Trajectory of Eating Disorder Symptom Change in an Online Sample of Patients Receiving Treatment in the Community

By

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Abstract

The best available eating-disorder (ED) treatments work for only about half of patients. Poor treatment outcomes exist, in part, because clinicians have limited information about how ED symptoms change, on average, during treatment. Without information about average rate of change, clinicians do not have data that can signal when clients are at risk for a poor outcome. The purpose of the current study was to identify typical patterns of change for ED symptoms in patients with EDs and to test how individual differences (e.g., age, illness duration, gender, and ED diagnosis) contribute to the rate of ED symptom reduction. A secondary aim was to test whether change in ED behaviors predicted change in ED cognitions or vice versa. Participants (87.2% female*;* N = 5,685) were Recovery Record users who completed the Eating Pathology Symptoms Inventory (EPSI) once per month for three months. Results from latent growth curve models indicated that, on average, ED psychopathology significantly declined over three months. Bivariate latent change score analyses indicated that ED behaviors and cognitions changed simultaneously and mutually predicted change in one another. This study was one of the largest studies, to date, to assess change patterns in a treatment-seeking sample of people with EDs. Information about the expected rate and direction of change is useful in clinical settings because it helps therapists better identify individuals who are at risk for slow treatment progress and intensify their ongoing treatment to avoid poor end-of-treatment outcomes.

Keywords: symptom trajectory, treatment, eating disorders

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Introduction

Individuals with eating disorders experience difficulties in several life domains above-and-beyond maladaptive eating. For example, eating disorders are serious by virtue of associated medical complications (Meczekalski, Podfigurna-Stopa, & Katulski, 2013; Westmoreland, Krantz, & Mehler, 2016), psychological comorbidities, and psychiatric impairment (Grilo, White, & Masheb, 2009; Hudson, Hiripi, Pope, & Kessler, 2007). Despite the serious consequences of eating disorders, less than 50% of individuals with an eating disorder receive treatment (Hudson et al., 2007). Even when treatment is sought, eating disorders tend to be chronic and difficult to change (Cooper et al., 2016; Hudson et al., 2007; Keel & Brown, 2010). To improve the treatment of eating disorders, it is necessary to understand the longitudinal trajectory of eating-disorder symptom change in routine treatment settings, as well as how individual differences can influence the trajectory of eating-disorder symptoms. The aim of the current study was to explore how eating-disorder symptoms change longitudinally over the course of treatment.

Eating Disorder Symptoms Diagnostic Criteria

Symptoms of eating disorders include maladaptive eating behaviors, as well as distorted cognitions and perceptions related to shape and weight. The *Diagnostic and Statistical Manual of Mental Disorders- Fifth Edition (DSM-5*; American Psychological Association, 2013) lists the criteria for three primary eating disorders, including: anorexia nervosa, bulimia nervosa, and binge eating disorder (see **Table 1**). Individuals with anorexia nervosa engage in a variety of

behaviors to maintain a significantly low body weight (e.g., self-starvation, excessive exercise, and purging). Despite their low weight, individuals with anorexia nervosa endorse a fear of gaining weight and have distorted perceptions of their body weight and shape. Bulimia nervosa is characterized by recurrent objective binge eating episodes and inappropriate compensatory behaviors (see **Table 1**) at a normal body weight. Individuals with anorexia nervosa and bulimia nervosa base much of their self-worth on their body shape and weight. Binge eating disorder is characterized by objective binge eating episodes in the absence of inappropriate compensatory behaviors. Binge eating disorder is associated with several cognitive symptoms, such as marked distress and feeling "depressed, disgusted, or very guilty" after overeating (p. 350; American Psychological Association, 2013). Finally, clinically significant eating disorders that do not meet criteria for one of these three primary diagnoses are categorized within 'other specified' feeding or eating disorders (OSFED). For example, an individual who has a normal body weight and repeatedly self-induces vomiting after eating a small- or normal-sized amount of food could not meet criteria for any of the three previously described eating disorder diagnoses, but would certainly warrant an eating disorder diagnosis (e.g., OSFED).

Treatment Approaches

Guidelines published by the National Institute for Health and Care Excellence (NICE) and the American Psychiatric Association (APA) (National Collaborating Centre for Mental Health, 2017; Yager et al., 2006) describe a range of psychotherapeutic approaches that can be used to treat eating disorders; these approaches differ in how much emphasis is placed on changing behaviors versus (vs.) cognitions. Some eating-disorder therapies take an indirect approach to changing eating-disorder-related behaviors and cognitions. For example, interpersonal psychotherapy (IPT) focuses on identifying and addressing interpersonal problems

associated with the onset of the eating disorder (Kass, Patmore, & Wilfley, 2015; Murphy, Straebler, Basden, Cooper, & Fairburn, 2012). Other treatment approaches directly target disordered-eating behaviors. For example, behavioral management for anorexia nervosa focuses on increasing body weight through the establishment of normal, consistent eating patterns (Attia & Walsh, 2009; Lock & Le Grange, 2013). Likewise, Family-Based Therapy for adolescents with anorexia nervosa focuses first on establishing normal eating habits that lead to weight gain, while later incorporating techniques to improve self-identity once the adolescent has reached 90% of his or her ideal body weight (Lock & Le Grange, 2013). Behavioral management for binge eating disorder focuses on reducing the total amount of calories consumed per day (de Zwaan et al., 2005; Raymond, de Zwaan, Mitchell, Ackard, & Thuras, 2002; Telch & Agras, 1993). Finally, rather than focusing solely on behavior, Fairburn's Enhanced Cognitive-Behavior Therapy for eating disorders (CBT-E) (Fairburn, Cooper, & Shafran, 2008) aims to reduce both eating-disorder behaviors and cognitions. CBT-E is based on a trans-diagnostic model that is designed to treat any type of clinically significant eating disorder, regardless of the patient's specific constellation of symptoms or the frequency with which they engage in disordered-eating behavior(s). Within the CBT-E model, problematic eating behaviors are directly targeted in the early stages of therapy and dysfunctional cognitions are addressed after the first month of therapy (i.e., after regular eating patterns have been established). For adults with eating disorders, NICE (National Collaborating Centre for Mental Health, 2017) recommends in-person CBT as the first-line treatment approach for anorexia nervosa, whereas in-person CBT approaches are recommended for binge eating disorder and bulimia nervosa after guided self-help programs have been attempted. For children and adolescents with anorexia nervosa or

bulimia nervosa, NICE (National Collaborating Centre for Mental Health., 2017) suggests family-based treatment as the treatment-of-choice, followed by CBT.

