26 (1.16) ^a	1.89 (1.44) ^b	2.05 (1.59) ^b	9.44	<.001**
NU	24.13 (6.70) ^a	29.77 (7.23) ^b	27.14 (8.65) ^b	15.98	<.001**
PU	46.07 (8.13) ^a	42.38 (8.38) ^b	43.00 (10.65) ^b	5.34	<.005*
SS	29.91 (7.37) ^a	27.42 (6.65) ^a	28.81 (10.52) ^a	2.52	.08
PERS	31.09 (4.44) ^a	29.38 (5.21) ^b	30.47 (5.06) ^b	3.18	<.042*
PRE	33.17 (5.20) ^a	31.60 (4.82) ^a	34.14 (5.98) ^a	2.30	.101
PROMISang	15.44 (5.47) ^a	18.30 (6.30) ^b	19.53 (7.54) ^b	9.06	<.001**
PROMISanx	13.98 (5.54) ^a	16.58 (7.37) ^b	19.71 (7.53) ^b	11.82	<.001**
PROMISdep	12.30 (5.67) ^a	17.05 (8.06) ^b	18.06 (9.47) ^b	19.19	<.001**
Negative PANAS	1.68 (0.58) ^a	2.04 (0.62) ^b	2.11 (0.52) ^b	12.35	<.001**
Positive PANAS	3.26 (0.77) ^a	2.92 (0.87) ^b	3.06 (0.99) ^b	4.36	.013*
DTS	51.61 (11.68) ^a	43.41 (10.34) ^b	47.50 (11.36) ^b	11.23	<.001**
DEERS	71.02 (19.59) ^a	91.30 (22.09) ^b	87.83 (24.91) ^b	26.97	<.001**
WBSI	44.28 (12.66) ^a	52.36 (12.49) ^b	49.44 (14.21) ^b	9.76	<.001**

Note. *M* = mean; *SD* = standard deviation; OBE = objective binge eating; NSSI = nonsuicidal self-injury; SBE = subjective binge eating; ANOVA = analysis of variance; EDE = Eating Disorder Examination; NU = negative urgency; PU = positive urgency; SS = sensation seeking; PERS = (lack of) perseverance; PRE = (lack of) premeditation; PROMISang = Patient-Reported Outcomes Measurement Information System anger; PROMISanx = anxiety; PROMISdep = depression; PANAS = Positive and Negative Affect Schedule; DTS = Distress Tolerance Scale; DEERS = Difficulties in Emotion Regulation Scale; WBSI = White Bear Suppression Inventory. Different superscripts denote significant differences between groups after post hoc comparisons, while same superscripts denote nonsignificant differences.

p* < .05, *p* < .001.

bers of this group did not report any lifetime suicide attempts. In short, the primary distinction between Class 2 and Class 3 was that Class 2 reported higher rates of OBEs and lifetime suicide attempts, and lower rates of SBEs than Class 3, while Class 3 reported significantly higher scores on coping motives for NSSI.

STUDY 1 DISCUSSION

The results of this mixture-modeling analysis clustered individuals into the following three classes: low psychopathology, OBE and NSSI, and SBE and NSSI. There were no significant differences between Class 2 and Class 3 in most of the second set of validators (i.e., ED symptoms, impulsivity affect, distress tolerance, emotion regulation, and thought suppression), with the exception of history of lifetime suicide attempts. A significantly larger proportion of Class 2 had a lifetime suicide attempt than Classes 1 or 3. This may indicate that those who engage in OBEs experience more severe psychopathology than individuals who engage in SBEs. However, their endorsement of variables related to negative affect, distress tolerance, and emotion dysregulation did not differ from Class 2. This prompted a question regarding which other variables relevant to emotion regulation and psy-

chopathology, if any, may differentiate these two classes. One such variable that was not considered in Study 1 is a history of child maltreatment. Child maltreatment is associated with both NSSI and ED symptoms, as well as multiple other forms of psychopathology (Baiden et al., 2017; Caslini et al., 2016).

