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The role of habit in maintaining binge/purge behaviors: An ecological momentary assessment study

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Abstract

Objective: Individuals with eating disorders transdiagnostically engage in binge eating (BE) and/or purging, despite life-threatening consequences. Little is known about factors that contribute to the persistence of these behaviors. This study explored whether habitual control over binge/purge (B/P) spectrum behaviors contributes to symptom persistence and whether negative reinforcement via reductions in negative affect is less influential in maintaining B/P behaviors that are under habitual control and are persistent.

Method: Women with BE and/or purging ($N = 81$) completed self-report measures assessing habit strength of BE and purging. Then, they completed a 14-day ecological momentary assessment (EMA) protocol during which they completed measures of negative affect, BE, and purging multiple times per day.

Results: Habitual control over purging was associated with a greater frequency of purging during the EMA period. However, habitual control over BE was not associated with the severity of loss of control eating or the frequency of BE episodes. Habitual control did not moderate temporal relations between negative affect and B/P behaviors during the EMA period. However, exploratory analyses revealed that individuals with a longer duration of BE and greater habitual control over BE showed a less pronounced reduction in negative affect following BE.

Discussion: Overall, these findings suggest that purging may be maintained by habitual stimulus–response learning. In addition, they support the possibility that reduction in negative affect may play a less prominent role in maintaining BE that is habitual and persistent.

Public significance: This study investigated whether habit contributes to the persistence of symptoms in women with binge/purge spectrum behaviors and whether negative reinforcement via reductions in negative affect is less influential in maintaining binge/purge behaviors that are under habitual control. The findings suggest that purging may be maintained through habit. This supports the potential utility of habit reversal interventions to decrease habitual purging.

KEYWORDS
binge eating, ecological momentary assessment, habit, negative affect, purging

1 | INTRODUCTION

Binge/purge (B/P) spectrum disorders (e.g., bulimia nervosa [BN], binge-eating disorder [BED]) are characterized by binge eating (BE) and/or compensatory behaviors (e.g., purging; American Psychiatric Association, 2022). A portion of individuals with B/P spectrum disorders persistently engage in BE and purging, despite adverse consequences and a lack of reward (Pearson et al., 2015; Steinhausen & Weber, 2009). An understanding of factors that contribute to the persistence of BE and purging is crucial for developing effective clinical interventions.

1.1 | Affect regulation and B/P symptoms

Affect regulation models propose that BE and purging are triggered by negative affect (NA) and serve as means to alleviate negative emotions (Heatherton & Baumeister, 1991). Accordingly, these behaviors are operantly conditioned to down-regulate NA and are maintained through negative reinforcement. Consistent with affect regulation models, research has shown that BE and purging are triggered by NA (Berg et al., 2015; Haedt-Matt & Keel, 2015; Schaefer et al., 2020). However, findings regarding changes in NA following BE and purging are mixed. Some EMA studies found that NA decreased over time after BE and purging (Culbert et al., 2016; Schaefer et al., 2020). In contrast, other studies found that BE and purging were followed by an increase in NA (Haedt-Matt & Keel, 2011; Lavender et al., 2016). Notably, studies have utilized two different analytical approaches, which may contribute to the inconsistent findings (Berg et al., 2017; Haedt-Matt & Keel, 2015). For example, research that examined trajectories of several NA ratings during a period of several hours before and after BE showed that NA increased prior to BE and decreased following BE (Wonderlich et al., 2022). In contrast, research that compared NA ratings most proximal to BE showed that NA increased from before to after BE (Haedt-Matt & Keel, 2011). Evidence that BE and purging are followed by an increase in NA contradicts the assumption of affect regulation models that BE and purging are maintained by a reduction in negative emotions. Pearson et al. (2015) theorized that reductions in NA following BE and purging may function as a maintenance factor during the initial stages of B/P spectrum disorders, but that this negative reinforcement becomes less relevant during later stages when symptoms have become persistent. However, little is known about mechanisms that could be maintaining persistent BE and purging. One possibility is that the persistence of BE and purging results from an imbalance in habitual versus goal-directed instrumental control over these behaviors.

1.2 | Instrumental responding: goal-directed versus habitual

Instrumental behaviors (e.g., BE and purging) are controlled by a goal-directed system and a habitual system. Behaviors controlled by the goal-directed system occur to achieve some desirable outcome (Dickinson & Balleine, 1994; Steinfeld & Bouton, 2020). They are sensitive to the degree to which the outcome is reinforcing; therefore, they are adjusted in response to changes in reinforcement value (Schwöbel et al., 2021). Over time, repeated pairings between the behavior and the desirable outcome strengthen the relation between the behavior and antecedent contextual stimuli and behavioral control transitions from goal-directed to habitual. Behaviors controlled by the habitual system are elicited by contextual cues (Wood & Rüger, 2015). Habitual behaviors are performed regardless of whether the desirable outcome is presented (Harvey et al., 2022). Because habitual behavior is stimulus-dependent, it is performed rigidly and reflexively, which mirrors the persistent nature of BE and purging (Wood & Rüger, 2015). Indeed, evidence suggests that BE and purging behaviors in eating disorders may result from excessive habitual control over these behaviors (Davis et al., 2020; Steinglass et al., 2018).