Treatment Outcomes

Research has shown that changes in eating-disorder behaviors are associated with improved treatment outcomes. For example, weight restoration in anorexia nervosa is correlated with increased diet variety, greater caloric density, and eating more frequently during the day (De Young et al., 2014; Doyle, Le Grange, Loeb, Doyle, & Crosby, 2010; Elran-Barak et al., 2015; Forman et al., 2014). CBT-E and IPT for bulimia nervosa are associated with significant reductions in inappropriate compensatory behaviors and binge eating at long-term follow-up (Agras, Walsh, Fairburn, Wilson, & Kraemer, 2000; C. G. Fairburn et al., 2015). A reduction in one eating-disorder behavior is typically correlated with reductions in other eating-disorder behaviors. For example, reductions in dietary restraint are correlated with reductions in binge eating (Elran-Barak et al., 2015; Mason, Heron, Braitman, & Lewis, 2016). Similarly, reduced frequency of purging predicts future abstinence from other bulimic behaviors post-treatment (Agras, Crow, et al., 2000; Thompson-Brenner, Shingleton, Sauer-Zavala, Richards, & Pratt, 2015). Finally, a recent literature review of behavioral weight-loss treatment trials for binge eating disorder showed that increased dietary restraint prospectively led to decreased binge eating at the end-of-treatment (da Luz et al., 2015).

Taken together, behavioral management and CBT-E for anorexia nervosa, bulimia nervosa, and binge eating disorder result in reductions in eating-disorder *behavior* across treatment settings and modalities. It is unclear, however, how reductions in maladaptive thinking patterns (*cognition*) affect treatment outcome. Eating-disorder cognitions are typically assessed via self-report items from the Eating Disorder Examination-Questionnaire (EDE-Q; Fairburn &

Beglin, 2008) and the Eating Disorder Inventory-3 (EDI-3; Garner, 2004). The EDE-Q has four subscale scores which reflect eating-disorder severity in Restraint, Eating Concern, Shape Concern, and Weight Concern. Each EDE-Q subscale contains items that assess both eating-disorder behaviors *and* cognitions. For example, the EDE-Q Eating Concern Subscale contains items that measure behavior (e.g., eating in secret) *and* cognition (e.g., feeling concerned that other people could see one eating). The EDI-3 contains three eating-disorder-related scales (Drive for Thinness, Bulimia, and Body Dissatisfaction). The EDI-3 subscales also combine items on behaviors and cognitions. For example, the Bulimia Subscale contains items that measure behavior (e.g., stuffing oneself with food) *and* cognition (e.g., worry about eating too much).

Baseline EDE-Q and EDI-3 scores predicted treatment outcomes at follow-up and post-treatment across eating-disorder diagnoses (Cooper et al., 2016; Dingemans, Spinhoven, & van Furth, 2007; Grilo, Masheb, & Crosby, 2012a; Hilbert et al., 2007; Le Grange et al., 2008; Wilson, Wilfley, Agras, & Bryson, 2010). Rapid reductions in EDE-Q scores (i.e., a significant decrease in EDE-Q scores within the first four weeks of treatment) were associated with full-remission status and a shorter number of therapy sessions (Raykos, Watson, Fursland, Byrne, & Nathan, 2013). However, because the EDE-Q and EDI-3 are comprised of items that assess both eating-disorder behaviors and cognitions, it is not possible to parse out how changes in eating-disorder behaviors vs. cognitions relate to treatment outcome. Like 'the chicken or the egg" question, it is unknown whether changes in eating-disorder behavior predict changes in eating-disorder cognition or vice versa. To fully understand the associations between reductions in maladaptive eating-related-thoughts and treatment outcome, a different assessment tool that does not conflate eating-disorder behaviors and cognitions would need to be used.

Individual Differences and Treatment Outcomes

Past research suggests that anorexia nervosa is associated with worse treatment outcome and prognosis compared to bulimia nervosa and binge eating disorder (Keel & Brown, 2010; Lowe et al., 2001). However, eating-disorder diagnoses were unrelated to treatment outcomes when outcomes were defined as: 1) reliable change, 2) a 50% reduction in baseline symptomatology, or 3) clinical significance cut-off scores in large samples of individuals seeking treatment for an eating disorder (Cooper et al., 2016; Dingemans et al., 2016; Doyle, Le Grange, Loeb, Doyle, & Crosby, 2010; Fairburn, Agras, Walsh, Wilson, & Stice, 2004; Grilo, Masheb, & Wilson, 2006; Grilo, White, Wilson, Gueorguieva, & Masheb, 2012; Masheb & Grilo, 2007; Olmsted, Kaplan, Rockert, & Jacobsen, 1996; Safer & Joyce, 2011). For example, in a sample of individuals with bulimia nervosa, binge eating disorder, or OSFED, eating-disorder diagnosis did not predict symptom severity as measured by the EDE global score at 60-week follow-up.

It is unclear whether demographic variables predict eating-disorder treatment outcomes. The NICE and APA treatment guidelines suggest that there are no gender differences in eating-disorder treatment outcome. Although a recent study found that men and women (N =145), receiving residential treatment for an eating disorder, did not differ at discharge or seven-month follow-up in eating-disorder-related quality-of-life improvement (Weltzin, Bean, Klosterman, Lee, & Welk-Richards, 2015), other evidence suggests that men with binge eating disorder had larger reductions (i.e., percentage change) in body mass index (BMI) compared to women with binge eating disorder (Grilo et al., 2012). When binge eating disorder was still categorized within the diagnostic category of eating disorder not otherwise specified (EDNOS) in previous versions of the *DSM*, men reached EDNOS remission in a median of three years whereas women reached EDNOS remission in a median of six years (Støving, Andries, Brixen, Bilenberg, & Hørder,

2011). More so, a larger percentage of males were remitted from EDNOS after five years compared to women (Støving, Andries, Brixen, Bilenberg, & Hørder, 2011).

Previous research on treatment outcomes for eating disorders indicate that some eating-disorder characteristics, such as illness duration and diagnosis, may influence eating disorder symptom change. For example, early symptom change may predict better end-of-treatment outcomes (Linardon, Brennan, & de la Piedad Garcia, 2016; Vall & Wade, 2015) and an initial diagnosis of anorexia nervosa may be associated with a more chronic, treatment-resistant course compared to other eating disorders (Arcelus, Mitchell, Wales, & Nielsen, 2011; Franko, et al., 2013; Hudson et al., 2007; Keel & Brown, 2010; Smink, van Hoeken, & Hoek, 2012). However, most studies on treatment outcome for eating disorders have been done within the context of Randomized Control Trials (RCTs), which use manualized therapies and place a high premium on internal validity and experimental control that may or may not occur in real-world contexts. Clinicians in the community may use a range of approaches or integrative techniques that do not always adhere to manualized therapies, such as CBT-E. Thus, little is known about eating disorder change trajectories in naturalistic, ecologically valid samples. Additionally, no studies have looked at the order of symptom change in eating disorders. Eating-disorder behaviors are typically targeted first in treatment and, therefore, may be the first symptoms to decrease in treatment prior to cognitive change.