There are various hypothesized pathways from child maltreatment to later psychopathology. For example, individuals who experience emotional abuse and other forms of maltreatment may not learn adaptive emotion regulation skills, which may then lead to maladaptive coping via NSSI or binge eating (e.g., Burns et al., 2012; Titelius et al., 2018). Child maltreatment may be a risk factor for the persistence and emergence of these behaviors, specifically in the period of emerging adulthood (Mahtani et al., 2019). Given these associations, we included a measure of child maltreatment in Study 2.

Study 2

The primary goal of Study 2 was to examine whether the class structure and validator analysis described in Study 1 would replicate in another sample with different measures of several of the same constructs. We also wished to examine a

question generated by our findings from Study 1. Given that most validators (i.e., impulsivity, affect, distress tolerance, emotion regulation, and thought suppression) did not distinguish between Class 2 and Class 3, would the experience of child abuse distinguish them?

Published results in studies of psychological science often fail to replicate in different samples or across labs (e.g., Wagenmakers & Pashler, 2012). This may be a particular concern in mixture-modeling or latent class analysis, as findings may be sample dependent. It is important to replicate model fit and class structures on multiple different samples (e.g., Lubke & Campbell, 2016), instead of relying on one sample for both model selection and hypothesis confirmation. In addition to examining the latent class structure of NSSI, binge eating, and coping motives in a different sample, we also used, in several cases, different measures of the same construct than were used in Study 1. If the class structure replicated in a different sample of people using different measures of the same construct, then we have increased confidence that the findings are reliable.

Thus, in Study 2, we conducted mixture modeling of a large sample of undergraduates. The following measures were the same across studies: UPPS-P, EDE-Q, DERS, and Motivations to Eat Scale. The following measures were different from Study 1: Beck Depression Inventory (BDI), Inventory of Statements About Self-Injury (ISAS), Thinness and Restricting Expectancy (TREI), and Eating Expectancy Inventory (EEI). Additionally, we used data from the Childhood Trauma Questionnaire (CTQ). We hypothesized that we would replicate the three-class solution found in Study 1. Given that Class 2 appeared to have more severe symptoms in Study 1, we hypothesized that this class would endorse significantly higher rates of childhood abuse than Classes 1 and 3.

METHOD

Participants

Participants were 478 undergraduates at a large public university in the southeastern United States (56.1% first-year students). The sample consisted of 73.2% women, 24.9% men, and 1.9% who did not disclose gender. The majority of the sample identified themselves as White (73.6%), with 10.5% identifying themselves as Black, 6.9% as Asian, and the remainder as Hispanic/Latino/a or another ethnicity. The mean age of the sample was 19.05 years, with a mode of 18, and a range from 18 to 27 years.

MEASURES

Indicators

Eating Disorder Examination Questionnaire (EDE-Q). OBEs and SBEs over the past month were used as indicators, and the global score ($\alpha = .92$) and frequency of purging were used as validators (Fairburn & Beglin, 1994).

Motivations to Eat Scale. This scale was also used in Study 1. Internal consistency for coping motives = .81 (Jackson et al., 2003).

Inventory of Statements about Self-Injury (ISAS). The ISAS (Klonsky & Glenn, 2009) is a self-report measure that assesses the frequency of 12 different types of NSSI, as well as 13 potential functions of NSSI. For the purposes of this study, items assessing the function of alleviating negative affect were used (e.g., the affect regulation function; α of these items = .86). Additionally, the frequency items were modified to determine whether or not a behavior had occurred in the past month, as well as in the participant's lifetime. Both the presence versus absence of NSSI in the past month, as well as continuous scores on affect regulation function, were used as indicators.

Validators

Childhood Trauma Questionnaire (CTQ). The CTQ (Bernstein & Fink, 1998) is a self-report questionnaire that assesses the experience of different forms of physical, sexual, emotional abuse, and neglect. Participants were prompted to report on experiences prior to age 14. Given that experiences of childhood abuse are often highly correlated, we used the total score from the CTQ in our analyses ($\alpha = .84$).

UPPS Impulsive Behavior Scale—Revised (UPPS-R). The UPPS-R (Whiteside & Lynam, 2001) was also used in Study 1.

Difficulties in Emotion Regulation Scale (DERS). The DERS (Gratz & Roemer, 2004) was also used in Study 1. For this study, the DERS total score was used as an overall indicator of difficulty in emotion regulation ($\alpha = .85$).

Beck Depression Inventory-II (BDI-II). The BDI-II (Beck et al., 1996) is a widely used 21-item self-report measure of symptoms of depression ($\alpha = .88$). The suicidal ideation item was removed for the purposes of this study. (See the "Procedure" section below).

Thinness and Restricting Inventory (TREI). The TREI (Hohlstain et al., 1998) is a self-report measure of outcome expectancies for life improvement from being thin and restricting food intake ($\alpha = .97$).

Eating Expectancies Inventory (EEI). The EEI (Hohlstain et al., 1998) is a self-report measure (five scales) that assesses expectancies for reinforcement from eating. The Eating Alleviates Negative Affect scale was used ($\alpha = .92$), which is consistently associated with binge eating (e.g., Fischer et al., 2013).

PROCEDURE

Undergraduates were recruited through classes for research participation credit. Inclusion criteria were the same as Study 1. The students completed questionnaires via an online platform and were given information about mental health services on campus. Due to anonymity of the data collection, and that students were not debriefed in person (as in Study 1), we did not ask questions about mental health history, including lifetime suicide attempts, in the “Demographics” section. This study was approved by the university IRB.

ANALYTIC PLAN

The analytic plan described in Study 1 was used in Study 2, using MPlus 7.0.

Results

LATENT CLASS ANALYSIS FINDINGS

A three-class solution demonstrated the most interpretable model fit (see Table 1) and had the highest entropy value. The information criterion values (AIC, BIC, ABIC) for the three- and four-class solutions showed better fit compared to the two-class solution. The LMR LRT indicated significant model fit improvement from the two- to three-class solution ($p = .0114$) and from the three- to four-class solution ($p = .0230$). However, convergence problems in the four-class model prevented the replication of the BLRT best solution, hampering its interpretation. Based on these results, the three-class solution was retained with the following classifications: low psychopathology, OBE and NSSI, and SBE and NSSI. The results of the comparisons of the motives and validator analysis are presented in Table 3.

Class 1: Low Psychopathology

Class 1 (419 participants; 87.66% of the sample) was characterized by low rates of both binge eating and NSSI. In this class, 2.6% engaged in self-harm in the past month, 12.2% engaged in OBEs, 9.5% engaged in SBEs, and 2.9% of the sample engaged in purging behaviors. Class 1 endorsed coping motives for NSSI at significantly lower

Table 3
Study 2: Group Differences in Psychopathology, Impulsivity, Emotion Regulation, and Child Abuse

Measures	Low psychopathology ($n = 419$) $M (SD)$	OBE and NSSI ($n = 32$) $M (SD)$	SBE and NSSI ($n = 27$) $M (SD)$	ANOVA	
				F	p
Eating motives	10.63 (5.11) ^a	11.00 (4.80) ^a	12.93 (7.17) ^a	2.47	.086
NSSI motives	0.03 (0.16) ^a	2.47 (0.51) ^b	4.96 (0.85) ^c	4,735.09	<.001**
EDE global	1.36 (1.21) ^a	1.61 (1.35) ^{a,b}	2.17 (1.58) ^b	5.51	.004*
NU	25.24 (7.08) ^a	27.91 (6.16) ^a	27.30 (8.09) ^a	2.18	.115
PU	25.36 (7.48) ^a	28.43 (6.54) ^a	26.50 (9.39) ^a	2.48	.085
SS	33.86 (6.68) ^a	35.31 (6.76) ^a	34.85 (6.76) ^a	0.91	.405
PERS	18.26 (5.13) ^a	18.52 (4.98) ^a	20.41 (6.38) ^a	2.16	.117
PRE	21.45 (5.33) ^a	20.71 (5.91) ^a	23.04 (6.64) ^a	1.30	.273
DEERS	78.04 (20.90) ^a	91.66 (20.10) ^b	90.44 (21.69) ^b	10.04	<.001**
BDI	9.71 (7.48) ^a	14.27 (7.46) ^b	16.76 (9.88) ^b	15.17	<.001**
EEI	41.35 (19.21) ^a	40.77 (15.78) ^a	44.92 (23.36) ^a	0.44	.642
TREI	159.37 (65.29) ^a	189.00 (66.95) ^b	173.22 (75.90) ^{a,b}	3.21	<.041*
CTQ	18.54 (4.67) ^a	21.10 (8.78) ^b	23.07 (6.51) ^b	12.39	<.001**

Note. M = mean; SD = standard deviation; OBE = objective binge eating; NSSI = nonsuicidal self-injury; SBE = subjective binge eating; ANOVA = analysis of variance; EDE = Eating Disorder Examination; NU = negative urgency; PU = positive urgency; SS = sensation seeking; PERS = (lack of) perseverance; PRE = (lack of) premeditation; DEERS = Difficulties in Emotion Regulation Scale; BDI = Beck Depression Inventory; EEI = Eating Expectancy Inventory; TREI = Thinness and Restriction Expectancy Inventory; CTQ = Childhood Trauma Questionnaire. Different superscripts denote significant differences between groups after post hoc comparisons, while same superscripts denote nonsignificant differences.

* $p < .05$, ** $p < .001$.

rates than the other two classes (see [Table 3](#)) and obtained lower scores on all of the validators than the other classes as well, including the CTQ.

Class 2: Objective Binge Eating and NSSI

Class 2 (32 participants; 6.69% of the sample) endorsed OBEs and NSSI at a higher rate than the low psychopathology class. In Class 2, 28.1% engaged in self-harm, 28.1% reported OBEs, 9.4% reported SBEs, and 6.3% endorsed purging behaviors in the past month. The OBE and NSSI class had similar endorsement of eating coping motives as Classes 1 and 3. This class scored significantly higher than the low psychopathology group on measures of NSSI coping motives, thinness expectancies, emotion regulation, and depression. Class 2 did not differ from the low psychopathology class on coping motives for eating, eating expectancies, and impulsivity. Class 2 had significantly lower endorsement of NSSI coping motives than Class 3. However, Classes 2 and 3 were equivalent on measures of emotion regulation, other ED symptoms, and depression. There were no significant differences between Class 2 and Class 3 on CTQ scores.

Class 3: Subjective Binge Eating and NSSI

Class 3 (27 participants; 5.65% of the sample) was characterized by higher rates of SBEs and NSSI than the low psychopathology class. In Class 3, 29.6% engaged in SBEs and 18.5% engaged in self-harm in the past month. Additionally, 14.8% of the class engaged in purging behaviors and 14.8% engaged in OBEs in the past month. Class 3 had significantly higher endorsement of NSSI coping motives than Classes 1 and 2. Classes 2 and 3 did not differ on the remaining validators. Class 3 endorsed higher scores than Class 1 on emotion regulation, depression, thinness expectancies, and ED cognitions. Similarly to Study 1, the primary distinctions between Class 2 and Class 3 were the presence of more frequent OBEs in Class 2 and higher endorsement of NSSI coping motives in Class 3.

STUDY 2 DISCUSSION

As in Study 1, individuals were clustered into a low psychopathology class, a class endorsing OBEs and NSSI, and a third class of individuals engaging in SBEs and NSSI. No significant differences were found between Class 2 and Class 3 on any validators (i.e., ED symptoms, impulsivity, depression, emotion regulation, and eating and thinness expectancies). Further, all three classes had similar endorsement of coping motives for eating. However, all three classes differed significantly on endorsement of NSSI coping motives. Class 3 had a significantly higher endorsement of

NSSI coping motives than Class 2. Our hypothesis regarding a history of child maltreatment was not supported. There were no significant differences between Class 2 and Class 3 on child abuse history.

Discussion

Using mixture modeling in two large, unique samples of undergraduates, we found that individuals clustered on the basis of NSSI, OBEs, SBEs, and coping motives for NSSI. The three classes, replicated in both studies, were (a) a low psychopathology class; (b) a class characterized by moderate levels of coping motives for NSSI, OBEs, and NSSI; and (c) a class characterized by high levels of coping motives for NSSI, SBEs, and NSSI. In the Study 1 validator analysis, Class 2 was distinguished from Class 3 only by the frequency of lifetime suicide attempts. In Studies 1 and 2, Classes 2 and 3 endorsed similar levels of distress tolerance, impulsivity, emotion dysregulation, and eating pathology. In Study 2, there were no significant differences in childhood maltreatment between Class 2 and Class 3. The study is notable in that the class structure was replicated and the frequency of behaviors and level of motive endorsement was very similar across the two samples. The fact that the class structure was replicated in two different samples, using different assessments of coping motives for NSSI, lends confidence to the findings.

Although the replication of class composition and size in two separate samples is meaningful and novel, there are limitations to the current study. One limitation is that we were not able to obtain information on lifetime suicide attempts in Study 2. This is unfortunate as Class 2 in Study 1 had the highest frequency of lifetime suicide attempts, potentially an important clinical distinction between Class 2 and Class 3. Additionally, the base rate of suicide attempts in the sample was small, so this finding should be replicated. The study solely used self-report measures, and binge eating may be more accurately assessed with interview or ambulatory assessment ([Wonderlich et al., 2015](#)). Finally, it is likely that class composition would change if we used a clinical or community sample. In a clinical sample, we would likely not obtain a “low psychopathology class.” We may instead obtain classes that had significantly higher levels of eating pathology than NSSI.

It is also important to note concerns with this statistical technique. Mixture modeling yields patterns based in part on the choice of indicators in the model. Although there are other functions for binge eating and NSSI, we chose to examine cop-

ing motives as indicators. We may have obtained different patterns if we also included self-punishment motives for NSSI or interpersonally related motives (such as conformity related motives for eating). It is possible that either we would have found a different set of classes or that Classes 2 and 3 may have different compositions based on those motives. The use of categorical variables in a model also runs the risk of loss of information. An additional risk is the assumption that the clusters found in the analysis are “true” representations of the population, when the use of different samples may yield different results. A strength of our analysis is that the results were replicated, but both samples were representative of the university student body in which the data were collected. Thus, these clusters may not be representative of other populations.

In addition to replication of class structure, the study also yielded several novel findings. Coping motives play a key role in determining class membership. The pattern of endorsement of coping motives was consistent across Studies 1 and 2. Endorsement of NSSI motives differentiated all three classes from one another. Class 1 had the lowest endorsement of these motives, and Class 3 endorsed these motives most strongly. In both studies, Class 2 scored between Class 1 and Class 3. Thus, the inclusion of coping motives in the analysis provided useful information: while a percentage of individuals in Classes 2 and 3 both reported NSSI, their levels of coping motives for this behavior were different.

The results suggest that ED behavior is associated with other forms of pathology in emerging adults, similar to population-based studies of EDs (Keski-Rahkonen & Mustelin, 2016). A mixture-modeling study of NSSI behaviors (using solely NSSI behaviors as indicators) found a class characterized by a high frequency of suicide attempts and the highest level of ED symptoms in the sample, very similar to Class 2 in Study 1 (Peterson et al., 2019). Our findings are also similar to a study that compared individuals with EDs, without NSSI, to those with current NSSI and those with a history of NSSI (Vieira et al., 2020). Individuals with EDs who had current NSSI or a history of NSSI had higher scores on measures of emotion regulation, negative urgency, and childhood invalidation than those who did not self-injure, and were similar to each other (Vieira et al., 2020).

NSSI and ED symptoms appear to have a bidirectional relationship, and to be associated with affect regulation functions (Kiekens & Claes, 2020). In the current study, one of the primary dis-

tinctions between Class 2 and Class 3 was that Class 3 endorsed the highest level of NSSI coping motives. These results also suggest that it may be helpful to focus not only on emotion dysregulation in treatment but also a client's underlying beliefs about the benefits of NSSI. Those who strongly endorse NSSI coping motives may use this as their primary regulation strategy and likely find it effective in the short term. Broadening a client's repertoire of strategies may reduce the likelihood that he or she turns to NSSI to obtain relief from distress. Treatment models, such as dialectical behavior therapy (Linehan, 2018), may achieve these goals for both NSSI and ED symptoms simultaneously (e.g., Fischer & Peterson, 2015).

Conflict of Interest Statement

The authors declare that there are no conflicts of interest.

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