1.3 | Habit and persistent B/P symptoms

Walsh (2013) applied instrumental learning theory to anorexia nervosa (AN), hypothesizing that dietary restriction begins as a goal-directed behavior that occurs to achieve a desirable outcome (e.g., praise), but over time transitions to a habitual behavior that occurs under certain conditions (e.g., distress) regardless of whether the desirable outcome is presented and persists despite negative consequences. Thus, restrictive eating behavior in AN results from excessive habitual control over eating. Research provides support for this model in AN (Coniglio et al., 2017). There also is evidence that habit may maintain BE and purging. For example, Voon et al. (2015) showed that higher-weight individuals with BED exhibited a greater propensity toward model-free (habitual) learning compared to higher-weight individuals without BED. To date, one study has investigated habit in relation to BN. Westwater et al. (2022) found that individuals with BN scored higher than non-eating disorder controls on a measure of automaticity of daily actions. While these findings suggest that individuals with BE and purging may have a propensity to develop strong habits, it remains unclear whether excessive habitual control over BE and purging underlies the persistence of these symptoms.

1.4 | An integrated model of affect regulation and instrumental responding

BE and purging may begin as goal-directed behaviors that are motivated by a desirable outcome (e.g., relief from distress). Over time, however, these behaviors may become habitual, whereby they are elicited by contextual cues associated with their performance (e.g., an increase in NA) and occur regardless of whether the desirable outcome (i.e., a reduction in NA) is consistently presented. According to this model, the reinforcing properties of BE and purging would contribute to the initial development of BE and purging, but have less of an impact on perpetuating them once they become habitual. BE and

purging would instead reflect stimulus-driven habits that are contingent upon the presence of conditioned contextual cues. The transition of BE and purging from goal-directed behaviors to behaviors under habitual control may help to explain why these behaviors persist in some individuals despite evidence that NA is not lowered and may be heightened following these behaviors (Haedt-Matt & Keel, 2011). That is, excessive habitual control over BE and purging may account for why these behaviors fail to extinguish in the absence of continued negative reinforcement via reductions in NA.

1.5 | The present study

Theoretical and empirical work suggests that habitual control over BE and purging may be one mechanism that contributes to the persistence of symptoms. Further, negative reinforcement of BE and purging via reductions in NA may be less influential in perpetuating these behaviors if they are habitual. The purpose of this study was to investigate this premise among women with BE and purging. We hypothesized that habitual control over BE and purging would be associated with more frequent BE and purging and a greater severity of loss of control eating. We also hypothesized that habitual control over BE and purging would moderate changes in NA surrounding these behaviors, such that individuals who endorsed more habitual control over BE and purging would exhibit greater increases in NA (i.e., less reinforcement) from before to after these behaviors, compared to those who endorsed less habitual control over BE and purging. Finally, we conducted exploratory analyses to investigate whether the moderating role of habitual control on changes in NA before and after BE and purging episodes would differ depending on the duration of BE and purging symptoms.

2 | METHOD

2.1 | Participants and procedures

Participants were 81 women with BE and/or purging symptoms (Table 1). To determine the sample size necessary to test the hypothesis that habitual control over BE and purging would predict more frequent BE and purging and a greater severity of loss of control eating, we conducted an a priori power analysis using G*Power (version 3.1). This indicated that a minimum of 46 participants were needed to detect a significant effect with 80% power and an alpha level of .05, assuming a large effect. To determine the sample size necessary to test the hypothesis that habitual control over BE and purging would moderate changes in NA surrounding these behaviors, we conducted an a priori power analysis using Optimal Design for Multi-Level and Longitudinal Research (version 3.01). This indicated that a minimum of 50 participants were needed to detect a significant effect with 80% power and an alpha level of .05, assuming a large effect. Large effect sizes were informed by prior work (e.g., Haedt-Matt & Keel, 2011). Inclusion criteria required participants to self-identify as female, be aged 18 or older, be able to read English and report at least one episode of BE (objective or subjective) or purging per week for the past 3 months.

TABLE 1 Sociodemographic characteristics of the sample.

Age, *M* (*SD*)	**28.30 (9.4)**
BMI, *M* (*SD*)	25.32 (8.3)
Binge eating duration,[a] *M* (*SD*)	11.03 (9.1)
Purging duration,[a] *M* (*SD*)	11.22 (9.7)
Race, *n* (%)	
Non-Hispanic White	51 (63.7)
Asian	13 (16.3)
Hispanic	11 (13.8)
Black	8 (10.0)
Other	6 (7.5)
Native Hawaiian/Other Pacific Islander	2 (2.5)
American Indian/Alaska Native	2 (2.5)
Geographic location, *n* (%)	
United States	67 (83.8)
Canada	6 (7.5)
United Kingdom	4 (5.0)
Germany	1 (1.3)
Romania	1 (1.3)
France	1 (1.3)
Education, *n* (%)	
College	52 (65.0)
High school	22 (27.5)
Other	5 (6.3)
Some high school	1 (1.3)

Abbreviation: BMI, body mass index.
[a]Duration in years.

Participants were recruited via social media websites and a university newsletter. Study postings invited women to participate in research about eating disorder behaviors and mood. Participants completed study procedures remotely. Inclusionary criteria were assessed using items adapted from the Eating Disorder Diagnostic Interview (EDDI; Stice et al., 2017). Eligible participants completed baseline questionnaires and a 14-day EMA protocol. During the phone screen, participants were trained on how to complete the EMA ratings. They were trained to identify objective and subjective BE as BE.

Participants completed EMA recordings over a 14-day period. SurveySignal software was used to send pre-scheduled text messages to complete EMA ratings with a link to complete each rating via Qualtrics. Text messages were sent to participants mobile devices. Participants were asked to complete EMA recordings on whatever device was convenient (e.g., tablet). Participants completed signal-contingent, event-contingent, and interval-contingent recordings (Wheeler & Reis, 1991). With the signal-contingent recordings, participants were signaled to complete EMA measures at five semi-random times throughout the day. With interval-contingent recordings,

participants were signaled to complete measures once nightly before bed. With event-contingent recordings, participants self-initiated measures immediately after BE or purging occurred. During interval- and signal-contingent recordings, participants reported BE or purging episodes that had not been previously recorded. During all recordings, participants rated their current mood. Participants provided informed consent prior to participating. Procedures were approved by the Illinois Institute of Technology Institutional Review Board. Participants received $25 for participating.

2.2 | Measures

2.2.1 | Demographics

Participants self-reported their age, height, weight, race/ethnicity, educational history, geographic location, and the age(s) at which BE and/or purging onset. Durations of BE and purging in years were calculated by subtracting the participant's age when each behavior onset from their age at the time they enrolled in the study.

2.2.2 | Habit strength

The Self-Report Behavioral Automaticity Index subscale (SBAI; Gardner et al., 2012) of the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003) was used to assess habitual control over BE and purging (SBAI BE $\omega = .81$; SBAI purging $\omega = .89$). The SBAI subscale assesses the automaticity of a behavior (Gardner et al., 2012). Automaticity is the core feature of habitual behavior (Gardner, 2012). The SBAI includes a generic stem (Behavior X is something…) followed by four items (e.g., "I automatically"), rated on a 5-point scale (1 = "strongly disagree"; 5 = "strongly agree"). The SBAI was tailored to assess BE in one version and purging in another version. Participants completed the SBAI relative to the behavior(s) they endorsed during the previous 3 months. The SBAI has demonstrated good internal consistency and convergent validity, and predictive validity for behavioral frequency (e.g., unhealthy snacking; Gardner et al., 2012).

2.2.3 | BE and purging

Participants indicated whether they had engaged in BE or purging since their last recording. Individuals who endorsed BE rated two follow-up questions about loss of control (e.g., "While you were eating, how much did you feel a sense of loss of control?") on a 5-point scale (1 = "not at all"; 5 = "a lot"). If a participant endorsed purging, they indicated the method(s) they used: (a) self-induced vomiting, (b) laxative abuse, (c) diuretic abuse. The total number of BE and purging episodes at each rating period were calculated and summed within-person to compute behavioral frequencies. Items assessing loss of control eating were averaged to create a composite score at each EMA signal. Composite scores were averaged within-person across all recordings during the EMA period to compute the total severity of loss of control eating.

2.2.4 | NA

The NA subscale of the Positive and Negative Affective Schedule (PANAS; Watson et al., 1988) was used to assess NA (10 items; $\omega = .90$). Items were rated on a 5-point scale (1 = "not at all"; 5 = "extremely"). This subscale has demonstrated good construct validity and high internal consistency (Crawford & Henry, 2004). Ratings for NA were summed to create a composite score for NA at each signal.

2.3 | Planned statistical analyses

Negative binomial regression and linear regression were used to investigate whether habitual control over BE and purging would be associated with more severe B/P symptoms. Negative binomial regression models examined habitual control over BE and habitual control over purging at baseline as predictors of BE and purging frequencies during the EMA period. Negative binomial regression was utilized to correct for overdispersion (Schaumberg et al., 2018). The linear regression model examined habitual control over BE at baseline as a predictor of loss of control eating severity during the EMA period.

Multilevel modeling (MLM) was used to investigate whether symptom duration and habitual control moderated within-person changes in NA surrounding BE and purging. MLM could accommodate a nested data structure and model subject-specific intercepts and slopes. MLM is robust to missing data and capable of handling unbalanced designs (Brown, 2021). Models were estimated with a first-order autoregressive correlation structure, using maximum likelihood estimation. To determine whether random slopes should be included in these models, likelihood ratio tests were conducted to test whether the inclusion of random slopes significantly improved model fit (Hesser, 2015). Random slopes were omitted if they did not improve model fit or if model parameters could not be estimated (e.g., due to a non-positive definite approximate variance–covariance matrix).

We investigated changes in NA surrounding BE and purging using two different analytical approaches (Berg et al., 2017). First, models were estimated to examine changes in NA from before to after BE and purging, using ratings most proximal to these behaviors, and explore the moderating effects of symptom duration and habitual control. To investigate changes in NA from pre-to post-BE and purging, MLM analyses tested whether NA during the first rating after the behavior (i.e., BE or purging) was different from NA during the last rating prior to the behavior. Reports of BE or purging that occurred within 1 h of a signaled response were considered present at that time point. If more than one behavior was reported in a single day, only ratings for the first behavior were used (Berg et al., 2013). Predictor

TABLE 2 Summary of multilevel models comparing negative affect before versus after binge eating.

Model 1				
Fixed effects	**Est.[a]**	***SE***	**95% CI**	***t* (*df*)**
Intercept	18.57	3.88	10.971, 26.166	4.79 (144)
Time	2.51	.86	.818, 4.205	2.91 (144)**
Variance components	Est.	*SD*	95% CI	
Within-person variance	31.59	5.62	4.999, 6.318	
Between-person intercept	45.92	6.78	5.142, 8.931	
Autocorrelation	−.03		−.206, .152	
Model 2				
Fixed effects	Est.[a]	*SE*	95% CI	*t* (*df*)
Intercept	18.76	4.22	10.622, 26.895	4.44 (139)
Time	2.30	1.01	.354, 4.244	2.28 (139)*
Habit	−.12	.45	−1.014, .770	−.27 (28)
BE duration	.19	.23	−.279, .655	.80 (28)
Habit × Time	.33	.29	−.231, .886	1.13 (139)
BE duration × Time	−.06	.14	−.326, .213	−.40 (139)
Habit × BE duration	−.02	.06	−.141, .092	−.42 (28)
BE duration × Habit × Time	.01	.03	−.049, .075	.39 (139)
Variance components	Est.	*SD*	95% CI	
Within-person variance	31.73	5.63	5.003, 6.342	
Between-person intercept	47.06	6.86	5.162, 9.116	
Autocorrelation	−.02		−.211, .169	

Note: Model 1 contains a random intercept and a fixed effect of time. Model 2 contains a random intercept and fixed effects of time, habitual control, binge eating duration (in years), and cross-level interactions between time, habitual control and binge eating duration. Models controlled for total number of completed EMA ratings. These effects are not depicted. Habitual control and binge eating duration variables were grand mean centered.
Abbreviations: time, before versus after binge eating; BE, binge eating; Est., estimate.
[a]Unstandardized beta coefficients.
*$p < .05$; **$p < .01$; ***$p < .001$.

variables included a time variable (pre-behavior = 0, post-behavior = 1), habitual control over BE, habitual control over purging, BE duration, purging duration, and Habit × Time × Symptom duration interactions. The outcome variable was momentary NA. Models were specified with a random intercept. Cohen's *d* was calculated as a measure of effect size for these analyses, with .2, .5, and .8 representing small, medium, and large effects, respectively (Cohen, 1988)

Next, multilevel models were estimated to examine within-person trajectories of NA in the hours before and after BE and purging. These models also tested symptom duration and habitual control as moderators of NA trajectories. Antecedent and consequent trajectories of NA were modeled separately for each behavior. If more than one behavior was reported in a day, ratings for the first behavior were used. Predictor variables included linear time components (hours before BE or purging, hours after BE or purging), habitual control over BE and habitual control over purging, BE duration, purging duration, and Habit × Time × Symptom duration interactions. Quadratic time components were also included. Time components were centered on the time at which BE or purging occurred. The linear effect indicated whether change in NA prior to or following BE or purging increased, decreased or remained flat. The quadratic effect represented the amount of acceleration or deceleration in the rate of change in NA prior to and following BE or purging. The model that examined changes in NA prior to BE was specified with a random slope. Random slopes were omitted from the remaining models. Effect size was estimated using a pseudo-R^2 value that represents the proportion of variance explained by the fixed and random effects (Shaw et al., 2023). All models controlled for the total number of completed EMA ratings.

3 | RESULTS

BMI and age were not predictors of any of the outcome variables; therefore, they were not controlled for in the final models. Approximately 41.3% ($n = 33$) of the sample endorsed a history of BE only and 58.8% ($n = 47$) endorsed BE and purging within the previous 3 months. Participants completed an average of 44.72 ± 24.25 ratings. They completed an average of 12 days of EMA ratings ($SD = 3.19$). Overall compliance with signal and interval-contingent ratings was 53%. Compliance was not associated with baseline study variables

TABLE 3 Summary of multilevel models comparing negative affect before versus after purging.

Model 1				
Fixed effects	**Est.[a]**	***SE***	**95% CI**	***t* (*df*)**
Intercept	22.22	6.31	9.865, 34.576	3.52 (76)
Time	2.32	1.02	.316, 4.329	2.27 (76)*
Variance components	Est.	*SD*	95% CI	
Within-person variance	41.55	6.45	5.260, 7.899	
Between-person intercept	37.39	6.11	3.789, 9.867	
Autocorrelation	.32		.019, .565	
Model 2				
Fixed effects	Est.[a]	*SE*	95% CI	*t* (*df*)
Intercept	15.42	7.71	.844, 29.988	2.00 (72)
Time	1.57	1.55	−1.361, 4.502	1.01 (72)
Habit	1.08	.89	−.824, 2.985	1.22 (9)
Purging duration	.50	.34	−.232, 1.225	1.46 (9)
Habit × Time	.57	.47	−.314, 1.454	1.22 (72)
Purging duration × Time	−.28	.19	−.640, .072	−1.51 (72)
Habit × Purging duration	−.09	.12	−.337, .163	−.75 (9)
Purging duration × Habit × Time	.05	.06	−.065, .161	.80 (72)
Variance components	Est.	*SD*	95% CI	
Within-person variance	36.65	6.05	4.800, 7.635	
Between-person intercept	25.03	5.00	2.814, 8.895	
Autocorrelation	.45		.172, .668	

Note: Model 1 contains a random intercept and a fixed effect of time. Model 2 contains a random intercept and fixed effects of time, habitual control, purging duration (in years), and cross-level interactions between time, habitual control, and purging duration. Models controlled for total number of completed EMA ratings. These effects are not depicted. Habitual control and purging duration variables were grand mean centered.

