Reward processing and risky decision making in college students with and without disordered eating behaviors

Senior Research Thesis

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by

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Abstract

Individuals with eating disorders may experience difficulties with reward processing and decision making, in which the focus is placed on immediate gains at the expense of long-term outcomes. Previous research has indicated the presence of impaired decision making as a function of diagnoses of Anorexia Nervosa, Bulimia Nervosa, and Binge Eating Disorder, three eating disorders classified in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). However, many college-aged individuals experience disordered eating behaviors—maladaptive eating behaviors that affect the individual’s life yet do not meet full DSM-5 criteria for an eating disorder. The present study sought to examine the presence of disordered eating behaviors among college students, as well as relationships between risky decision making and disordered eating behaviors. Participants were 412 undergraduate students who completed a baseline screening of eating behaviors with the Eating Attitudes Test and Eating Disorder Examination. Of these, 86 participants (a mix of DE and non-DE participants) completed assessments of risky decision making and other executive functions. Results indicated higher levels of disordered eating behaviors were associated with a greater preference for immediate over long-term gains, riskier decision making, and slower responses times. These results indicate that the decision making deficits seen in eating disorders may be present at a subclinical level of disordered eating behaviors.

Keywords: disordered eating; risky decision making; reward processing; eating disorders
Eating behaviors, in general, can be categorized into normal eating patterns, disordered eating (DE), and clinical eating disorder pathologies. Of interest to the present study is DE, a class of maladaptive eating behaviors observed in non- and subclinical populations that have been purported to represent an at-risk stage in the development of diagnosable clinical eating disorders (Hudson, Hiripi, Pope, & Kessler, 2007). Much of the research to date has sought to highlight factors related to DE, thereby providing a more complete assessment of DE and potentially generating new treatment interventions. In particular, research has examined the relationships between DE and emotion regulation (Cooper & Wade, 2015; Cooper, O’Shea, Atkinson, & Wade, 2014), impulsivity (Lundahl, Wahlstrom, Christ, & Stoltenberg, 2015), and perfectionism (Boone & Soenens, 2015; Wade, Wilksch, Paxton, Byrne, & Austin, 2015; Peixoto-Plácido, Soares, Pereira, & Macedo, 2015). However, no research to date has examined decision making task performance in a DE population, despite multiple studies showing risky decision making across different eating disorder populations. The present study sought to examine behavioral decision making and reward processing in college students with and without self-reported DE behaviors.

**Eating Disorders and Disordered Eating**

Eating disorders are serious and life-threatening disorders that impair physical and psychosocial functioning. According to the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5; American Psychiatric Association [APA], 2013), eating disorders have been categorized into the following: Anorexia Nervosa (AN), Bulimia Nervosa (BN), and Binge-Eating Disorder (BED). AN, BN, and BED vary in diagnostic criteria and severity of symptoms, leading to different treatment approaches (APA, 2013). AN centers on three diagnostic features: 1) persistent food restriction; 2) intense fear surrounding weight gain, or
continual behavior that interferes with weight gain; and 3) a disturbed perception of body weight/shape (APA, 2013). The diagnostic features of BN include: 1) recurrent episodes of binge eating; 2) employment of compensatory mechanisms (e.g., excessive exercise, use of laxatives or diuretics, and/or purging) to prevent weight gain; and 3) distorted self-evaluation rooted in body weight/shape (APA, 2013). Finally, BED, a new diagnostic category in the DSM-5, includes: 1) recurrent episodes of binge eating that are often regarded as dissociative, in that some individuals identify intense feelings of loss of control during binges; 2) binges that are associated with factors such as eating more rapidly than normal, feeling uncomfortably full, eating when not physically hungry, and feeling guilty/disgusted after eating; and 3) distress during the binge episode (APA, 2013). Importantly, BED differs from BN in that binge eating is not followed by compensatory behaviors to prevent weight gain. In addition, BED often occurs in overweight/obese individuals (APA, 2013).

DE can be thought of as a non- or subclinical eating pathology, in that such eating behaviors can cause severe detriment to one’s quality of life but fail to meet the diagnostic criteria for one of the three identified eating disorders (DiPasquale & Petrie, 2013). Research has sought to examine the risk factors associated with eating disorder development, and, in doing so, such research has highlighted behaviors that may constitute DE although the precise symptoms have not been agreed upon (Hudson et al., 2007; Rohde, Stice, & Marti, 2015; Wilksch et al., 2015). In particular, some research has examined DE in college-aged populations, finding high rates of maladaptive eating patterns (e.g., ritualistic food/caloric consumption, food restriction, and binge/purge eating patterns, extreme dieting) and employment of compensatory mechanisms (e.g., vomiting, use of laxatives or diuretics, or exercise; Cooley & Toray, 2001; Krahn, Kruth, Gomberg, & Drewnowski, 2005; Loth, MacLehose, Bucchianeri, Crow, & Neumark-Sztainer,
The present study investigates DE from this framework, holding that many features may constitute DE behaviors among college-aged participants.

Such DE behaviors are similar to the behaviors observed in clinical eating disorder pathologies; however, the adoption of such eating behaviors is more generalized in DE populations, with the intensity (e.g., frequency/severity) of such behaviors often falling within non- or subclinical levels of eating disorders (DiPasquale & Petrie, 2013; Uzun et al., 2006). Of note, some researchers have theorized that examining college-aged populations would find few who meet full criteria for an eating disorder yet higher numbers who exhibited DE behaviors (Uzun et al., 2006). However, published rates of DE vary considerably due to factors such as the types of behaviors assessed, participant gender, and intensity of eating symptoms (Uzun et al., 2006). Some estimates hold that 80% of first-year women in college engaged in extreme dieting patterns while 50% engaged in binge eating patterns (Uzun et al., 2006). Other research examining eating attitudes indicated 82% of women demonstrated a marked drive to lose weight throughout college, with numbers dropping to 68% after college (DiPasquale & Petrie, 2013).

Of note, research examining DE behaviors from the male perspective is lacking. This gender discrepancy is also seen in examinations of eating disorders in men (Bunnell, 2015). It may be the case that eating disorders are socially constructed as “feminine” disorders, thereby discouraging men to openly discuss maladaptive eating patterns with friends, family, and health professionals (Bunnell, 2015). Although we expect this trend to be reflected in DE populations, it is certainly the case that DE behaviors are present in men as well as women (Uzun et al., 2006). Many researchers have identified college as a period of time in which stress levels are high and academic achievement and identify exploration are at the forefront, factors that have been purported to exasperate DE behaviors (Uzun et al., 2006). The present study seeks to add to the
research examining DE prevalence rates while also furthering our understanding of how variables such as decision making and reward processing may be related to the severity of DE behaviors.

**Decision Making and Reward Processing**

Neuropsychological studies have revealed impairments in several cognitive domains across eating disorder populations (see Tchanturia et al., 2004, for review). Most notably, impairments in executive functioning have been observed in various eating disorders (Juarascio, Manasse, Espel, Kerrigan, & Forman, 2015). Executive functioning refers to various higher-order processes coordinated by the frontal lobe, including set shifting, problem solving, planning, organization, and working memory (Lezak, Howieson, & Loring, 2004; Wiechmann, Hall, & Azimipour, 2015). Another commonly assessed executive function is decision making, a process that can be defined as, at its simplest, a selection between two or more options. From a clinical perspective, risky decision making has been defined as a myopic focus on immediate rewards at the expense of long-term outcomes (Bechara, Damasio, Damasio, & Anderson, 1994). It could be that individuals with eating disorders may make riskier decisions, in that they focus on rewarding immediate behaviors over less rewarding but more positive/healthy long-term behaviors. As it pertains to eating disorder research, reward processing can be understood as magnified levels of reward (e.g., food deprivation [AN]; binge/purge cycles [BN]; binging behaviors [BED]) appearing to outweigh potential consequences (e.g., abnormally slow heart rate and low blood pressures, osteoporosis, gastric rupture and peptic ulcers) (Wierenga et al., 2014). Moreover, this pattern of reward can also be conceptualized as a preference for short-term, immediate gains at the expense of long-term outcomes, mimicking riskier performance on behavioral decision making tasks. In fact, despite marked differences in behavioral patterns that
make up the clinical criteria of the eating disorders, research has identified similar patterns of risky decision making among individuals diagnosed with AN (Brogan, Hevey, & Pignatti, 2010; Cavedini et al., 2004), BN (Boeka & Lokken, 2006; Brogan et al., 2010; Liao et al., 2009), and BED (Danner, Ouwehand, van Haastert, Hornsveld, & de Ridder, 2011), as well as other forms of unhealthy eating patterns such as those seen in obesity (Brogan et al., 2010; Brogan, Hevey, O’Callaghan, Yoder, & O’Shea, 2011). In fact, risky decision making can predict successful weight loss in a weight management program (Emery, Buelow, Olson, Landers, & Thaxton, 2016).

In keeping with the current conceptualization of reward processing as a preference for short-term, immediate gains over long-term outcomes, it is important to highlight how such a model of reward may function in eating disorder populations. Individuals with AN have been shown to display increased activation in brain regions sensitive to reward (e.g., ventral striatum) while restricting food intake (Ehrlich et al., 2015), findings that are further supported by research demonstrating less temporal discounting in populations with AN (Ehrlich et al., 2015). Temporal discounting, a variable often assessed via the Delay Discounting Task (Kirby et al., 1999), specifically examines individuals’ preferences for short-term versus long-term gains. The immediate gains are smaller than the more distant gains (Ehrlich et al., 2015), and delay discounting is seen when individuals prefer short-term gains at the expense of larger, long-term gains. Individuals with AN demonstrate excessive self-control in delaying monetary reward (i.e., prefer long-term gains; Ehrlich et al., 2015). In considering the relative time per gain ratios with food restriction and binge/purge cycles (as modeled in BN; see below), it is evident that food restriction does indeed take more time to achieve gains (weight loss) than the immediate gains accessed with binge/purge cycles. However, one must be careful in concluding that individuals
with AN typically make decisions focused on the long-term, as it is troublingly evident that individuals with AN demonstrate cognitive rigidity (i.e., inability to change habits) as exemplified by a lack of consideration of future health outcomes (Tchanturia et al., 2004). Along these same lines, it could be conceptualized that the drive for weight loss accomplished by the act of starvation models risky decision making in part because of the disregard for one’s future health.

Interestingly, research has shown that individuals with BN display attenuated brain activation (e.g., striatum and right anterior insular cortex) to food rewards (Bohon & Stice, 2011). Such differential activation in BN has been examined in the context of altered feedback sensitivity: heightened reward sensitivity decreases overall responses to food-related rewards, in turn motivating reward-seeking behavior as manifested in binging/purging episodes (Wierenga et al., 2014). Moreover, increased reward sensitivity is often cited in BN (Wierenga et al., 2014), as individuals demonstrated greater temporal discounting that are modeled in pathological binge eating/purging behaviors characteristic of the disorder (Wierenga et al., 2014). Such reward-seeking behaviors could be further understood in terms of risky decision making. Tasks such as the Iowa Gambling Task (IGT), a measure designed to assess risky decision making, examine decision making in terms of an overreliance on immediate gains at the expense of long-term outcomes (Bechara et al., 1994). In the case of BN, the overreliance on immediate gains could reflect the need of such individuals to ritually binge and purge while failing to consider the bodily harm caused by such behaviors (i.e., long-term outcomes). As such, the present study seeks to utilize the IGT as well as other decision making tasks to better assess the potential for risky decision making—and thus faulty reward processing—in a DE population relative to healthy controls.
While the focus of research to date is on eating disorder populations, the present study extends the notion that risky decision making and faulty reward processing may also be present in a DE population as both share clinical/pathological diagnostic features. The present study stands alone in its examination of decision making outcomes in a disordered eating population. Moreover, such research could identify potential risk factors that underlie eating disorder development, thereby potentially providing insight into treatment programs targeting risky decision making and faulty reward processing among DE populations.

The Present Study

The present study sought to examine decision making and reward processing in a DE population. Previous research has found risky decision making in various eating disorder populations, and in considering that eating disorders and DE share many clinical/pathological diagnostic features, similar findings may also be present in a DE population. Research examining reward processing among eating disorder populations has been somewhat mixed, with some pointing to differences in reward processing among AN and BN in terms of reward magnitude and the behaviors that elicit such brain activation (Ehrlich et al., 2015; Wierenga et al., 2014).

The first study aim was to assess rates of DE behaviors in a college student population. It was hypothesized that individuals with greater disordered eating behaviors will display riskier decision making compared to individuals with fewer disordered eating behaviors, as DE populations may rely more on immediate, emotion-centered decision making strategies. It was also hypothesized that greater delay discounting and worse performance on other executive function measures will be seen with greater rather than fewer self-reported disordered eating behaviors.
Methods

Participants

Participants first completed an online screening assessing eating behaviors. A total of 412 participants, ages 18-64, completed this online screening (181 males, $M_{age} = 18.76$ [$SD_{age} = 2.98$], 71.0% Caucasian). A subgroup of 86 participants (a mix of DE and non-DE participants) took part in the lab-based protocol (22 males, $M_{age} = 18.26$ [$SD_{age} = 0.62$], 69.1% Caucasian). The present study was approved by the university’s Institutional Review Board.

Measures

**Disordered Eating and Health Questionnaire (DEHQ).** For the present study, a series of questions were developed assessing eating and other health behaviors (Appendix A). Questions assessed various factors including current weight, history of dieting and purging behaviors (e.g., use of laxatives/diuretics, vomiting, and excessive exercise to lose weight), and average food intake, including each of the major food groups (e.g., fruits, vegetables, grains, proteins).

**Eating Attitudes Test-26 (EAT-26).** The EAT-26 (Appendix B) is a 26-item measure used as a screening tool for the presence/absence of an eating disorder (Garner et al., 1982). Responses ranged from 0 (*none to minimal*) to 3 (*always*), with higher scores indicating a greater likelihood of eating disorder pathology. Summed scores were calculated for the present study. Additionally, scores on this measure were split by participants scoring above or under the cut-off score of 20 put forth by the authors to indicate DE (Garner et al., 1982).

**Eating Disorder Examination Questionnaire (EDE-Q).** The EDE-Q (Appendix C) is a 28-item measure of eating disorder severity (Fairburn, 2008). The EDE-Q includes four subscales that further assess the cognitive structure of eating disorders: Restraint (Items 1-12),
Eating Concern (Items 13-18), Shape Concern (Items 19-21), and Weight Concern (Items 22-28). Responses were calculated according to the amount of days (out of the past 28 days) one has acted on the question (e.g., “Have you been deliberately trying to limit the amount of food you have been eating to influence your shape or weight (whether or not you have succeeded)?”), with scores ranging from 0 (No days) to 6 (Every day). Summed scores for each of the four subscales were calculated for the present study, with higher scores indicative of more severe eating disorder symptomology (Fairburn, 2008).

**Balloon Analogue Risk Task (BART).** The BART was designed to assess real-world risk-taking behavior in both adolescents and adults (Lejuez et al., 2002). This computerized task presents participants with 30 balloons, one at a time, with money earned by pumping up each balloon. Balloons will pop if pumped up too much, resulting in the loss of accumulated money for that balloon. To be successful on the BART, participants must stop pumping and bank the accumulated money before the balloon pops as banked money cannot then be lost on subsequent trials. Each balloon has an explosion point—unbeknownst to the participant—ranging from 1 to 128 pumps (Lejuez et al., 2002); thus, risk taking is rewarded (increased money) via increased pumps. However, as the amount of pumps increases for each balloon, so too does the amount of risk. Risk taking on the BART is then defined as a higher number of pumps per unexploded balloon (it is unclear how far participants are willing to pump on exploded balloons, and thus exploded balloons were omitted from analysis). The present study analyzed the average number of pumps per balloon, with higher numbers indicative of increased risk-taking behavior.

**Columbia Card Task-Cold (CCT).** The CCT, a measure of risky decision making, was designed to measure both hot and cold decision making (Figner & Voelki, 2004). The present study focused on the CCT-cold, which was designed to mimic cold decision making processes: a
focus on cognitive/evaluative strategies that are removed from immediate, emotion-centered
decision making purported in hot decision making processes (Figner, Mackinlay, Wilkening, &
Weber, 2009). At the start of each trial, participants are given information concerning the
number of potential loss cards, the amount that be gained per win card, and the amount that can
be lost with a loss card (Figner & Voelki, 2004). Participants then see a series of numbered
buttons (0 to 32) onscreen and are told to click the button that is indicative of the total number of
selected cards per trial. Participants are not given any feedback regarding gains/losses in points.
As such, the CCT-cold is thought to assess cold decision making in that the participants are
solely relying on provided information—and not immediate feedback/emotion-centered (gut
feelings) components—to make a decision on the number of cards to select (Figner et al., 2009).

Game of Dice Task (GDT). The computerized GDT assess risk-taking behavior as a
function of decision making (Brand et al., 2005). The GDT mimics a gambling-type situation,
taking into consideration the possible impact of executive functions on decision making.
Participants were told to maximize profit within 18 throws of a single virtual die (Brand et al.,
2005). Prior to each throw, participants were instructed to select a single number or combination
of numbers (up to four numbers), with each selection bearing potential gain/loss amounts.
Selecting a single number yields in the greatest gain but also the greatest loss ($1000).
Conversely, selecting a combination of numbers yields smaller gain but also smaller loss ($200).
Selections (1,2,3,4) indicate greater (1,2) or lesser (3,4) risky decision making (Brand et al.,
2005). The present study assessed risky decision making by utilizing the net score, which was
calculated by subtracting the number of risky choices (1 or 2 numbers) from less risky (3 or 4
numbers) choices.
Iowa Gambling Task (IGT). Participants completed the standard computerized version of the IGT to assess risky decision making (Bechara, 2007; Bechara et al., 1994). Participants start with a loan of $2,000 and were given instructions to maximize profit over 100 trials. Participants made selections from four decks of cards (Decks A, B, C, and D). Decks A and B result in an average profit of $100 per selection, whereas Decks C and B result in an average profit of $50 per selection. However, after making 10 selections from Decks A and B, participants have incurred a net loss of $250. After making 10 selections from Decks C and D, participants have incurred a net gain of $250 (Bechara et al., 1994). Thus, Decks A and B are terms “disadvantageous” decks, whereas Decks C and D are termed “advantageous” decks. It is important to analyze performance on the IGT as the task progresses, for such information provides important distinctions in decision making performance across earlier and later deck selections. The initial trials of the IGT, termed decision making under ambiguity (Brand, Recknor, Grabenhorst, & Bechara, 2007), usually constitute deck selections from both disadvantageous and advantageous decks as participants do not know much about the relative risks and benefits of each deck. The final trials (60 [Brand et al., 2007] or 40 [Ko et al., 2010; Noel, Bechara, Dan, Hanak, & Verbanck, 2007]), termed decision making under risk, are different from the initial trials in that participants have gained enough experience with the IGT to learn of the relative risks and benefits of each deck. Thus, continued selections from disadvantageous decks during the final trials constitutes risky decision making. To examine the influence of DE behaviors on both decision making under ambiguity and decision making under risk, the present study analyzed performance as a difference score: advantageous minus disadvantageous deck selections across five, 20-card blocks of trials (Blocks 1-5).


**Delay Discounting Task (DDT).** The 27-item DDT uses varying levels of reward and time intervals to assess delay discounting: a preference for smaller, immediate rewards over larger but distant rewards. (Kirby et al., 1999). Participants viewed various scenarios (e.g., “$55 today or $75 in 61 days”; Kirby et al., 1999) followed by selections of preference. $k$-values were calculated. Higher $k$-values were indicative of a preference for smaller, immediate rewards over larger but distant rewards (Kirby et al., 1999). As previously stated, research has linked various eating disorder populations such as BN to greater temporal discounting, reflecting deficits in self-control that show a preference for more short-term/immediate reward over long-term/distant reward (Wierenga et al., 2014).

**Tower of London (TOL).** The TOL, a measure designed to assess problem solving and planning ability, uses three beads and three equally sized posts that can each support three beads (Shallice, 1982). The three beads are placed in a starting configuration and the participant is instructed to move the beads to a target configuration while also following rules for bead movement: can only move one bead at a time; bead moved must be available for movement (i.e., cannot be a bead beneath stacked beads); and the target configuration must be met within a certain amount of moves (Shallice, 1982). Three measures are assessed by the TOL: (1) planning time: time from presentation of the item and first movement; (2) errors: the number of excess moves needed to satisfy the target configuration; and (3) action time: the time spent completing each task (Shallice, 1982). The present study assessed total score (including the number of errors) and time to complete the task, with lower scores and greater time to complete indicating decreased planning ability.

**Wisconsin Card Sorting Task (WCST).** The WCST, a measure designed to assess set-shifting (i.e., flexibility with changing principles/reinforcement), tasked participants with
matching cards to one of four key cards (Heaton, Chelune, Talley, Kay, & Curtiss, 1993). Feedback is provided on a trial-by-trial basis, for the sorting principles change over time and without warning. Thus, participants must be able to adapt to changes in the sorting principles, an ability that is implicated in various executive functions measured by the WCST: abstract thinking, problem solving, preservation, and cognitive set shifting (Heaton et al., 1993). The present study analyzed total errors (i.e., total incorrect responses), total perseverative errors (i.e., rule-governed responses despite a change in the stimulus requiring a different rule), and failures to maintain set (i.e., response consistency, or the ability to make (or not make) several correct responses in a row).

**Procedure**

Participants gave informed consent for both the online and in-lab sessions and were debriefed at the end of each session. The online session included administration of the DEHQ, EAT-26, EDE, and demographic questionnaires. Completion of the online session allowed interested participants to sign up for the lab-based session. The second session consisted of the BART, CCT, DDT GDT, IGT, TOL, and WCST in a randomized order. Participants were given course credit after each session.

**Data Analysis**

First, prevalence rates of DE behaviors were examined. For the EAT, responses were scored according to Garner et al. (1982), with higher scores indicating greater DE behaviors. In addition, the cut-off score of 20 (Garner et al., 1982) was utilized to classify individuals into groups based on the presence or absence of DE behaviors. The same occurred for the EDE (Fairburn, 2008). The present study also sought to consider gender differences in eating behaviors. To assess the second hypothesis, that there would be relationships between DE
behaviors and decision making and other executive functions, correlations were calculated between EAT and EDE scores and the BART, CCT, GDT, IGT, DDT, TOL, and WCST. In addition, independent-samples *t*-tests were conducted comparing task performance as a function of presence (coded 1) or absence (coded 0) of DE behaviors on the EDE and EAT separately.

**Results**

EAT summary and EAT cutoff scores were calculated, with descriptive statistics highlighting minimum, maximum, and mean scores of DE behaviors across all participants and by gender presented in Table 1. EAT cutoff scores revealed 10.9% of the sample reported high levels of DE behaviors. Broken down by gender, 5.0% of males and 15.8% of females scored above the cut-off on the EAT. An independent samples *t*-test comparing DE behaviors by gender revealed higher levels of DE behaviors (summed score) among females than males on the EAT, \( t(407) = -4.95, p < .001 \). A Pearson chi-square test on the EAT cutoff score indicated a greater proportion of DE behaviors among females than males, \( \chi^2(1, N = 409) = 12.06, p = .001 \).

Examining the EDE, females reported greater DE behaviors than males on Restraint, \( t(407) = -6.87, p < .001 \); Shape Concern, \( t(407) = -4.22, p < .001 \); and Weight Concern, \( t(407) = -8.76, p < .001 \). No differences were found for Eating Concern, \( t(407) = -1.30, p = .20 \). Given the small sample size for the in-person study session and the low number of males, no gender comparisons could be made for the in-person session data.

Means and standard deviations for the decision making tasks are presented in Table 2. Correlations were calculated between DE questionnaires and the decision making tasks (Table 2). Higher levels of EDE Restraint and Weight Concern were associated with riskier decision making on the BART. Similarly, EDE Restraint and EAT summed scores were correlated with the DDT, revealing that higher levels of DE behaviors were associated with preferences for
short-term, immediate rewards over longer-term but temporally distant rewards. Significant
correlations also emerged between EDE Eating Concerns and the IGT. On the later trials (Blocks
4 and 5), higher DE behaviors were associated with more disadvantageous (or riskier) decision
making. No significant correlations emerged with the EAT and EDE measures and performance
on the other decision making tasks (GDT, CCT).

Correlations between measures of executive functioning and DE behaviors were also
observed (Table 2). In particular, significant correlations emerged between EDE Restraint, Shape
Concern, and Weight Concern and the TOL in terms of time to complete and total score on the
task. Such correlations reveal that higher levels of DE behaviors were associated with a general
slowness in planning on the task, as well as lower scores (greater number of moves and more
errors). Correlations also emerged between EDE Weight Concern and the WCST. Specifically,
and contrary to expectation, individuals with higher levels of DE behaviors had fewer failures to
maintain set (i.e., better ability to adjust to changing task demands and maintain focus on the
current task instructions).

Discussion

The present study sought to examine DE prevalence rates in a college sample during a
screening session, as well as how DE behaviors might be related to risky decision making and
other executive functions. First, prevalence rates of self-reported DE behaviors were examined,
in general and split by gender. In total, 10.9% of the sample self-reported behaviors indicative of
DE (i.e., scored above the cut-off on a measure of DE behaviors). Moreover, DE prevalence rates
were significantly higher in females (15.8%) than males (5.0%). These findings reflect previous
research pointing to higher prevalence rates of DE behaviors among women compared to men, as
well as higher rates of eating disorders among women compared to men (Bunnell, 2015; Uzun et
These preliminary findings show that there is likely a high rate of problematic eating behaviors among college-aged adults, but it is as of yet unclear the percentage of individuals with DE behaviors that transition to clinical eating disorders. The present study sought to provide evidence for the existence of this subclinical stage of eating disorders, with results suggesting that earlier onset of cognitive sequelae could occur prior to diagnosis of an eating disorder.

It was also hypothesized that risky decision making would be seen in a DE population, and this hypothesis was partially supported. More specifically, risky decision making was observed as a function of DE behaviors across the BART, DDT, and IGT, but not the CCT or GDT. Significant correlations were observed between the Restraint and Weight Concern subscales and the BART, with higher ratings on each subscale associated with more pumps per unexploded balloon (i.e., risky decision making). The Restraint subscale and the EAT were positively correlated with the DDT, with greater DE associated with a preference for short-term, immediate gains over larger, long-term outcomes. Finally, negative correlations were observed between the Eating Concern subscale and the IGT, with greater DE associated with more selections from disadvantageous decks. The results with the IGT are consistent with previous research, in that a type of eating disturbance was associated with risky decision making (Brogan et al., 2010; Cavedini et al., 2004; Danner et al., 2011). Previous research with the DDT revealed risky decision making in a population with BN (Boeka & Lokken, 2006; Brogan et al., 2010; Liao et al., 2009). Findings with a DE population appear to mimic this impairment in reward processing seen in BN, rather than the relative improvement (i.e., greater focus on long-term outcomes) observed in populations with AN (Cavedini et al., 2004; Ehrlich et al., 2015).

The present study is the first to examine eating behaviors on the BART, CCT, and GDT, with results suggesting that impairments are mixed on these tasks. Importantly, not all measures
of decision making assess the same type of decision making (Buelow & Blaine, 2015). