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The Role of Affect in the Maintenance of Anorexia Nervosa: Evidence from a Naturalistic Assessment of Momentary Behaviors and Emotion

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Abstract

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The current study examines the relationship of affect and eating disorder behavior in anorexia nervosa (AN) using ecological momentary assessment. Participants were 118 adult females recruited at three sites from eating disorder treatment centers and community advertisements. All participants met full DSM-IV criteria or sub-threshold criteria for AN. Participants were provided handheld computers and asked to report positive affect, negative affect, loss of control (LOC) eating, purging, exercise, drinking fluids to curb appetite, and weighing one's self multiple times per day as well as dietary restriction once daily over a two-week interval. Mixed-effects models were used to examine the extent to which affective states predict dietary restriction. Additionally, we used two analytic approaches to compare affect prior to and after other eating disorder behaviors. We found that higher daily ratings of negative affect were associated with a greater likelihood of dietary restriction on subsequent days. When examining the single rating immediately before and after behaviors, we found that negative affect increased significantly following LOC eating, purging, the combination of LOC and eating/purging, and weighing of one's self. Using this same analytic approach we also found negative affect to decrease significantly following the consumption of fluids to curb appetite and exercise. When examining the covariation of AN behaviors and negative affect assessed multiple times in the hours and minutes before the behaviors, we found negative affect significantly increased prior to LOC eating, purging, the combination of LOC eating/and purging, and weighing behavior. Negative affect also significantly decreased following the occurrence of these behaviors. These findings are consistent with the idea that that negative affect is potentially a critical maintenance mechanism of some AN symptoms, but that the analytic approach used to examine affect and behavior may have significant implications on the interpretation of findings.

Keywords

anorexia nervosa; ecological momentary assessment (EMA); negative affect; positive affect; restriction

Most conceptual models of eating disorders currently invoke emotional states as a key causal variable in the etiology and maintenance of symptoms. For example, over two decades ago Heatherton and Baumeister (1991) proposed a model of bulimia nervosa (BN) suggesting that patients with BN engaged in binge eating and purging behaviors in an effort to escape negative emotional experiences. Since that time other models have also focused on the role that negative emotional states serve as causal antecedents to bulimic behavior (e.g., Safer, Telch, & Agras, 2001; Wonderlich et al., 2008). Other evidence in support of the importance of negative emotion in eating disorders is the high rate of co-occurring mood disorders, particularly major depression, and anxiety disorders among individuals with eating disorders (Grucza, Przybeck, & Cloninger, 2007; Hudson Hiripi, Pope, & Kessler, 2007; Kaye, Bulik, Thornton, Barbarich, & Master, 2004; Wonderlich & Mitchell, 1997). Lastly, negative affect appears to be a prospective risk factor for the development of disordered eating behavior (Stice, 2002).

Consistent with early theories of the functional nature of eating disordered behaviors in relation to aversive emotional experiences (e.g., escape theory; Heatherton & Baumeister, 1991), research on the role of emotion in eating disorders has traditionally focused on BN

and binge eating disorder. Conceptually, this focus on these particular forms of psychopathology seems logical given that these two disorders are defined, in part, by discrete behaviors (i.e., binge eating and purging) that have been viewed as being inherently associated with negative affect (e.g., guilt following an eating binge; fear of weight gain as a motivation for purging). In our work with individuals with BN we found that negative affect significantly increases prior to a binge or purge episode and that following these behaviors, negative affect decreases significantly over time (Smyth et al., 2007).

Recent theoretical work in individuals with anorexia nervosa (AN) has focused on the important role of emotion in relation to the behaviors that maintain the disorder. Haynos and Fruzzetti (2011), for example, have proposed a comprehensive, transactional model of emotion dysregulation in AN that emphasizes emotion vulnerability and dysregulation, behavioral dysregulation (e.g., disordered eating behaviors), and invalidating environmental responses. Specifically, the model posits the presence of an underlying temperamental disturbance in emotional processing that produces elevated emotional arousal and associated emotion dysregulation. Eating disorder behaviors are conceptualized as resulting from this dysregulation and associated starvation/weight-loss. Other models (e.g., Wildes et al., 2010) have also proposed a functional relationship between emotion and AN behaviors. These theoretical models are further supported by empirical findings suggesting that individuals with AN display elevated emotion regulation difficulties (e.g., Brockmeyer et al., 2012 ; Harrison, Sullivan, Tchanturia, & Treasure, 2010) and a reduced ability to tolerate distress (Hambrook et al., 2011). Taken together, evidence from the recent theoretical and empirical literature provides support for the utility of examining emotion-related factors in AN. Further elaboration of the role of emotional factors in AN will be useful both in clarifying the etiology and maintenance of the disorder, as well as identifying potentially important mechanisms to target in treatment.

One useful method for examining emotions, particularly momentary emotional states, is ecological momentary assessment (EMA; Stone & Shiffman, 1994). EMA is a means of gathering momentary data from participants in their natural environment, typically through the use of small, hand-held digital devices. A key strength of EMA is that it helps circumvent many of the limitations and biases (e.g., lack of ability to determine temporal order, simple forgetting, artificiality of environment associated with laboratory settings) associated with most of the research designs that have been employed in eating disorder research (e.g., cross sectional and long-term longitudinal studies; Smyth et al., 2007). Our research group has previously presented momentary data from individuals with BN (e.g., Smyth et al., 2007), binge eating disorder (e.g., Engel et al., 2009), and night eating syndrome (e.g., Boseck et al., 2007).

Of particular relevance to the current paper was a small pilot study using EMA methodology in a sample of ten female participants who met criteria for DSM-IV AN (none of these data are included in the current manuscript). The study was primarily done for the purposes of assessing the feasibility of EMA research in AN and showed that AN participants had excellent compliance (greater than 90% of signaled recordings were completed), experienced no significant adverse events associated with the study, and generally rated their experiences in the study as very positive. Additionally, participants reported considerable

between participant and within participant (both within day as well as between day) variability on both positive and negative affect. Most importantly, this study demonstrated the feasibility of using EMA methodology in individuals with AN.

The primary purpose of this study is to investigate the possible role of emotional states in the maintenance of AN symptoms and behaviors. More specifically, we sought to determine the role of positive and negative affect as precipitants and consequences of dietary restriction, LOC eating, purging, exercising, and weighing one's self. We hypothesized that negative affective states would predict restrictive eating behaviors in AN. We also hypothesized that, consistent with our findings in BN (Smyth et al., 2007), negative emotional states would rise before AN behaviors and decrease significantly after the occurrence of these behaviors. Additionally, positive emotional states would show the opposite pattern: they would decrease prior to AN behaviors and increase significantly after these behaviors. We also anticipated that different AN behaviors would have different functional relationships with momentary affective states and that behaviors involving LOC eating would be associated with greater levels of negative affect than those behaviors that did not include LOC eating.

Method

Participants

A total of 118 female participants who met *Diagnostic and Statistical Manual of Mental Disorders* (4th Edition: *DSM-IV*; American Psychiatric Association, 1994) criteria for anorexia nervosa (AN; restricting or binge-purge type) or sub-threshold AN (defined below) were included in the current study. A total of 601 potential participants were originally phone screened for eligibility. Of those, 166 (27.6%) were further evaluated for eligibility at one of three participating research facilities. Participants were eligible to participate if they were at least 18 years of age, female, met DSM-IV criteria for AN or met criteria for subthreshold AN. Subthreshold AN criteria for the study were defined as meeting all of the DSM-IV criteria for AN except: (1) body mass index between 17.5 and 18.5, or (2) absence of amenorrhea or an absence of the cognitive features of AN. Based on these criteria, 121 (20.1% of the originally screened sample) participants met eligibility for the study, agreed to participate, and were enrolled. Three participants had EMA compliance rates of less than 50% and their data were not included in the final analyses, resulting in a total of 118 participants. Exactly half (n=59) met DSM-IV criteria for full threshold AN and half were entered into the study meeting criteria for subthreshold AN. We recently demonstrated that the full and subthreshold AN participants in this sample did not differ significantly on a large number of baseline measures of eating disorder pathology, personality variables, and comorbid psychology (le Grange et al., 2012).

Measures for the current study were administered as part of a larger battery of self-report assessments. First, participants were thoroughly evaluated with diagnostic interviews. Second, participants completed questionnaire assessments on palmtop computers as part of the EMA protocol. Interview and EMA measures are described below.

Structured Interviews

Structured Clinical Interview for DSM-IV Axis I Disorders, Patient Edition (SCID-I/P)—

The SCID-I/P (First, Spitzer, Gibbon, & Williams, 1995) is a semi-structured interview to assess DSM-IV Axis I psychiatric disorders. The SCID-I/P was used to determine DSM-IV diagnostic criteria for AN and subthreshold AN. Also, the SCID-I/P was conducted to determine current and lifetime criteria for other Axis I disorders. SCID-I/P interviews were recorded and an independent assessor rated current eating disorder diagnoses in a random sample of 25% (n = 30) of these interviews. Inter-rater reliability for current AN diagnosis (full vs. subthreshold) was excellent based upon a kappa coefficient = .929.

Eating Disorders Examination (EDE)—

The EDE (Cooper & Fairburn, 1987) served as the primary measure of eating disorder pathology. The EDE contains four subscales (restraint, eating concerns, shape concerns and weight concerns) as well as frequency measures of binge eating and compensatory behaviors. The validity and reliability of the EDE have been well-documented (Fairburn, 2008; Fairburn & Cooper, 1993). EDE interviews were recorded and 25% (n = 31) were rated by a second independent assessor. Intraclass correlations coefficients representing agreement between raters on the EDE scales ranged from .894 (shape concerns) to .997 (restraint). Although the Eating Concern alpha was slightly lower (α=.634), the other subscales and total score of the EDE met a minimum bar of .70 as adequate (Kline, 1999): Shape Concern α=.855; Weight Concern α=.762; Restraint α=.739; Global α=.912.

Daily Diary Methodology – EMA Measures

Positive and Negative Affect Schedule (PANAS)—

An abbreviated version of the PANAS (Watson, Clark & Tellegen, 1988) that is appropriate for EMA applications was used to assess momentary positive and negative affect. Items were chosen on the basis of high factor loadings and clinical/theoretical relevance to the study of AN. The items included eight negative affect (NA) items (nervous, disgusted, distressed, ashamed, angry at self, afraid, sad, and dissatisfied with self) and eight positive affect (PA) items (strong, enthusiastic, proud, attentive, happy, energetic, confident, and cheerful). Participants rated their current emotional state for each of these items on a 5-point scale ranging from (1) *not at all* to (5) *extremely*. Alpha coefficients for positive affect were .920 and for negative affect were .943 in the current study.

Eating disorder-related behaviors—

Participants were asked to report specific eating disorder behaviors including binge eating, vomiting or laxative use for weight control, weighing one's self on a scale, exercising, skipping a meal, drinking fluids to curb appetite, making sure thighs do not touch, and checking joints and bones for fat. Participants were also asked to report all eating episodes and to indicate whether the episode was a snack, a meal, or a binge. They also indicated whether they felt out of control or driven to eat. Participants were trained in standard definitions of eating events by clinical research staff during the EMA training session. The definition provided to participants for an unusually large amount of food was “an amount of food that most people would consider excessive,” and examples that were tailored to the participants' eating habits were provided. LOC was

defined as “the inability to stop eating,” and feeling driven to eat was defined as “the inability to prevent the eating episode.”

The EMA measure of binge eating was defined as a participant endorsing the “binge” option regarding their eating episode. This could be indicated either during the current rating or during a random signal recording (described below) in which the participant indicated that they had binge ate since their last signal. Because reporting a binge eating episode this way may indicate either an objective or subjective binge episode (Fairburn, 2008), we will refer to this behavior as LOC eating hereafter. Purging was defined as the participant endorsing either “I vomited” or “I used laxatives for weight control”. Exercise was indicated when a participant endorsed “I exercised” and weighing one's self was similarly reported when a participant endorsed “I weighed myself”. Finally, caloric restriction was recorded at the end of a recording day when the participant endorsed either “I went for eight waking hours without eating” or “I limited daily intake to less than 1200 calories”. We have noted elsewhere that many of the EMA constructs mentioned above converge reasonably well with EDE measurement of similar constructs (Crosby et al., 2012), which supports the validity of the EDE recordings.

Procedure

Participants were recruited at three sites (Fargo, ND; Minneapolis, MN; Chicago, IL) from eating disorder treatment facilities, mailings to eating disorder treatment professionals, on-line postings, advertisements in community and campus newspapers, and flyers posted in clinical, community and campus settings. Institutional review board approval for the study was obtained at each site. Potential participants were initially phone screened and participants who had a high likelihood of qualifying for the study attended an informational meeting where they received further information regarding the study and provided written informed consent. Participants were then scheduled for two assessment visits during which a physical examination screening and laboratory tests were conducted to ensure medical stability. Participants also completed self-report questionnaires and structured interviews during this visit.

Participants were trained on how to use the palmtop computers at the end of first assessment. During one of these initial assessment visits, a trained research staff member met with participants to discuss the goals of the study, what to expect during participation, and how to deal with any questions that might arise from the signaling of the palmtop computer. Participants were instructed not to complete entries at any times when they felt unable to reply or if safety was a concern (e.g., when driving), but instead delay responding until a later, more convenient time. Participants carried the palmtop computer for 2 practice days. After these practice days, participants returned to the research center and provided the data recorded during their practice period, but these data were not used in analyses. This practice period was used to help ensure participants were familiar with the protocol and to minimize reactivity to the recording procedures (although past literature suggests little evidence of reactivity; e.g., Stein & Corte, 2003). These practice data were reviewed by a research assistant and participants were given feedback regarding their compliance rates and any questions were answered. Participants were next given the palmtop computer to

complete EMA recordings over the following two weeks. To maintain contact with the participants, minimize the loss of data, and proactively address any potential problem with the hardware (e.g., a broken or lost palmtop computer) attempts were made to schedule 2-3 visits for each participant during this two week interval to obtain recorded data. Participants were given feedback at each visit regarding their compliance rates. Participants completed a study evaluation questionnaire at the end of the study and were compensated $100 per week for completing assessments. Additionally, they were given a $50 bonus for a compliance rate of at least 80% responding within 45 minutes to random signals.

The EMA schedule in the current study was identical to that used in our previous EMA study of BN (Smyth et al., 2007). This approach implements the three types of daily self-report methods described by Wheeler and Reis (1991): signal-contingent, event-contingent, and interval-contingent recordings. *Signal-contingent* protocols require individuals to report on experiences at various times throughout the day in response to a signal. In the current study, participants were signaled at six semi-random times throughout the day to complete recordings of emotional state, stressful events and behaviors. Signal times were determined by randomly selecting times around “anchor points” that subdivided the day into six approximately equal blocks of time: 8:30 a.m., 11:10 a.m., 1:50 p.m., 4:30 p.m., 7:10 p.m., and 9:50 p.m. The signal times were randomly distributed around these anchor times in a normal distribution with a standard deviation of 30 minutes to provide assessments evenly across the waking hours of the day. When signaled, participants were asked to rate their current emotional state, any stressful events, and to report any recent behaviors that occurred after the last signal but that they had not yet recorded. Using an *event-contingent* schedule, participants were also asked to record any eating episodes or AN behaviors including exercise, laxative use for weight control, skipping meals, drinking fluids to curb appetite, purging, and LOC eating (examples of each were listed on a card attached to the palmtop computer) at the time of occurrence. Finally, using an *interval-contingent* schedule, participants were asked to complete ratings at the end of each day. Interval contingent recordings included items assessing emotion, dietary restriction, and an estimate of caloric intake for that day.

Interview-based assessments were conducted by masters and doctoral level assessors. In this protocol, assessors were trained in the administration of structured interviews at the beginning of the study by one of the coauthors (CBP) via a training seminar, which included didactic sessions that involved role-playing exercises and audiotape reviews. In addition, SCID-I/P training utilized videotapes developed by the authors of the SCID-I/P. To ensure consistency and prevent drift, assessors from all sites communicated regularly using teleconferencing and e-mail. Further, they also met in person at least once each year for advanced training and audiotape reviews. All participants were asked to have their assessments audiotaped (approximately 10% declined) and 20% of the audiotapes were randomly selected to be rated by an independent assessor to determine inter-rater reliability, both at each site and across sites.

Statistical Analyses

Past research examining the temporal association between affect and eating disorder behaviors has commonly made use of two different analytic approaches. One approach is to examine the proximal affect ratings immediately before and after the behavior of interest (e.g., Haedt-Matt & Keel, 2011). Another approach is to examine all data before and after a behavior in an attempt to show the trajectory of affect as it changes over time in relation to the occurrence of an eating disorder behavior (e.g., Smyth et al., 2007). Given the inconsistency in findings across these methods, we include both approaches below.

To compare proximal affect ratings before and after eating disorder behaviors, we used a mixed-effects model with a random intercept to compare positive and negative affect ratings obtained immediately before and after LOC eating, purging, LOC eating+purging, exercise, weighing behavior, and drinking fluids to curb one's appetite. To examine the trajectory of affect as it changed over time in relation to eating disorder behaviors, linear, quadratic and cubic components were estimated separately for pre-behavior and post-behavior portions of each trajectory curve. A common intercept was estimated for the pre-behavior and post-behavior portions of the graph so that the affect line is continuous; if separate intercepts were estimated for the pre-behavior and post-behavior portions of the graph, the graph could appear to show a precipitous rise or fall in affect immediately at the time of the behavior, although there would likely be very few actual affect recordings immediately surrounding the behavior to support such a rise or drop. The linear component of the curve indicates whether the initial slope of the line immediately before (for the-pre behavior portion of the curve) or after (for the post-behavior curve) is increasing, decreasing or flat; the quadratic component of the curve indicates whether the initial slope (from the linear component) deflects downward or upward; the cubic component indicates whether the initial deflection (from the quadratic component) intensifies (if the same sign as the quadratic component) or diminishes (if the opposite sign from the quadratic component).

Although compliance in the current study was good, we examined whether our findings may be biased by missing data. Participants were signaled 11,799 times during the course of the study. Of these signals, 9,085 were responded to in sufficient time to deem them “compliant responses”. This resulted in a compliance rate of 77% and 2,714 recordings which were “missing”. We examined whether EMA compliance rates were associated with 56 different baseline demographic and clinical characteristics, finding significant relationships with only three (DAPP Stimulus Seeking, Frost Organization, age). These results suggest that EMA compliance rates are only marginally associated with baseline characteristics in the current sample.

Dietary restriction—Generalized estimating equation (GEE; Zeger & Liang, 1992) models with a logit response function were used to assess the relationship between dietary restriction and affect. Momentary negative affect ratings across an entire day (not aggregated) were used to predict whether dietary restriction occurred on the subsequent day, after controlling for dietary restriction on day one[1]. Additionally, the last negative affect

[1]Because binge, purge, and binge-purge episodes are discrete events, analyses related to them were conducted using momentary data. Because restriction is not a discrete event, analyses related to it were limited to daily-level analyses.

rating of the day was used to predict restriction on the following day. Mixed-effects linear models were used to compare affect on the day after dietary restriction versus non-restriction days.

Momentary analyses—To examine the temporal relationship between affect and anorexia related behavior, the pre- and post-behavior trajectories of negative affect and positive affect were modeled prior to and after the time at which the behavior occurred (i.e., time centered on behavior). The approach used for these analyses was to include "all available data" from the three forms of EMA assessment (i.e., event-, behavior-, and signal-contingent). When more than one behavior was reported in a single day, only the first behavior of the day was used to avoid confounding the relationship between antecedent and consequent emotion ratings in relation to the multiple behaviors that occurred throughout any one day (Smyth et al., 2007). Mixed-effects linear models included a random intercept, fixed effects for the linear (hours), quadratic (hours-squared) and cubic (hours-cubed) time before/after the behavior, as well as interactions between those time components and a dummy-coded variable representing pre- vs. post-behavior. Behavior type (e.g., LOC eating-only, purge-only, LOC eating+purge) was added to the model both as a main effect and interactions with other effects in the model, allowing the determination of separate pre- and post-behavior trajectories for each behavior.

Results

Demographic Characteristics

One hundred eighteen participants were included in this study. The ages of the participants ranged from 18 to 58 years with a mean of 25.3 (SD = 8.4). Mean body mass index in the sample was 17.2 kg/m^2 (SD = 1.0; Range = 13.4–18.5). Participants were predominantly Caucasian (96.6%), single (75.4%), and the majority (90.7%) had at least some college education.

EMA Measurements

The 118 participants included in this study provided 14,945 separate EMA recordings representing 1768 separate participant days. These recordings included 9085 responses to signals, 3383 reports of eating episodes, 999 reports of AN behaviors, and 1478 end-of-day recordings. Compliance rates to signals (defined as responding to signals within 45 minutes) averaged 87% across participants (range = 58-100%); 77% of all signals were responded to within 45 minutes. Compliance with end-of-day ratings averaged 89% (range = 24-100%).

Of the 1768 total days, 551 (31.2%) were reported as dietary restriction days, defined as either not eating for eight continuous hours or consuming less than 1200 kcals for the day. Dietary restriction days were reported by 69.5% of the sample. Participants reported an average of 2.5 LOC eating episodes (*SD*=4.9; range = 0-30) and 4.8 purging episodes (*SD*=9.1; range = 0-4) over the two-week interval. LOC eating episodes were reported by 42.4% of the participants and purging episodes were reported by 44.9% of the sample. At least one LOC eating episode was indicated on 17% of the days and at least one purging episode on 20.1% of the days. Simultaneously reported LOC eating/purging episodes

occurred on 8.3 % of the days. Participants reported weighing themselves an average of 4.98 (*SD*=7.17) times during the EMA period, 62.7% of the sample reported at least one instance of weighing themselves, and weighing one's self was reported on 25.3% of the total days included in the study. Participants reported drinking fluids to curb their appetite an average of 10.42 (*SD*=12.34) times during the EMA measurement window, 79.7% of the sample reported at least one instance of this behavior, and it was reported on 38.5% of days. Finally, exercising was reported an average of 6.28 (*SD*=7.89) times during the EMA period, 72.0% of the sample reported exercising at least once, and exercise was reported on 30.7% of the days included in the study.

Dietary Restriction

All analyses in this section controlled for day one levels of the outcome variable on the prior day.

Negative affect—A comparison between days with versus without dietary restriction revealed that momentary negative affect on the day after dietary restriction was not significantly different (p=0.392) than momentary negative affect after non-restriction days. However, higher momentary negative affect on a given day was associated with greater likelihood of restriction on the following day (estimate =.022, *OR*=1.022, p=.008). Likewise, higher negative affect on the last rating of a given day was associated with greater likelihood of restriction on the following day (estimate =.023, *OR*=1.023, p=.011).

Positive affect—A comparison between days with versus without dietary restriction revealed that momentary positive affect on the day after dietary restriction was not significantly different (p=.241) than momentary positive affect after non-restriction days. However, higher momentary positive affect on a given day was associated with lower likelihood of restriction on the following day (estimate =-.023, *OR*=0.98, p=.034). Likewise, higher positive affect on the last rating of a given day was associated with lower likelihood of restriction on the following day (estimate =-.032, *OR*=0.97, p=.007).

Comparison of Proximal Affect Rating Before and After Eating Disorder Behavior

Negative affect—On the last affect rating prior to LOC eating participants' negative affect averaged 21.83 (SE=1.20) and significantly increased to an average of 27.25 (SE=1.21) on the first affect rating following LOC eating (p<.001). Participants' negative affect averaged 21.79 (SE=1.02) on the last affect rating prior to engaging in an episode of purging and increased to 23.35 (SE=1.03; p=.007) on the first affect rating following the behavior. Prior to engaging in both LOC eating and purging (reported simultaneously), participants negative affect averaged 21.59 (SE=1.10) on the last affect rating prior to the behaviors, while after these behaviors their negative affect had significantly increased to an average of 25.69 (SE=1.11; p=<.001) on the first affect rating following the behaviors. For exercise, negative affect significantly decreased from immediately before the behavior (*M*=18.83, SE=0.88) to immediately after (*M*=17.91, SE=0.87, p=.004). Regarding weighing one's self negative affect significantly increased from an average of 18.0 (SE=0.91) on the last affect rating before reporting of weighing to an average of 19.56 (SE=0.87) on the first affect rating immediately after (p=.001). Finally, negative affect significantly decreased from

immediately before a participant reported drinking fluids to curb her appetite (*M*=18.48, SE=0.78) to immediately after she engaged in this behavior (*M*=17.87, SE=0.77, *p*=.036).

Positive affect—Prior to LOC eating participants' positive affect averaged 18.27 (SE=0.87) on the last affect rating prior to the behavior and significantly decreased to an average of 14.25 (SE=0.87) on the first affect rating following LOC eating (*p*<.001). Participants' positive affect averaged 17.45 (SE=0.69) on the last affect rating prior to engaging in an episode of purging and decreased to 15.71 (SE=0.71; *p*<.001) on the first affect rating following the behavior. Prior to engaging in both LOC eating and purging (reported simultaneously), participants' last negative affect rating averaged 17.36 (SE=0.78), while after these behaviors their negative affect had significantly decreased to an average of 15.05 (SE=0.80) on the first reported rating following the behavior (*p*=.001). For exercise, positive affect significantly increased from immediately before this behavior (*M*=19.15, SE=0.64) to immediately after (*M*=20.91, SE=0.64, *p*<.001). However, positive affect did not significantly change from immediately before reporting of weighing one's self to immediately after (*p*=.143). Finally, positive affect significantly increased from immediately before a participant reported drinking fluids to curb her appetite (*M*=18.28, SE=0.57) to immediately after she engaged in this behavior (*M*=18.95, SE=0.55, *p*=.013).

Trajectory Analysis

Results of the multilevel regression models of eating disorder behaviors for negative and positive affect, which will be described below, can be seen in Tables 1 and 2.

Negative affect—As can be seen in Figure 1A, the general pattern of negative affect showed a considerable rise before the occurrence of an eating disorder behavior and a drop after each of the eating disorder behaviors. More specifically, antecedent negative affect for combined LOC eating+purge episodes showed a significant linear (estimate = 2.58, *SE* = 0.37, *p* < .001), quadratic (estimate=0.31, *SE*=0.08, *p*<.001), and cubic (estimate=0.01, *SE*=0.004, *p*=.004) association. Based on the model, at the time of a LOC eating+purge behavior, the level of negative affect was 24.81 (*SE* = 1.02). Immediately after the occurrence of a LOC eating+purge episode, negative affect decreased significantly in a linear fashion (estimate=-3.67, *SE* = 0.67, *p* < .001). Comparatively, negative affect for LOC eating only behaviors did not differ from LOC eating+purge behaviors (the reference group) in the trajectory preceding the behavior (*p's* > 60), at the moment of the behavior (*p*=.54), or in trajectory following the behavior (*p's* > .35). However, when comparing LOC eating +purge behaviors (again, the reference group) to purge only behaviors, a significantly different pattern was observed. Negative affect preceding the purge only behaviors increased significantly less rapidly in both the linear (estimate = -1.54, *SE* =0.43, *p*<.001) and quadratic (estimate=-.21, *SE* = 0.09, *p* = .015) functions when compared to LOC eating +purge behaviors. Also, purge only behaviors were associated with significantly less negative affect at the time of the behavior than the negative affect reported during LOC eating+purge behaviors (estimate =-1.94, *SE*=.59). Finally, negative affect following the purge only behavior decreased less rapidly than for the LOC eating+purge behaviors (estimate=1.89, *SE*=0.76, *p*=.013). For exercise, there was no significant linear change in negative affect before (*p*>.05) or after (*p*>.05) this behavior. Before weighing behavior

negative affect showed a significant linear rise (*estimate=0.223, SE=0.065, p=.001*), but no significant drop after weighing behavior (*p's*>.05). Finally, no significant changes in negative affect were found prior to or following drinking fluids to curb one's appetite (*p's*>.15).

Positive affect—Consistent with the pattern seen in negative affect, positive affect generally decreased up to the time of eating disorder behaviors and increased following such behaviors (see Figure 1B). However, prior to a LOC eating+purge behavior, positive affect significantly decreased in both linear (estimate=-1.55, *SE*=0.32, *p*<.001) and quadratic (estimate = -0.17, *SE*=0.07, *p*=.012) functions. Based on the model, at the moment of a LOC eating+purge episode, the level of positive affect was 15.31 (*SE*=0.78). Following LOC eating+purge episodes positive affect significantly increased in a linear fashion (estimate=1.95, *SE*=0.58, *p*=.001). No differences in the pattern of positive affect were seen when comparing purge only and binge only behaviors to LOC eating+purge behaviors. This was true for positive affect preceding the behavior (*p's*>.40), the level of positive affect at the time of the behavior (*p's*>.90), and positive affect following the behavior (*p's*>.55). Prior to exercise antecedent positive affect increased significantly in a linear (estimate=0.119, *SE*=0.046, *p*<.010) and cubic (estimate=-0.001, *SE*=0.0003, *p*=.003) manner, and positive affect after the occurrence of exercise decreased significantly in a linear (estimate=-0.283, *SE*=0.072, *p*<.001), quadratic (estimate=-0.008; SE=0.004, p=.05) and cubic (estimate=0.001, *SE*=0.0004, *p*=.004) manner. While no significant changes in positive affect were found prior to or following weighing behavior (*p's*>.16), positive affect did increase after weighing behavior in a linear (estimate=0.272, SE=0.076, p<.001) and quadratic (estimate=-0.012, SE=0.005, p=.016) manner. Finally, antecedent positive affect increased significantly before drinking fluids to curb one's appetite in a linear (estimate=0.44, *SE*=0.20, *p*=.025) and quadratic (estimate=0.085, *SE*=0.041, *p*=.039) manner as well as a cubic trend (estimate=0.004, *SE*=0.002, *p*=.054) manner, and positive affect after the occurrence of exercise decrease significantly in linear (estimate=-1.02, *SE*=0.30, *p*=.001) and cubic (estimate=-0.01, *SE*=0.003, *p*=.007).

Discussion

The main objective of this study was to examine the relationship of affect and eating disorder behavior in AN. Using an EMA design, data on affective and behavioral experiences was collected in a momentary fashion in the natural environment. Such a design allowed for a more precise examination of the nature and temporal order characterizing the association between affective experiences and AN behaviors. Specifically, antecedent and consequent levels of positive and negative affect were examined in reference to the occurrence of several important AN behaviors including LOC eating, purging, exercising, and weighing. EMA data was also used to assess associations between affective states and daily dietary restriction.

We found that increased negative affect on one day predicted a greater likelihood of dietary restriction on the subsequent day. Importantly, the reciprocal relationship was not found: restriction on one day did not predict increased negative affect on the following day. This finding is important as it demonstrates both temporal precedence of negative affect and a

significant association, both between negative affect and restriction, which are necessary factors in determining causation. This finding is in contrast to the findings of Moreno-Dominguez and colleagues (2012), who studied a sample of individuals with BN. In that study, both participants with BN and healthy control participants reported increased food cravings when in a calorically restricted state. The participants with BN, and not the healthy control participants, however, reported improved emotional states when they restricted food intake. These findings and the results of the current study suggest that decrements in negative affect may serve as a trigger for periods of dietary restriction in individuals with both BN and AN.

In our efforts to examine the momentary relationship between affect and AN behaviors, we used two different analytic approaches. When examining momentary behaviors using a single assessment of affect immediately preceding and following behaviors, the findings were generally consistent with a recent meta-analysis by Haedt-Matt and Keel (2011). Specifically, we found that negative affect significantly increased following the occurrence of LOC eating, purging, simultaneously reported LOC eating/purging, and weighing one's self. However, we also found that negative affect significantly decreased following momentary reports of exercise and drinking fluids to curb appetite. These findings suggest that while some eating disorder behaviors in women with AN are associated with increasing negative affect immediately after behaviors, other eating disorder behaviors have the opposite effect.

We can only speculate as to why exercise and drinking fluids to curb one's appetite decrease negative affect while the other behaviors result in more subsequent negative affect in close proximity to the behavior. It may be that individuals with AN view fluid consumption positively as a means of facilitating caloric restriction, and exercise may be seen as a means of further reducing one's weight. Engaging in LOC eating, purging, LOC eating+purging, and weighing one's self may all produce one particularly relevant facet of negative affect: guilt. Guilt has been shown to be an important component of negative affect in BN (Berg et al., 2013), which may help to explain the increased negative affect reported in our AN participants soon after they engaged in these behaviors.

In addition to the analysis of affect represented by single data points preceding and following eating disorder behavior, we also conducted analyses investigating the trajectories of affect in the hours before and after AN behaviors. This analytic technique, which we have used before (e.g., Smyth et al., 2007; Muehlenkamp et al., 2009), makes use of multiple momentary assessments of affect both prior to and after the reporting of AN behaviors. This analytic approach produced a notably different pattern of results. The trajectory analysis revealed a significant increase in negative affect in the hours before LOC eating, purging, LOC eating+purging, and weighing one's self. Importantly, negative affect displayed a trajectory characterized by a significant decrease following the occurrence of LOC eating, purging, and simultaneously reported LOC eating and purging. In contrast, negative affect did not significantly change following weighing behavior and did not have any significant association with exercise or drinking fluids to curb appetite. These findings suggest that increases in negative affect may trigger LOC eating, purging, LOC eating+purging, and

weighing behavior. Further, engaging in these behaviors (with the exception of weighing) appears to result in a subsequent reduction of negative affect.

It is interesting to note the differences in findings and conclusions that logically follow from the results of the two different analytic approaches used to examine the data. Both approaches are justifiable and indeed, there is precedence for the use of each approach in the eating disorder literature (e.g., Haedt-Matt & Keel, 2011; Smyth et al., 2007). Further study is needed to better understand the strengths and weaknesses of each approach, as well as to determine in which cases the findings from each approach may best apply.

The current findings have implications for the treatment of AN, particularly given that emotion has recently become a more substantive focus in the treatment of AN. For example, Corstorphine (2006) has outlined a treatment of AN (and other eating disorders) called Cognitive-Emotional-Behavioural Therapy, which places emotion in a central role of treatment and "is aimed at enabling patients with eating disorders to understand the experience and expression of emotions, so that they can identify and challenge their beliefs and attend and respond to their emotions adaptively" (p. 451). Also, Wildes and colleagues (2010) have proposed a treatment model of AN called Emotion Acceptance Behavior Therapy. This new psychotherapy, which focuses on enhancing emotional awareness and decreasing emotional avoidance, has been conducted with a small number of AN patients, and preliminary results are quite promising (Wildes & Marcus, 2011). Importantly, these psychotherapy models and treatments for AN are conceptualized as fundamentally momentary in nature and include interventions designed to help patients learn to be more aware of and to respond more appropriately to negative affective states in the moment when they occur. In striking contrast, nearly all of the data supporting these treatment models are either cross-sectional or rely on relatively long-term longitudinal studies in which the window between assessments typically ranges from many months to years. As has been noted previously, many psychological treatments rely on momentary associations between clinical targets (e.g., affect and binge behavior), but test the conceptual model underlying the treatment with designs that fail to assess these relationships in a momentary manner. The present findings, therefore, may be particularly relevant to treatment development (Wonderlich et al., 2010). In particular, findings in the current study supporting the role of negative affect as a significant antecedent for numerous AN behavior provides support for treatment models that address methods of responding to negative affect as a trigger for eating disorder behaviors. Also, the possible evidence suggesting a decreasing trajectory of negative affect subsequent to certain AN behaviors may suggest the utility of techniques focused on reducing functional emotion-behavior associations.

There are several strengths of the current study that are worth noting. This study utilized well validated, psychometrically supported assessment measures with a relatively large sample individuals with full or subthreshold AN. Another considerable strength of this study is that the momentary nature of the data minimize the possibility that retrospective recall bias influenced the participants' ratings of affect and AN symptoms (e.g., "I binge ate, so I must have felt upset"). Because the antecedent affect ratings were collected before the behaviors occurred, the temporal order of behaviors and emotional states can be examined without the confound of retrospective recall biases. However, there were also limitations to

the current investigation. It is worth noting that although EMA data are collected in the moment, they are nonetheless subject to some of the biases and problems inherent to information that is obtained via self-report (Stone & Shiffman, 1994). Another important limitation of EMA is that only a small portion of the data collected occurs in the moments immediately before and/or after the behaviors of interest. It may in fact be the few seconds surrounding AN behaviors that are most informative about the interplay between the behavior and emotional states. However, we are unaware of any assessment method, including EMA, that can adequately tap these very brief windows of time without causing significant reactivity and substantially reducing ecological validity. Another limitation of the current paper has to do with precipitants of negative affect. In the current study we have shown that one precipitant of AN behaviors is negative affect. However, the question of what precipitates negative affect in individuals with AN is not addressed in the present study. Could cognitive variables such as anticipating that one's eating will be out of control result in negative affect, which subsequently results in binge eating? Might interpersonal conflict be a more common precipitant of the negative affect that subsequently predicts AN behaviors? To more fully understand the precipitants of AN behaviors, these and other questions regarding the behavioral, cognitive, or social precipitants of negative affect may be worthy of further study. Finally, it is worth mentioning that even though participants diagnosed with the restricting subtype reported both LOC eating and purging behaviors, they did so less frequently than participants diagnosed with the AN-binge-purge subtype. As such, the analyses conducted on behaviors relevant to the subtype distinction (LOC eating, purging, LOC eating/purging) may be more applicable to participants with the AN-binge-purge subtype versus the AN-restricting subtype.

In summary, the current study supports theoretically important relationships between momentary emotional states and AN behaviors. The nature of these associations, including their temporal order, is conceptually important for developing and refining maintenance models of AN, as well for improving the treatment of AN. The presence of high negative affect prior to AN behaviors was generally consistent across results from the two primary analytic approaches employed in this study and consistent with findings regarding antecedent negative affect reported in the the meta-analysis by Haedt-Matt & Keel (2011). Findings from this study regarding negative affect consequent to AN behaviors, however, were dependent upon the analytic approach implemented. It would appear that the timeframe utilized to examine emotion and behavior (i.e., hours following behavior vs. immediately after behavior) and unit of analysis (i.e., trajectory vs. level) significantly impact findings and should be considered in future studies. Thus, the current findings support the role of negative affect as an antecedent to numerous eating disorder behaviors in AN, whereas further study is needed to clarify the nature of negative affective experiences following eating disorder behavior, as well as to better understand which of the two analytical approaches used in this study (or possibly an alternative approach) is most appropriate and valid for characterizing the nature of the association between affect and AN behaviors.

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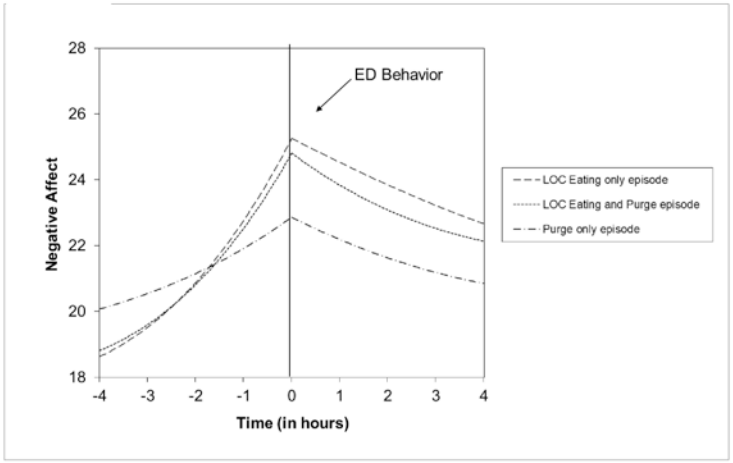


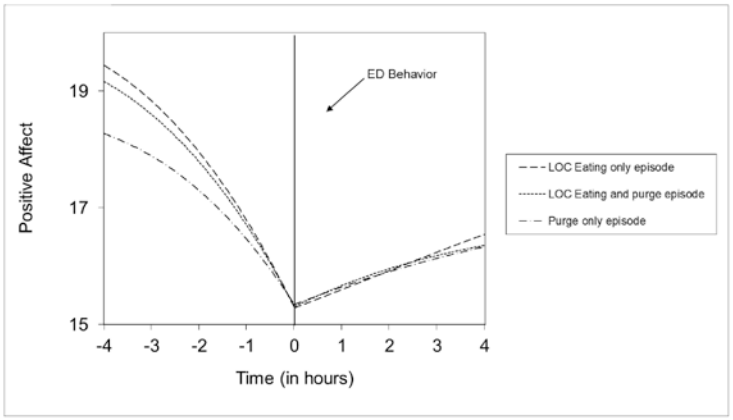
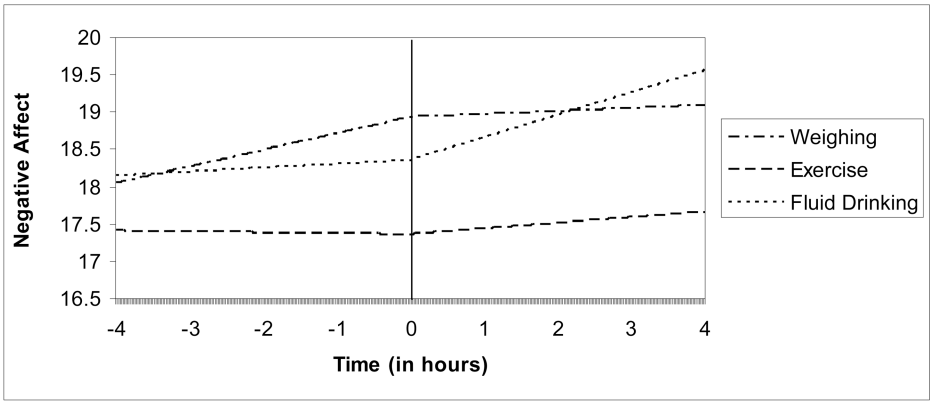


Figure 1.

Temporal Association between Affect and LOC Eating and Purging Behaviors. The figure shows the momentary levels and trajectories of affect associated with LOC eating only, purge only, and LOC eating and purge behaviors.



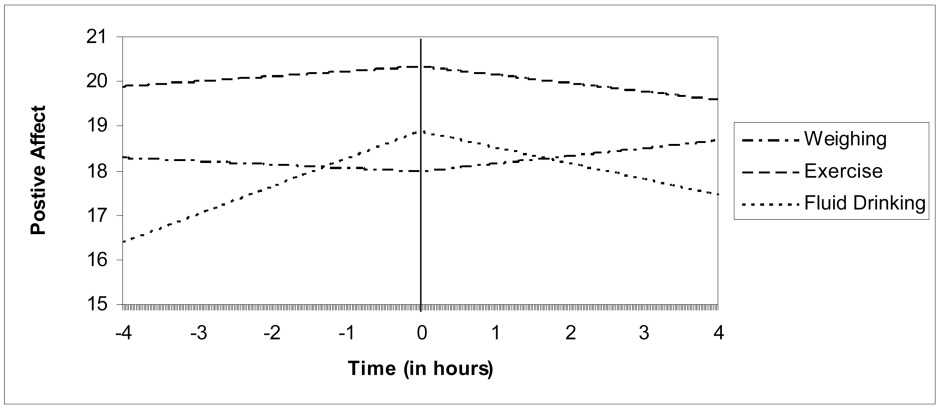


Figure 2.

Temporal Association between Affect and Weighing, Exercise, and Fluid Drinking Behaviors. The figure shows the momentary levels and trajectories of affect associated with weighing one's self, exercising, and drinking fluids to curb appetite.

Table 1

Multilevel Models for Binge, Purge, and Binge/Purge Episodes.

	Negative Affect				Positive Affect			
Variable	**Estimate**	**S.E.**	**P**	**CI**	**Estimate**	**S.E.**	**P**	**CI**
Intercept	24.808	1.023	**<0.001**	22.778,26.838	15.308	0.781	**<0.001**	13.760,16.857
Binge-only	0.446	0.728	0.540	-0.982,1.875	-0.024	0.633	0.969	-1.266,1.217
Purge-only	-1.944	0.587	**0.001**	-3.096,-0.792	0.034	0.511	0.946	-1.681,0.922
Hours to behavior	2.582	0.369	**<0.001**	1.858,3.306	-1.551	0.322	**<0.001**	-2.183,-0.918
(Hours to behavior)^2	0.314	0.075	**<0.001**	0.167,0.462	-0.165	0.065	**0.012**	-0.294,0.036
(Hours prior behavior)^3	0.011	0.004	**0.004**	0.003,0.019	-0.004	0.003	0.183	-0.011,0.002
(Hours to behavior)*Pre/Post	-3.671	0.668	**<0.001**	-4.980,-2.363	1.948	0.582	**0.001**	0.806,3.091
(Hours to behavior)^2*Pre/Post	-0.194	0.118	0.101	-0.426,0.038	0.127	0.103	0.219	-0.075,0.329
(Hours to behavior)^3*Pre/Post	-0.015	0.007	0.031	-0.029,-0.001	0.006	0.006	0.131	-0.007,0.018
(Hours to behavior)*Binge-only	0.227	0.489	0.642	-0.731,1.185	-0.114	0.426	0.790	-0.951,0.723
(Hours to behavior)^2*Binge-only	0.018	0.095	0.848	-0.169,0.206	-0.010	0.083	0.907	-0.174,0.154
(Hours to behavior)^3*Binge-only	0.0001	0.005	0.970	-0.009,0.009	-0.0001	0.004	0.978	-0.008,0.008
(Hours to behavior)*Binge-only*Pre/Post	0.123	0.874	0.887	-1.590,1.837	0.025	0.763	0.974	-1.471,1.521
(Hours to behavior)^2*Binge-only*Pre/Post	-0.128	0.144	0.373	-0.410,0.154	0.058	0.125	0.644	-0.188,0.304
(Hours to behavior)^3*Binge-only*Pre/Post	0.007	0.008	0.435	-0.010,0.023	-0.003	0.007	0.633	-0.018,0.011
(Hours to behavior)*Purge-only	-1.536	0.434	**<0.001**	-2.387,-0.686	0.287	0.379	0.448	-0.455,1.030
(Hours to behavior)^2*Purge-only	-0.211	0.086	**0.015**	-0.381,-0.041	0.01	0.076	0.894	-0.138,0.159
(Hours to behavior)^3*Purge-only	-0.007	0.004	0.103	-0.016,0.001	-0.001	0.004	0.756	-0.009,0.006
(Hours to behavior)*Purge-only*Pre/Post	1.885	0.756	**0.013**	0.403,3.368	-0.365	0.660	0.580	-1.660,0.929
(Hours to behavior)^2*Purge-only*Pre/Post	0.153	0.129	0.237	-0.100,0.406	0.01	0.112	0.925	-.210,0.231
(Hours to behavior)^3*Purge-only*Pre/Post	0.010	0.007	0.181	-0.004,0.025	<0.0001	0.007	0.998	-0.013,0.013

Note: Binge-purge is the reference group for behavior episode contrasts.

Table 2

Multilevel Models for Exercise, Weighing, and Fluid Drinking

Behavior	Variable	Negative Affect				Positive Affect			
		Estimate	S.E.	Significance	95% CI	Estimate	S.E.	Significance	95% CI
Exercise	Intercept	17.360	0.798	**<0.001**	15.773,18.946	20.329	0.616	**<0.001**	19.104,21.555
	Hours to behavior	-0.017	0.046	0.708	-0.108,0.073	0.119	0.046	**0.010**	0.029,0.209
	(Hours to behavior)^2	0.002	0.002	0.385	-0.003,0.007	-0.002	0.002	0.446	-0.006,0.003
	(Hours prior behavior)^3	0.001	0.001	0.087	-0.0001,0.001	-0.001	0.0003	**0.003**	-0.001,-0.0003
	(Hours to behavior)*Pre/Post	0.090	0.068	0.189	-0.044, 0.224	-0.283	0.072	**<0.001**	-0.425,-0.141
	(Hours to behavior)^2*Pre/Post	-0.001	0.004	0.784	-0.008,0.006	-0.008	0.004	**0.05**	-0.015,-0.0003
	(Hours to behavior)^3*Pre/Post	-0.0003	0.001	0.465	-0.001,0.001	0.001	0.0004	**0.004**	0.0004,0.002
Weighing	Intercept	18.932	0.873	**<0.001**	17.193,20.671	17.975	0.652	**<0.001**	16.675,19.275
	Hours to behavior	0.223	0.065	**0.001**	0.093,0.352	-0.077	0.057	0.178	-0.190,0.035
	(Hours to behavior)^2	0.0002	0.003	0.921	-0.005,0.005	0.001	0.002	0.809	-0.004,0.005
	(Hours prior behavior)^3	-0.0001	0.0003	0.693	-0.001,0.001	-0.0004	0.0003	0.164	-0.001,0.0002
	(Hours to behavior)*Pre/Post	-0.167	0.087	0.056	-0.338,0.004	0.272	0.076	**<0.001**	0.123,0.422
	(Hours to behavior)^2*Pre/Post	-0.008	0.006	0.155	-0.019,0.003	-0.012	0.005	**0.016**	-0.022,-0.002
	(Hours to behavior)^3*Pre/Post	0.0005	0.0005	0.328	-0.0005,0.001	-0.0003	0.0004	0.512	-0.001,0.0006
Fluid Drinking	Intercept	18.354	1.396	<0.001	12.246,24.462	18.877	1.560	**<0.001**	15.819,21.935
	Hours to behavior	0.088	0.265	0.740	-0.432,0.608	0.442	0.197	**0.025**	0.056,0.829
	(Hours to behavior)^2	-0.015	0.055	0.785	-0.123,0.093	0.085	0.041	**0.039**	0.004,0.165
	(Hours prior behavior)^3	-0.002	0.003	0.405	-0.008,0.003	0.004	0.002	0.054	0.0001,0.008
	(Hours to behavior)*Pre/Post	0.425	0.407	0.296	-0.373,1.224	-1.022	0.303	**0.001**	-1.615,-0.428
	(Hours to behavior)^2*Pre/Post	-0.088	0.064	0.168	-0.214,0.037	0.020	0.048	0.667	-0.113,0.073
	(Hours to behavior)^3*Pre/Post	0.009	0.004	**0.012**	0.002,0.017	-0.007	0.003	**0.007**	-0.013,-0.002