Abbreviations: Est., estimate; time, before versus after purging.

[a]Unstandardized beta coefficients.

*p < .05, **p < .01, ***p < .001.

(ps > .272). Participants reported an average of 6.84 BE episodes (SD = 6.70) and 4.37 purging episodes (SD = 7.05). BE duration was not associated with habitual control over BE, $r(73) = .20$, $p = .090$. Purging duration was not associated with habitual control over purging, $r(45) = -.10$, $p = .508$.

3.1 | Habitual control as a predictor of BE and purging

Baseline habitual control over BE was not a significant predictor of BE frequency during the EMA period ($B = .02$, $SE = .02$, $z = .67$, $df = 77$, $p = .504$, 95% CI [−.031, .063]). However, baseline habitual control over purging was a significant positive predictor of purging frequency during the EMA period ($B = .08$, $SE = .03$, $z = 2.55$, $df = 44$, Incidence Rate Ratio = 1.08, $p = .011$, 95% CI [.021, .138]). Baseline habitual control over BE was not a significant predictor of loss of control eating during the EMA period ($B = .05$, $SE = .03$, $t = 1.97$, $df = 74$, $p = .052$, 95% CI [<−.001, .100]).

3.2 | Habitual control and symptom duration as moderators of pre-to-post BE/purging change in NA

Results of the analyses investigating pre-to-post behavior changes in NA using only ratings most proximal to the behavior are presented in Tables 2 and 3. NA during the first rating following BE ($M = 20.20$, $SE = 1.42$) was significantly higher than NA during the last rating prior to BE ($M = 17.70$, $SE = 1.42$), suggesting that NA increased from before to after BE ($B = 2.51$, $SE = .86$, $p = .004$, 95% CI [.818, 4.205], Cohen's $d = .30$). The Habit × Time interaction was not significant ($B = .33$, $SE = .29$, $p = .261$, 95% CI [−.231, .886]). In addition, the BE duration × Habit × Time interaction was not significant ($B = .01$, $SE = .03$, $p = .696$, 95% CI [−.049, .075]).

NA during the first rating following purging ($M = 20.20$, $SE = 2.01$) was significantly higher than NA during the last rating prior to purging ($M = 17.90$, $SE = 2.01$), suggesting that NA increased from before to after purging ($B = 2.32$, $SE = 1.02$, $p = .026$, 95% CI [.316, 4.329], Cohen's $d = .30$). The Habit × Time interaction was not significant ($B = .57$, $SE = .47$, $p = .227$, 95% CI [−.314, 1.454]). The

TABLE 4 Summary of multilevel models examining temporal changes in negative affect relative to binge eating.

	Pre-binge								Post-binge							
	Model 1				Model 2				Model 3				Model 4			
	Est.[a]	*SE*	95% CI	*t* (*df*)	Est.[a]	*SE*	95% CI	*t* (*df*)	Est.[a]	*SE*	95% CI	*t* (*df*)	Est.[a]	*SE*	95% CI	*t* (*df*)
Fixed effects																
Intercept	24.13	2.46	19.310, 28.956	9.80 (556)	25.27	2.76	19.897, 30.638	9.14 (535)	20.77	2.22	16.420, 25.117	9.35 (688)	21.58	2.38	16.950, 26.211	9.07 (651)
Hours	1.58	.29	1.004, 2.146	5.40 (556)***	1.51	.34	.849, 2.172	4.44 (535)***	−.54	.15	−.829, −.252	−3.67 (688)***	−.67	.20	−1.046, −.285	−3.40 (651)**
Hours^2	.11	.03	.058, .165	4.09 (556)***	.11	.03	.041, .172	3.17 (535)**	.03	.01	.008, .060	2.53 (688)*	.04	.02	.002, .084	2.03 (651)*
Habit					.12	.36	−.595, .835	.33 (47)					−.22	.27	−.766, .321	−.81 (57)
BE duration					.15	.16	−.168, .458	.92 (47)					.10	.11	−.122, .315	.88 (57)
Habit × Hours					.07	.10	−.128, .271	.70 (535)					.04	.05	−.055, .144	.88 (651)
Habit × Hours^2					.01	.01	−.012, .027	.74 (535)					<−.01	.01	−.016, .007	−.81 (651)
Habit × BE duration					.04	.05	−.051, .137	.92 (47)					.03	.04	−.045, .095	.72 (57)
BE duration × Hours					−.02	.05	−.110, .065	−.50 (535)					−.03	.02	−.069, .016	−1.23 (651)
BE duration × Hours^2					<−.01	<.01	−.010, .007	−.26 (535)					<.01	<.01	−.003, .007	.69 (651)
BE duration × Habit × Hours					.01	.01	−.010, .037	1.10 (535)					.01	<.01	.001, .020	2.08 (651)*
BE duration × Habit × Hours^2					<.01	<.01	−.001, .003	.77 (535)					<−.01	<.01	−.002, <.001	−1.26 (651)
	Est.	*SD*	95% CI		Est.	*SD*	95% CI		Est.	*SD*	95% CI		Est.	*SD*	95% CI	
Variance components																
Within-person variance	24.94	4.99	4.658, 5.354		25.12	5.01	4.673, 5.376		37.57	6.13	5.747, 6.537		37.22	6.10	5.710, 6.518	
Between-person intercept	51.97	7.21	5.773, 9.003		50.26	7.09	5.625, 8.936		44.63	6.68	5.459, 8.175		42.83	6.54	5.300, 8.081	
Autocorrelation	.19		.085, .295		.19		.079, .292		.34		.256, .419		.34		.256, .423	

Note: Model 1 contains a random intercept and random effects of time. Model 2 contains a random intercept, random effects of time, and fixed effects of habitual control, binge eating duration (in years), and cross-level interactions between time, habitual control, and binge eating duration. Model 3 contains a random intercept and fixed effects of time. Model 4 contains a random intercept and fixed effects of time, habitual control, binge eating duration (in years), and cross-level interactions between time, habitual control, and binge eating duration. Models controlled for total number of completed EMA ratings. These effects are not depicted. Habitual control and binge eating duration variables were grand mean centered.

Abbreviations: BE, binge eating; Est., estimate; Hours, linear effects; Hours^2, quadratic effects.

[a]Unstandardized beta coefficients.

*p < .05.**p < .01.***p < .001.

TABLE 5 Summary of multilevel models examining temporal changes in negative affect relative to purging.

	Pre-purge								Post-purge							
	Model 1				Model 2				Model 3				Model 4			
	Est.[a]	*SE*	95% CI	*t* (*df*)	Est.[a]	*SE*	95% CI	*t* (*df*)	Est.[a]	*SE*	95% CI	*t* (*df*)	Est.[a]	*SE*	95% CI	*t* (*df*)
Fixed effects																
Intercept	25.56	4.45	16.852, 34.265	5.74 (280)	26.23	3.95	18.605, 33.847	6.63 (274)	18.79	3.50	11.937, 25.642	5.37 (480)	19.73	3.75	12.461, 26.997	5.27 (467)
Hours	.70	.18	.345, 1.063	3.84 (280)***	.69	.23	.254, 1.123	3.05 (274)**	−.49	.18	−.846, −.125	−2.64 (480)*	−.42	.19	−.801, −.046	−2.17 (467)*
Hours^2	.02	.01	−.010, .047	1.27 (280)	.01	.02	−.025, .050	.64 (274)	.03	.02	−.002, .066	1.82 (480)	.03	.02	−.007, .065	1.56 (467)
Habit					1.00	.36	.269, 1.735	2.77 (23)*					.54	.33	−.135,1.213	1.62 (28)
Purging duration					.02	.18	−.339, .370	.09 (23)					.02	.20	−.387, .418	.08 (28)
Habit × Hours					.01	.08	−.137, .154	.12 (274)					−.03	.05	−.127, .075	−.50 (467)
Habit × Hours^2					<.01	.01	−.012, .015	.21 (274)					<−.01	.01	−.011, .010	−.03 (467)
Habit × Purging duration					.06	.05	−.041, .161	1.20 (23)					−.03	.06	−.144, .093	−.44 (28)
Purging duration × Hours					.03	.03	−.025, .093	1.11 (274)					<.01	.03	−.051, .060	.15 (467)
Purging duration × Hours^2					<.01	<.01	−.001, .009	1.46 (274)					<−.01	<.01	−.007, .004	−.51 (467)
Purging duration × Habit × Hours					−.01	.01	−.028, .012	−.75 (274)					<.01	.01	−.017, .019	.12 (467)
Purging duration × Habit × Hours^2					<−.01	<.01	−.003, <.001	−1.46 (274)					<.01	<.01	−.001, .003	.56 (467)
	Est.	*SD*	95% CI		Est.	*SD*	95% CI		Est.	*SD*	95% CI		Est.	*SD*	95% CI	
Variance components																
Within-person variance	29.26	5.41	4.942, 5.921		28.53	5.34	4.881, 5.845		35.66	5.97	5.506, 6.476		34.75	5.89	5.429, 6.400	
Between-person intercept	56.16	7.49	5.530, 10.154		40.43	6.36	4.645, 8.704		50.36	7.10	5.446, 9.247		48.02	6.93	5.279, 9.098	
Autocorrelation	.18		.047, .316		.18		.035, .311		.41		.313, .497		.41		.317, .503	

Note: Model 1 contains a random intercept and fixed effects of time. Model 2 contains a random intercept and fixed effects of time, habitual control, purging duration (in years), and cross-level interactions between time, habitual control, and purging duration. Model 3 contains a random intercept and fixed effects of time. Model 4 contains a random intercept and fixed effects of time, habitual control, purging duration (in years), and cross-level interactions between time, habitual control, and purging duration. Models controlled for total number of completed EMA ratings. These effects are not depicted. Habitual control and purging duration variables were grand mean centered.

Abbreviations: Est., estimate; Hours, linear effects; Hours^2, quadratic effects.

[a]Unstandardized beta coefficients.

*p < .05.**p < .01.***p < .001.

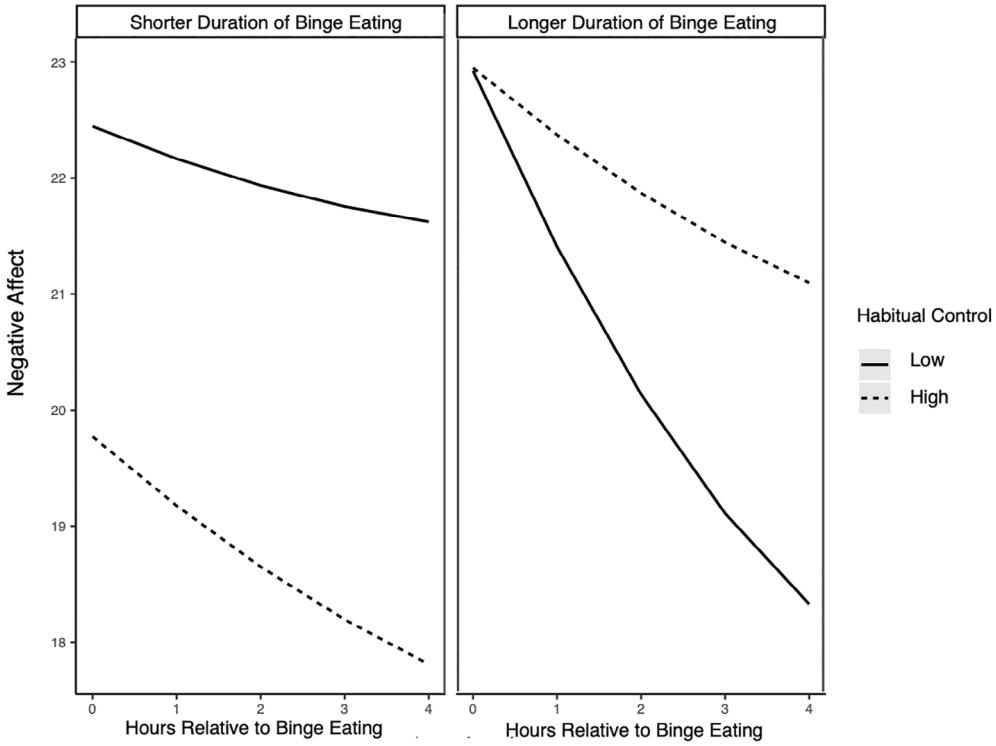

FIGURE 1 Three-way interaction among binge eating duration, habitual control and change in negative affect following binge eating. High and low values reflect 1 *SD* above and below the mean, respectively.

Purging duration × Habit × Time interaction was also not significant ($B = .05$, $SE = .06$, $p = .427$, 95% CI [−.065, .161]).

3.3 | Habitual control and symptom duration as moderators of trajectories of NA before and after BE and purging

Results of the analyses investigating trajectories of NA prior to and following BE and purging are presented in Tables 4 and 5. The models investigating BE indicated that NA increased in a linear manner over time prior to BE ($B = 1.58$, $SE = .29$, $p < .001$, 95% CI [1.004, 2.146]) and the rate of change in NA accelerated in the hours closest to the BE episode ($B = .11$, $SE = .03$, $p < .001$, 95% CI [.058, .165], pseudo-$R^2 = .63$). Habitual control over BE did not interact with the linear ($B = .07$, $SE = .10$, $p = .484$, 95% CI [−.128, .271]) or quadratic components ($B = .01$, $SE = .01$, $p = .459$, 95% CI [−.012, .027]). In addition, the three-way interactions between BE duration, habitual control, and linear ($B = .01$, $SE = .01$, $p = .271$, 95% CI [−.010, .037]) and quadratic ($B = <.01$, $SE = <.01$, $p = .444$, 95% CI [−.001, .003]) components were not significant. Following BE, NA decreased in a linear manner ($B = -.54$, $SE = .15$, $p < .001$, 95% CI [−.829, −.252]), and the decline in NA accelerated over time ($B = .03$, $SE = .01$, $p = .012$, 95% CI [.008, .060], pseudo-$R^2 = .55$). Habitual control did not interact with linear ($B = .04$, $SE = .05$, $p = .381$, 95% CI [−.055, .144]) or quadratic components ($B = <-.01$, $SE = .01$, $p = .420$, 95% CI [−.016, .007]). The three-way interaction between BE duration, habitual control and the linear component was significant ($B = .01$, $SE = <.01$, $p = .038$, 95% CI [.001, .020], pseudo-$R^2 = .57$; Figure 1). Follow-up analyses indicated that habitual control moderated changes in NA following BE when there was a longer duration of BE (1 *SD* above the mean duration). Individuals with a longer duration of BE and greater habitual control over this behavior, exhibited a less pronounced reduction in NA following BE, relative to individuals with a longer duration of BE and less habitual control over this behavior.

NA increased in a linear manner over time prior to purging ($B = .70$, $SE = .18$, $p < .001$, 95% CI [.345, 1.063], pseudo-$R^2 = .67$). Habitual control over purging did not interact with the linear ($B = .01$, $SE = .08$, $p = .908$, 95% CI [−.137, .154]) or quadratic components ($B = <.01$, $SE = .01$, $p = .836$, 95% CI [−.012, .015]). The three-way interactions between purging duration, habitual control, and linear ($B = -.01$, $SE = .01$, $p = .452$, 95% CI [−.028, .012]) and quadratic components ($B = <-.01$, $SE = <.01$, $p = .145$, 95% CI [−.003, <.001]) were not significant. Following purging, NA decreased in a linear manner ($B = -.49$, $SE = .18$, $p = .009$, 95% CI [−.846, −.125], pseudo-$R^2 = .59$). Habitual control over purging did not interact with the linear ($B = -.03$, $SE = .05$, $p = .617$, 95% CI [−.127, .075]) or quadratic components ($B = <-.01$, $SE = .01$, $p = .977$, 95% CI [−.011, .010]). The three-way interactions between purging duration, habitual control, and linear ($B = <.01$, $SE = .01$, $p = .908$, 95% CI [−.017, .019]) and quadratic ($B = <.01$, $SE = <.01$, $p = .573$, 95% CI [−.001, .003]) components were not significant.

4 | DISCUSSION

This study aimed to investigate whether habit perpetuates BE and purging and to determine whether negative reinforcement of BE

and purging via reductions in NA is less influential in perpetuating these behaviors if they are habitual. As hypothesized, habitual control over purging was associated with more frequent purging. However, habitual control over BE was not related to BE frequency or loss of control eating severity. Contrary to the hypothesis, habitual control did not moderate changes in NA surrounding BE and purging. However, exploratory analyses revealed that individuals with a longer duration of BE and greater habitual control over this behavior, exhibited a less pronounced reduction in NA following BE. Overall, the findings support the idea that purging is maintained through habit. They also support the possibility that reinforcement via a reduction in NA is less influential in maintaining BE that is habitual and persistent.

Habitual control over purging was associated with more frequent purging, which aligns with research reporting a link between habit and AN (Coniglio et al., 2017; Davis et al., 2020). Purging that is habitual may occur more frequently due to repeated encounters with contextual triggers. Habitual control was not associated with BE frequency or loss of control eating severity, which may suggest that habit is less influential in maintaining BE.

In terms of changes in NA surrounding BE and purging, post-behavior ratings of NA were higher than pre-behavior ratings. In addition, NA increased over time prior to BE and purging and decreased over time following these behaviors. Results of the trajectory and comparison analyses may appear contradictory, but, in actuality, they provide different information. Collectively, they suggest that NA may increase prior to BE and purging, peak after these behaviors occur, and then gradually decline, which partially supports the assumption of affect regulation models that these behaviors are maintained by reductions in NA (Heatherton & Baumeister, 1991). Notably, NA ratings in the analyses that compared changes in NA from before to after BE and purging may not have immediately preceded or immediately followed these behaviors, given that participants did not provide exact times at which they occurred. Thus, the results suggesting that NA increased following BE and purging should be interpreted with caution. It is also possible that NA decreased *during* BE and purging episodes, as changes in NA during episodes were not captured in the present study. Future research should assess changes in NA during BE and purging to determine if similar findings emerge.

Individuals with a longer duration of BE and greater habitual control over BE experienced a less pronounced reduction in NA following BE. Although these findings are preliminary, they provide support for the idea that NA plays a less prominent role in maintaining BE that is habitual and persistent. With repetition, BE may transition from goal-directed to habitual, and become less emotionally reinforcing. Indeed, there is evidence of reduced reward responsivity among individuals with more enduring patterns of BE (Yu et al., 2022). Notably, duration of BE was not associated with habit strength of BE; thus, BE may not always become more habitual over time. Future research should attempt to clarify other factors that may be involved in promoting habitual control over BE (e.g., stress exposure; Schwabe & Wolf, 2010). Studies should also investigate other factors that may impact relations between NA and BE and purging (e.g., temperamental characteristics).

This study has several limitations. Changes in NA were assessed before and after BE and purging which provides an incomplete picture of the role of reinforcement in maintaining these behaviors. Additionally, only the role of negative emotional reinforcement was considered. There are other psychological and biological factors (e.g., dopamine stimulation) that may maintain BE and purging through reinforcement that would be useful to investigate (Bello & Hajnal, 2010). A self-report measure was used to assess habitual control. Future research should utilize more rigorous methods to assess this construct (e.g., a response time task). Compliance with EMA procedures was modest. Lastly, the sample was comprised of women who were predominantly non-Hispanic White. Given the high prevalence of eating disorders in racial/ethnic and gender minority groups (Cheng et al., 2019; Parker & Harriger, 2020), it is important to determine whether the findings would generalize to these individuals.

5 | CONCLUSION

Findings from this study suggest that habit may underlie the persistence of purging. Additional research is needed to understand the role of negative reinforcement in maintaining habitual BE and purging. Research should continue to investigate the role of habit and NA in perpetuating BE and purging to further clarify the behavioral processes underlying the persistence of these symptoms.

AUTHOR CONTRIBUTIONS

Elizabeth Dougherty: Conceptualization; methodology; writing – original draft; writing – review and editing. **Jennifer E Wildes:** Writing – review and editing. **Alissa A. Haedt-Matt:** Supervision; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data and code are available from the first author upon request.

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