The Current Study

The purpose of the current study was to test change patterns of eating-disorder symptoms in a large-scale treatment-seeking sample of patients with an eating disorder using latent growth curve modeling. Specifically, I was interested in whether age, illness duration, gender, and/or clinician-established diagnosis influenced symptom change patterns. A secondary aim was to test

whether change in eating-disorder behaviors predicted change in eating-disorder cognitions or vice versa. First, I hypothesized that overall eating-disorder pathology would decrease over the course of treatment. Second, I hypothesized that individuals with a longer illness duration would have slower rates of symptom reduction than individuals with a shorter illness duration because having an eating disorder for a longer period of time is typically associated with a poor prognosis (Fichter, Quadflieg, & Hedlund, 2006; Ratnasuriva, Eisler, Szmukler, & Russell, 1991). Third, I hypothesized that individuals with bulimia nervosa and binge eating disorder would have faster rates of symptom reduction than individuals with another eating disorder, including anorexia nervosa, because anorexia nervosa tends to be a more chronic, treatment-resistant diagnosis. Fourth, I hypothesized that men would show faster reductions in binge eating compared to women because men with binge eating disorder have faster reductions in BMI compared to women. Fifth, I hypothesized that current age would significantly influence the rate of eating-disorder symptom change, although I did not specify a directional hypothesis because there is limited research that tests current age as a predictor of eating-disorder treatment outcomes. Sixth, I hypothesized that changes in eating-disorder behaviors would predict changes in eating-disorder cognitions because eating-disorder behaviors are treated first in many of the recommended treatments for eating disorders (e.g., CBT-E and other variations of CBT for eating disorders).

Method

Participants

Participants (*N*=63,199) were users of a popular mobile phone application, Recovery Record, Inc. (Tregarthen, Lock, & Darcy, 2015). Recovery Record primarily functions as a self-monitoring tool for eating-disorder management. The app serves as a platform for users to enter

information on several clinically relevant domains including: content of daily meals, thoughts, emotions, and specific eating-disorder behaviors (e.g., dietary restricting, binge eating, purging, weighing, body checking and avoidance, and exercise). Using an Ecological Momentary Assessment (EMA) framework, users are prompted to enter information for each domain throughout the day. Users may choose to utilize the app on their own or to link their Recovery Record account with their clinician. Linked clinicians can monitor their client's self-reported eating-disorder behaviors as a way to track outcomes and formulate treatment plans. The sample for the current study was selected only from Recovery Record users who were working in tandem with a clinician (n=36,163) to treat their eating disorder because I was interested in how eating-disorder symptoms change while undergoing treatment with a clinician.

Recovery Record can be downloaded for free from two major mobile app stores, Apple App Store and Google Play Store. Prior to use, users must agree to Recovery Record's terms and conditions. Within these terms and conditions, Recovery Record users agreed to their data being used for research purposes and permission was granted from the Recovery Record Corporation to obtain de-identified data for the current study. Recovery Record is compliant with the Health Insurance Portability and Accountability Act of 1996. The University of Kansas IRB approved all study procedures.

Inclusion criteria included users who: 1) completed the Eating Pathology Symptoms Inventory (EPSI; Forbush et al., 2013) within the Recovery Record App on at least three separate occasions and 2) had their Recovery Record user profile linked with their clinician. Linked clinicians had access to their client's data through a clinician-only Recovery Record portal. Clinicians could use the portal to monitor their client's progress and to enter their client's eating-disorder diagnosis. A proportion of Recovery Record users were excluded because they did not

link their account with a clinician (38%; *n*=24,036) or because they did not complete the EPSI at three time points (53%; *n*=33,465). Thirteen individuals had a clinician-rated diagnosis of Avoidant/Restrictive Energy Intake (ARFID), a feeding disorder that is characterized by a failure to meet nutritional needs due to an avoidance of eating foods based on their sensory characteristics (e.g., avoiding foods with a particular texture). These 13 individuals were excluded from the present study because we were interested in modeling symptom trajectories for eating disorders rather than feeding disorders. The final sample (87.2% female; *N*=5,685) ranged in age from 11-78 years with a mean (*SD*) age of 29.34 (*11.68*). Clinicians' eating disorder chart diagnoses included: anorexia nervosa (30.1%; *n*=1,710), bulimia nervosa (15.3%; *n*=871), binge eating disorder (18.7%; *n*=1,063), or OSFED (17.5%; *n*=994). The mean (*SD*) self-reported duration of an eating disorder was 12 (*10.9*) years. The mean (*SD*) of calculated age of onset was 17.15 (*7.77*) years. Participants' demographic characteristics were comparable to community samples of persons with an eating disorder in terms of mean age and age of onset, although the current sample appears to be marginally older (three to four years older) than other community (Forbush, Siew, & Vitevitch, 2016) and nationally representative samples (Hudson et al., 2007).

Measures

Recovery Record users were prompted to complete monthly assessments to track their eating pathology over time using a self-report assessment, the Eating Pathology Symptoms Inventory.

The Eating Pathology Symptoms Inventory. (EPSI; Forbush et al., 2013) is a 45 item self-report questionnaire that assesses eight dimensions of eating-disorder pathology including Body Dissatisfaction, Binge Eating, Cognitive Restraint, Restricting, Purging, Excessive

Exercise, Muscle Building, and Negative Attitudes Towards Obesity. However, participants in the sample were not administered the Muscle Building or Negative Attitudes toward Obesity scales because these scales were not included within the Recovery Record app at the time of the study. The EPSI has shown evidence for convergent validity with other measures of eating-disorder pathology and discriminant validity from measures of anxiety and depression across clinical, community, and college aged samples (Forbush, Wildes, & Hunt, 2014; Forbush et al., 2013). The EPSI had good to excellent internal-consistency at baseline in the current sample (*Cronbach's alpha* ranged from .77 for Cognitive Restraint to .92 for Binge Eating).

Self-Reported variables. Recovery Record users had the option to enter their self-reported gender, age, and illness duration when setting up their account profile or at a later time. Gender was a two-level categorical variable with options to choose female or male (gender data were missing for 8.4% of the sample; *n*=478). Age was collected as a continuous variable. Ages that were thought to be inaccurate (e.g., ages above 100 years-old) were coded as missing (17.3%; *n*=983). Illness duration is the amount of time that an individual had been experiencing eating-disorder symptoms at the time of signing up for Recovery Record. Recovery Record users were not required to enter their illness duration at sign-up, although they were given the option to provide this information at the end of their sixth meal log. Most users reported their illness duration in years. When another unit of time was entered (e.g., months or days), the response was converted into years. Responses that were not numerical representations (e.g., "forever") or considered inaccurate entries (e.g., "over 100 years") were coded as missing (41.3%; *n*=2,350).

Clinician-Rated diagnosis. Recovery Record users could invite their treatment provider to be linked to their account. Once linked, clinicians could enter an eating-disorder diagnosis for

their client within the clinician interface of Recovery Record. Some clinicians did not enter their client's diagnosis in the current study (18.4%; *n*=1,047).

Statistical Approach

All analyses were performed using Mplus 7.0 (Muthén & Muthén, 1998-2012). Latent Growth Curve Modeling (LGCM) was used to test average change in eating-disorder symptoms over time and individual difference variables that contribute to eating-disorder symptom change. Covariates were individual difference variables that I hypothesized would influence symptom change rates. The model included a total of 18 latent variables (i.e., six EPSI scales assessed at three time points) which were regressed on six covariates, including: illness duration, age[1], clinician-rated eating disorder diagnosis (anorexia nervosa, bulimia nervosa, and binge eating disorder), and gender. Illness duration and age were entered as continuous covariates. Gender was entered as a dichotomous covariate. To compare trajectories for individual eating disorders, three categorical variables were created: anorexia nervosa, bulimia nervosa, and binge eating disorder. The clinician-rated diagnosis covariates (anorexia nervosa, bulimia nervosa, and binge eating disorder) utilized effect coding with OSFED coded as the reference group. Effect coding made it possible to compare how the rate of symptom change differed for members of one particular diagnostic group compared to individuals with any other eating disorder. For example, intercept and slope differences for the anorexia nervosa covariate compared individuals with anorexia nervosa to individuals with any other eating disorder (e.g., binge eating disorder, bulimia nervosa, or OSFED).

To model accurate eating-disorder symptom change as opposed to change associated with measurement error, we corrected for the transient error that exists when implementing a longitudinal design. For example, different EPSI scores could be observed at different time

points simply because the participant was in a certain psychological state when responding to items. EPSI scales within each time point were correlated with each other to account for transient error (i.e., random variations in participants' psychological states across time points).

Intercepts at each time point were set to 1.0 and regression weights for slopes were constrained to 0.0, 1.0, and 2.0 to test a linear model (See **Figure 1**). Quadratic models were tested by constraining regression slope weights to 0.0, 1.0, and 4.0. Four fit indices were used to determine model fit: 1) Standardized Root Mean Square Residual (SRMR) values < .06 suggest acceptable fit (Hu & Bentler, 1999), 2) Comparative Fit Index (CFI) values >.9 suggest acceptable fit (Bentler, 1990; Schweizer, 2010), 3) Tucker-Lewis Index (TLI) values >.9 suggest acceptable fit (Schweizer, 2010; Tucker & Lewis, 1973), and 4) the Root Mean Square Error of Approximation (RMSEA) <.06 suggest acceptable fit (Schweizer, 2010; Steiger, 1990).

Dynamic bivariate latent change score models (LCSMs) (Ferrer & McArdle, 2010) were computed to assess whether behavioral changes predicted cognitive changes or vice versa (See **Figure 2**). The Binge Eating, Purging, Restricting, and Excessive Exercise scales assessed behavioral change. The Body Dissatisfaction and Cognitive Restraint scales assessed cognitive change. Given that EPSI scales have different numbers of items, *z*-score standardization made it possible to compare different EPSI scales on the same metric. The means of all eating-disorder symptom scales were expected to decrease during treatment. Because we were interested in representing how much a person's score had changed compared to baseline, raw EPSI scores at each time point were transformed into z-scores [$z\text{-score}_i = (x_{it} - \mu_1) / \sigma_1$] where x was the score for person i at time t, μ was the mean score at time 1 for all Recovery Record users, and σ was the standard deviation of the score at time 1 for all Recovery Record users.

For each dynamic bivariate LCSM, a cognitive EPSI scale was paired with a behavioral EPSI scale (see **Figure 2** for a path diagram). Two latent change scores were computed for each variable in the model by taking the difference between latent scores: 1) at time 1 and time 2 and 2) at time 2 and time 3 to model how much symptom change occurred between time points. Change scores were associated with both systematic and proportional change. Systematic change is influenced by time – which is independent of the previous latent variable score. Proportional change is influenced by the score of the same latent variable at the previous time point (e.g., binge eating at time 1 predicting change in binge eating at time 2). Because two latent variables are included in the model, coupling coefficients could also be modeled in order to represent the influence of a different latent variable at a previous time point (e.g., binge eating at time 1 predicting change in cognitive restraint at time 2). Considering both proportional and systematic change allowed us to model whether eating-disorder symptom change was constant over time (systematic) or influenced by the status of eating-disorder symptoms at the previous time point (proportional and coupling coefficients).

Results

Latent Growth Curve Model Results

The LGCM showed an excellent fit to the data, $\chi^2(72)=305.161$, $p<.001$; CFI= .995; RMSEA=.032; TLI=.982; SRMR=.010. A linear model fit better than a quadratic model. Results indicated that EPSI scale scores declined in a linear fashion over three months (see **Table 2** for descriptive statistics). Below, I discuss how differences in age, illness duration, gender, and clinician-rated eating disorder diagnosis influenced eating-disorder psychopathology at baseline (intercept estimates in **Table 3**) and over time (slope estimates in **Table 4**).

Baseline/Intercept Differences. There was individual variation in the amount of eating-disorder psychopathology (as measured by EPSI scale scores) Recovery Record users reported when they first signed up for the mobile phone application at baseline. Differences in eating-disorder symptoms at baseline are represented by significant intercept differences (see **Table 3**).

Individuals with a longer illness duration had higher scores on Body Dissatisfaction, Purging, and Restricting at baseline compared to individuals with a shorter illness duration. Women had higher scores on Body Dissatisfaction, Cognitive Restraint, and Purging at baseline compared to men. Younger individuals had higher scores on Body Dissatisfaction, Cognitive Restraint, Excessive Exercise, Purging, and Restricting at baseline compared to older individuals.

Compared to individuals with other eating disorders, individuals with anorexia nervosa had lower scores on Body Dissatisfaction, Binge Eating, and Purging and higher scores on Cognitive Restraint, Excessive Exercise, and Restricting at baseline. When compared to individuals with other eating disorders, individuals with bulimia nervosa had lower scores on Restricting and higher scores on Binge Eating and Purging at baseline. When compared to other eating disorders, individuals with binge eating disorder had higher scores on Body Dissatisfaction and Binge Eating and lower scores on Cognitive Restraint, Excessive Exercise, Purging, and Restricting at baseline.

Change Rate/Slope Differences. There was individual variation in rates of eating-disorder symptom change among Recovery Record users over three months. Differences in rates of eating-disorder symptom change are represented by significant slope differences (see **Table 4**).

Individuals with a shorter illness duration had faster reductions in Restricting scores compared to individuals with a longer illness duration. Women had faster reductions in Body Dissatisfaction and Purging scores compared to men. Younger individuals had faster reductions in Cognitive Restraint, Excessive Exercise, and Purging scores compared to older individuals.

Compared to other eating disorders, individuals with anorexia nervosa had faster decreases in Restricting scores. Individuals with anorexia nervosa also had faster increases in Body Dissatisfaction, Binge Eating, and Purging scores compared to individuals with another eating disorder. Compared to other eating disorders, individuals with bulimia nervosa had faster reductions Binge Eating and Purging scores. Compared to other eating disorders, individuals with binge eating disorder had faster decreases in Body Dissatisfaction, Binge Eating, and Cognitive Restraint scores. Individuals with binge eating disorder also had faster increases in Restricting scores compared to individuals with another eating disorder.

Bivariate Latent Change Score Model Results

Eating-disorder cognitions at baseline significantly predicted eating-disorder cognitions at Time 2 and Time 3. Similarly, eating-disorder behaviors at baseline significantly predicted eating-disorder behaviors at Time 2 and Time 3 (see **Table 6** for coupling coefficients). Next, I tested the directionality of cognitive and behavioral symptom changes. Results showed that eating-disorder cognitions and behaviors had significant bidirectional relationships with one another, suggesting that change in one domain (either cognitive or behavioral) led to change in the other domain (see Table 5).

Discussion

The primary goal of the current study was to assess how eating-disorder symptoms changed, on average, over three months and how individual client variables influenced the rate of symptom change. I hypothesized that eating-disorder pathology would decrease over three months of treatment. I also hypothesized that several client variables would influence the rate of symptom change, including: 1) shorter illness duration would be associated with faster reductions in eating-disorder symptoms compared to longer illness duration; 2) diagnoses of bulimia nervosa and binge eating disorder would be associated with faster reductions in eating disorder symptoms compared to a diagnosis of anorexia nervosa; 3) men would have faster reductions in binge eating compared to women; and 4) client age would significantly influence the rate of eating disorder symptom change;. A secondary goal was to test whether eating-disorder behavior change predicted eating-disorder cognition change or vice versa. I hypothesized that eating-disorder behavior change would predict eating-disorder cognition change.

Results supported my first hypothesis; patients with an eating disorder had significant decreases in self-reported body dissatisfaction, binge eating, cognitive restraint, restricting, purging, and excessive exercise over three months of treatment. These findings were encouraging and suggest that, on average, treatment was helpful because Recovery Record users reported less eating-disorder behaviors and cognitions (as measured by the EPSI) over time. Although, on average, Recovery Record users had lower eating pathology scores over time, several individual difference variables influenced how quickly or slowly eating-disorder symptoms changed. For example, age had a significant influence on the rate of eating-disorder symptom change such that younger individuals had faster reductions in cognitive restraint, excessive exercise, and purging compared to older individuals. In addition, individuals with a

shorter illness duration had faster reductions in restricting compared to individuals with a longer illness duration. Finally, individuals with bulimia nervosa and binge eating disorder had faster reductions in binge eating and purging compared to patients with other eating disorders.

Not all hypotheses were supported. I hypothesized that men would be faster to reduce binge-eating behavior, although results indicated that men and women had similar binge eating change trajectories overtime. More research is needed to understand why men with eating disorders characterized by binge-eating symptoms have faster remission rates compared to women (Støving, Andries, Brixen, Bilenberg, & Hørder, 2011) given that binge-eating symptom change does not differ between men and women.

Results partially supported my hypothesis about the directionality of cognitive and behavioral change. Change in eating-disorder behaviors did significantly predict change in eating-disorder cognitions, although the reverse was also true. Thus, changes in eating-disorder-related thoughts and changes in eating-disorder-related behaviors were mutually predictive of each other and occurred simultaneously. The primary premise of CBT-E is that negative thoughts lead to (cause) negative emotions and behaviors; thus, behavior change is predicated on changing distorted cognitions. Within the depression literature, there is evidence to support that changes in thoughts precede decreases in depressive symptoms (Tang & DeRubeis, 1999). However, there is also evidence to suggest that depressive symptoms can change in the absence of thought change (Cristea et al., 2015; Ekers et al., 2014; Longmore & Worrell, 2007; Oei, Bullbeck, & Campbell, 2006). The question about whether cognitive changes lead to behavioral changes or vice versa has not been directly studied in the field of eating disorders. The mutual relationship between cognitive and behavioral change suggests that therapy could feasibly target maladaptive

eating-disorder behaviors and cognitions at the start of treatment, rather than emphasizing behaviors first and cognitions later in treatment, which is the current approach used in CBT-E.

Some findings were unexpected. A goal of any treatment for mental illness is reduction in psychopathological symptoms. Although many symptoms declined over time (suggesting improvement in mental health), certain eating-disorder behaviors *increased* over the course of treatment. For example, persons with anorexia nervosa had faster increases in body dissatisfaction and binge eating as treatment progressed over three months. Treatment for anorexia nervosa attempts to establish regular eating habits with the ultimate goal of weight gain (De Young et al., 2014; Doyle, Le Grange, Loeb, Doyle, & Crosby, 2010; Elran-Barak et al., 2015; Forman et al., 2014), which is feared. To achieve weight gain, individuals with anorexia nervosa must increase their caloric intake substantially. For example, Forbush and Hunt (2014) reviewed the literature and found that among individuals with anorexia nervosa, one kilogram of weight gain is associated with consuming 8000 (± 2000) kcal. Given the large increase in calories consumed, it is not surprising that individuals undergoing treatment for anorexia nervosa reported higher Binge Eating scores over time as Binge Eating items assess eating large amounts of food, eating when not hungry, and stuffing oneself with food to the point of feeling sick. Weight gain is often upsetting to an individual with anorexia nervosa, who fears weight gain, which may explain the increase in body dissatisfaction during treatment (by virtue of successful weight gain).

Although increases in binge eating and body dissatisfaction among patients with anorexia nervosa may be expected due to increased food intake and weight gain, there is no clear explanation for why an individual with anorexia nervosa would purge more over the course of treatment. Diagnostic migration (shifting among eating disorder diagnoses over time without

recovering) is common among individuals with anorexia nervosa (Castellini et al., 2011). One of the most common patterns of diagnostic migration is shifting from the restricting subtype of anorexia nervosa to the binge-purge subtype of anorexia nervosa (Eddy et al., 2008). It could be that individuals with anorexia nervosa who are starting the process of weight restoration feel very full, physically uncomfortable, and "fat." To cope with feelings of worsening body dissatisfaction and the physical discomforts associated with increased caloric intake, individuals with anorexia nervosa may begin purging as a way to relieve some of their physical discomfort and as a way to avoid weight gain. If laxative use and other purging behaviors (e.g., self-induced vomiting, diuretic use, insulin omission) are being used to compensate for the weight gain achieved in treatment, this could indicate that the patient has not successfully improved and may need intensified intervention.

Individuals with binge eating disorder reported increased food restriction during treatment, which is not surprising because most treatment protocols for binge eating disorder focus on reducing an individual's caloric intake (de Zwaan et al., 2005; Raymond, de Zwaan, Mitchell, Ackard, & Thuras, 2002; Telch & Agras, 1993). However, it is difficult to say whether increases in self-reported eating-disorder symptoms (e.g., restricting) represent a treatment "success" or "failure." For example, the goal for an individual with binge eating disorder is to increase healthful eating behaviors by reducing their overall caloric intake. The increase in EPSI Restricting scores over time could represent successful treatment, in which patients are transitioning from binge eating to normal, balanced eating. However, increases in the EPSI restricting scale could also represent diagnostic migration from binge eating disorder to non-purging bulimia nervosa.

Certain limitations of the current study are worth noting. First, the Recovery Record mobile app does not ask users about the type of treatment and level of care they are receiving, which could significantly impact change trajectories, particularly if individuals are in highly supervised environments that make it more difficult to engage in disordered-eating behaviors. Future studies could test whether eating-disorder symptom trajectories are different when different treatment modalities or different levels of treatment intensity are implemented. Second, there was no measure of clinical impairment to determine whether symptom changes were associated with improvement in psychosocial functioning, which would have informed whether certain increases in symptoms were due to diagnostic migration or true improvement. Third, clinician-rated diagnoses could not be confirmed, and it is possible that clinician-rated diagnoses are less reliable and valid than diagnoses based on structured clinical interviews. On the other hand, the current study had high ecological validity because it followed real-world patients in the community being treated by real-world clinicians who were providing the treatment they believed would be most effective based on their diagnostic assessment and judgement. Thus, an advantage of the current study is that it provides eating-disorder clinicians and researchers with a "snapshot" of how eating-disorder symptoms change for individuals receiving treatment in the community rather than for persons participating in highly controlled randomized clinical trials. Another important strength of our study is that it is one of the only studies to examine symptom change in men with eating disorders – a population that is understudied relative to women.

Results from this study demonstrated that eating-disorder cognitions are predictive of eating-disorder behavior change. Thus, monitoring client thought records could predict whether a client is "slipping" in treatment or relapsing and could signal the client and therapist when exacerbations in symptoms are imminent. Future research could utilize Artificial Intelligence

(AI) and machine learning to create algorithms that predict poor treatment outcomes using daily thought records. AI could also be utilized to provide computer-based treatment (as an adjunct to traditional face-to-face therapy) that responds to dysfunctional thought and behavior patterns directly, in real-time, to provide a more personalized treatment for individual clients.

In conclusion, this was one of the largest studies to test symptom change trajectories and patterns in community adults with eating disorders. The results of the current study are significant because they can be leveraged to provide researchers and clinicians the information they need to identify individuals who are at risk for slow treatment progress so that they can change and/or intensify their treatment to avoid poor end-of-treatment outcomes. Results also suggest that instead of the "chicken or the egg," cognitions and behaviors have bidirectional relationships and that patient success may be improved if eating-disorder cognitions and behaviors are treated simultaneously at the start of treatment, rather than addressing cognitions only after the first month of treatment.

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Table 1. DSM-5 Eating Disorder Diagnostic Terms and Criteria.

Term	Definition
Objective binge eating episodes (OBEs)	Eating an amount of food that is definitely larger than what most others would eat under similar circumstances in a discrete period of time (e.g., within two hours). A subjective sense of loss-of-control (e.g., feeling as though one could not stop eating once one had started eating) must be present during the eating episode.
Inappropriate compensatory behaviors (ICBs)	Behaviors used to reduce the effects of caloric intake on body weight and shape. Inappropriate compensatory behaviors include both purging behaviors (i.e., forced expelling of calories from the body such as self-induced vomiting or laxative use) and non-purging behaviors (e.g., fasting and excessive exercise).
Anorexia nervosa (AN)	Extreme energy restriction that leads to a significantly low body weight (BMI $\leq$ 17.5). Low body weight is accompanied by a fear of weight gain and a distorted perception of one's body weight or shape. Some individuals with anorexia nervosa report objective binge eating episodes and/or purging behaviors.
Bulimia nervosa (BN)	Objective binge eating episodes and inappropriate compensatory behaviors that occur, on average, one time per week for three months. Shape and weight largely influence self-evaluation among individuals with bulimia nervosa. These criteria must occur at a normal body weight (BMI $\geq$ 19).
Binge eating disorder (BED)	Objective binge eating episodes that occur in the absence of inappropriate compensatory behaviors. The binge eating is accompanied by marked distress and three or more of the following symptoms: eating rapidly, eating until uncomfortably full, eating when not hungry, eating alone due to embarrassment, or feeling guilty with oneself. These criteria must occur at a normal body weight (BMI $\geq$ 19).
Other specified feeding or eating disorder (OSFED)	Clinically significant EDs that do not meet the criteria for anorexia nervosa, bulimia nervosa, or binge eating disorder.

Table 2. Latent Growth Curve Model- Intercept Estimates.

Body Dissatisfaction			
Covariate	Estimate	Standard Error	p-value
Age	-.049	.016	.002
Duration	.078	.015	<.001
Gender	-5.790	.570	<.001
AN	-1.178	.189	<.001
BN	.310	.209	.137
BED	.429	.203	.035
Binge Eating			
Age	-.010	.016	.535
Duration	-.004	.017	.818
Gender	-.070	.590	.906
AN	-6.500	.200	<.001
BN	2.366	.275	<.001
BED	5.969	.255	<.001
Cognitive Restraint			
Age	-.029	.007	<.001
Duration	-.003	.007	.724
Gender	-.583	.243	.017
AN	.793	.091	<.001
BN	.108	.103	.294
BED	-1.191	.103	<.001
Excessive Exercise			
Age	-.057	.012	<.001
Duration	-.020	.013	.115
Gender	.337	.452	.457
AN	.692	.176	<.001
BN	.278	.196	.156
BED	-1.472	.184	<.001
Purging			
Age	-.049	.010	<.001
Duration	.031	.010	.002
Gender	-1.066	.296	.001
AN	-.592	.144	<.001
BN	1.747	.168	<.001
BED	-1.434	.153	<.001
Restricting			
Age	-.062	.013	<.001
Duration	.028	.013	.033
Gender	-.230	.477	.629
AN	3.844	.172	<.001
BN	-.505	.194	.009
BED	-4.251	.178	<.001

Note. AN= anorexia nervosa. BN= bulimia nervosa. BED= binge eating disorder. Gender was coded such that 0 represented females and 1 represented males. Anorexia nervosa was coded such that 1 represented a diagnosis of anorexia nervosa and 0 represented a diagnosis of any other eating disorder. Bulimia nervosa was coded such that 1 represented a diagnosis of bulimia nervoa and 0 represented a diagnosis of any other eating disorder. Binge eating disorder was coded such that 1 represented a diagnosis of binge eating disorder and 0 represnted a diagnosis of any other eating disorder.

Table 3. Latent Growth Curve Model- Slope Estimates.

Body Dissatisfaction			
Covariate	Estimate	Standard Error	p-value
Age	.007	.005	.182
Duration	.002	.005	.713
Gender	.453	.184	.014
AN	.314	.072	<.001
BN	-.027	.083	.740
BED	-.505	.090	<.001
Binge Eating			
Age	.011	.008	.152
Duration	-.012	.008	.133
Gender	-.301	.314	.338
AN	1.381	.090	<.001
BN	-.436	.127	.001
BED	-1.498	.137	<.001
Cognitive Restraint			
Age	.014	.003	<.001
Duration	.0	.003	.997
Gender	.035	.107	.742
AN	.020	.040	.628
BN	.002	.049	.967
BED	-.139	.050	.005
Excessive Exercise			
Age	.023	.005	<.001
Duration	-.001	.005	.882
Gender	-.270	.198	.173
AN	-.079	.072	.272
BN	-.050	.078	.517
BED	-.033	.074	.652
Purging			
Age	.014	.004	<.001
Duration	-.003	.004	.512
Gender	.284	.132	.031
AN	.257	.056	<.001
BN	-.332	.067	<.001
BED	-.008	.062	.900
Restricting			
Age	.007	.005	.124
Duration	.009	.005	.040
Gender	-.143	.177	.419
AN	-.366	.071	<.001
BN	.051	.074	.486
BED	.224	.067	.001

Note. AN= anorexia nervosa. BN= bulimia nervosa. BED= binge eating disorder. Gender was coded such that 0 represented females and 1 represented males. Anorexia nervosa was coded such that 1 represnted a diagnosis of anorexia nervosa and 0 represented a diagnosis of any other eating disorder. Bulimia nervosa was coded such that 1 represented a diagnosis of bulimia nervoa and 0 represented a diagnosis of any other eating disorder. Binge eating disorder was coded such that 1 represented a diagnosis of binge eating disorder and 0 represnted a diagnosis of any other eating disorder.

Table 4. Model Fit Indices for Bivariate Latent Change Score Models.

Model	χ^2	df	CFI	RMSEA	TLI	SRMR
Cognitive Restraint & Binge Eating	2967.201	14	.793	.193	.778	.180
Cognitive Restraint & Excessive Exercise	3429.920	14	.808	.207	.794	.192
Cognitive Restraint & Purging	2180.316	14	.852	.165	.841	.151
Cognitive Restraint & Restricting	2351.107	14	.877	.171	.868	.156
Body Dissatisfaction & Binge Eating	2492.297	14	.857	.176	.847	.129
Body Dissatisfaction & Excessive Exercise	1994.364	14	.888	.158	.880	.112
Body Dissatisfaction & Purging	2083.452	14	.878	.161	.870	.152
Body Dissatisfaction & Restricting	1274.542	14	.935	.126	.930	.088

Note. df= degrees of freedom. CFI= comparative fit index. RMSEA= root mean square error approximation. TLI= Tucker-Lewis Index. SRMR= standardized root mean residual.

Table 5. Latent Change Score Model Results- Coupling Coefficients.

Behavior Predicting Congition		
	Cognitive Restraint	Body Dissatisfaction
Binge Eating	.091**	.072**
Excessive Exercise	.162**	.080**
Purging	.116**	.079**
Restricting	.115**	.096**
Cognition Predicting Behavior		
	Cognitive Restraint	Body Dissatisfaction
Binge Eating	.020*	.046**
Excessive Exercise	.157**	.070**
Purging	.177**	.113**
Restricting	.188**	.097**

Note. Latent Change Score Model coupling coefficients are represented in the table above. Coupling coefficients represent the effect of a different latent variable at the previous time point. The first half of the table provides coupling coefficents for changes in behavior predicting changes in cognition. Thus, coupling coefficients in the first half of the table represent the influence of Binge Eating, Excessive Exercise, Purging, and Restricting scores at the previous time point on Cognitive Restraint and Body Dissatisfaction. The second half of the table provides coupling coefficeints for changes in cognition predicting changes in behavior. Thus, coupling coefficietns in the second half of the table represent the influence of Cognitive Restraint and Body Dissatisfaction scores at the previous time point on Binge Eating, Excessive exercise, Purging, and Restricting respectively.

*$p<.05$

**$p<.01$

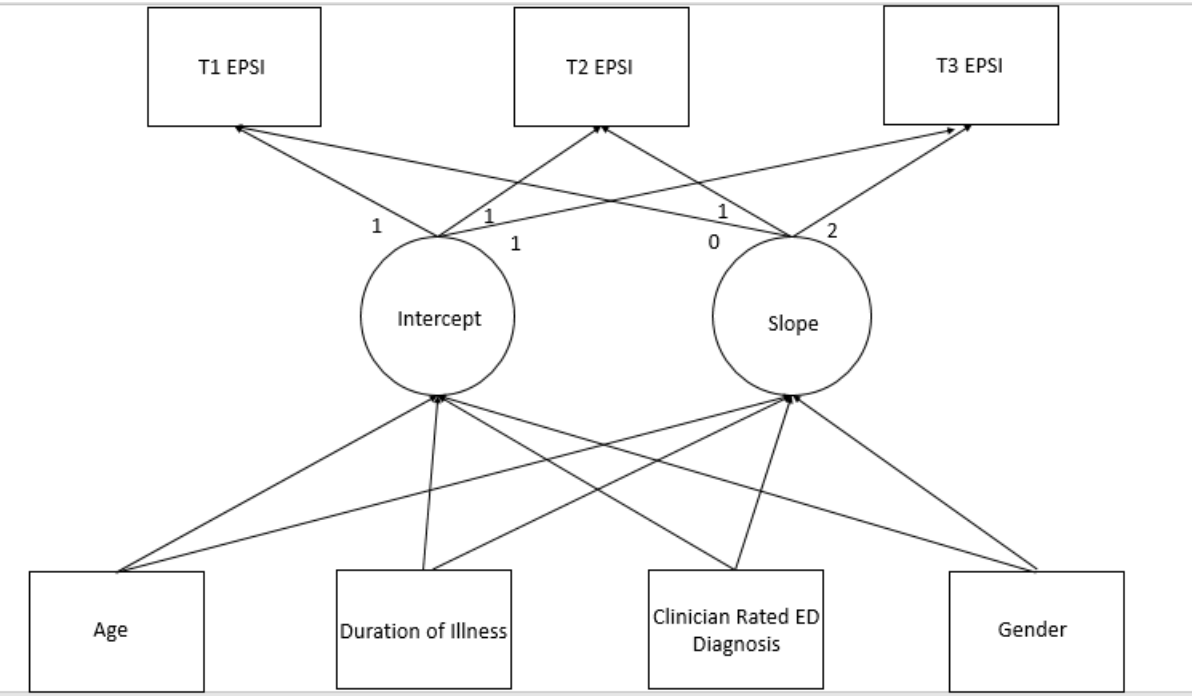

Figure 1. Latent Growth Curve Model

Note. This model is simplified to represent the general approach; one model tested all EPSI scale scores. Thus, the model included six EPSI scales using total scores from the EPSI Body Dissatisfaction, Binge Eating, Cognitive Restraint, Restricting, Purging, and Excessive Exercise Scales at Time 1, 2, and 3.

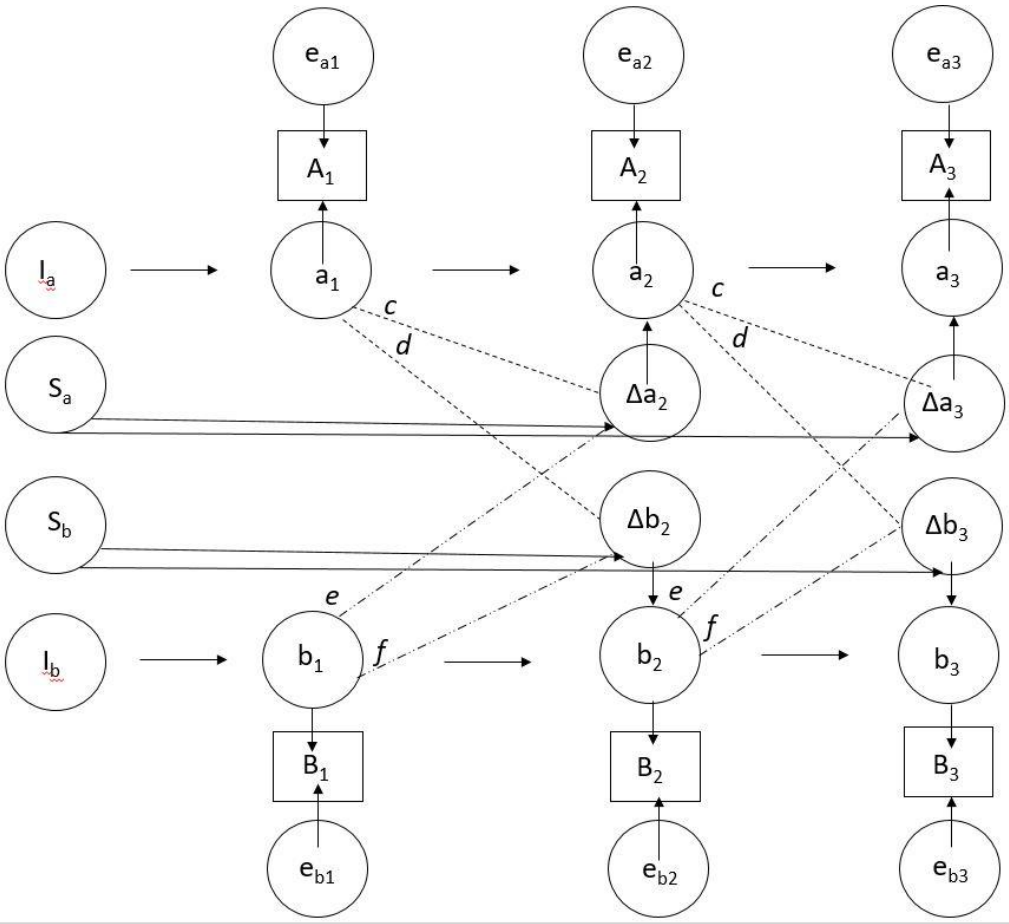

Figure 2. Bivariate Latent Change Score Model.

Note. Path diagram of bivariate latent change score (LCS) model of two variables, variable a and variable b. For the current study, we were interested in modeling specifically paths notated by d and e which represent coupling coefficients. Coupling coefficients represent how behavioral change at the previous time point influenced cognitive change and how cognitive change at the previous time point influenced behavioral change.
a= latent score of variable a at each time point
b= latent score of variable b at each time point
A= observed/measured score of variable a at each time point
B= observed/measured score of variable b at each time point
e= error variance of each variable at each time point
Δa = change score of variable a between two time points
Δb= change score of variable b between two time points
c= time-invariant proportional coefficient for variable a
d= coupling coefficient for variable a
e= coupling coefficient of variable b
f= time-invariant proportional coefficient for variable b

Footnotes

[1]We were also interested in how age of onset would influence the change rate of eating-disorder symptoms. Because age of onset can be calculated from age and illness duration, all three variables (i.e., age, illness duration, and age of onset) could not be included in the same model due to issues of multicollinearity. In a separate model, age of onset was included as a covariate to see how it influenced eating-disorder symptoms at baseline as well as the change rate of eating-disorder symptoms over time. Individuals with a younger age of onset reported higher scores on Body Dissatisfaction, Cognitive Restraint, Purging, and Restricting at baseline compared to individuals who developed their eating disorder later in life. Individuals with a younger age of onset had faster symptom reductions in Cognitive Restraint, Excessive Exercise, and Purging compared to individuals with an older age of onset. Please see **Table 8** provided in the supplemental information section.

Supplemental Tables & Figures

Table 8. Latent Growth Curve Model-Age of Onset Intercept and Slope Estimates

	Intercept		
	Estimate	Standard Error	p-value
Body Dissatisfaction	-.063	.015	<.001
Binge Eating	-.003	.015	.823
Cognitive Restraint	-.014	.006	.034
Excessive Exercise	-.020	.012	.092
Purging	-.041	.009	<.001
Restricting	-.046	.012	<.001
	Slope		
Body Dissatisfaction	.003	.005	.580
Binge Eating	.012	.007	.116
Cognitive Restraint	.007	.003	.012
Excessive Exercise	.012	.005	.008
Purging	.008	.004	.017
Restricting	-.001	.004	.862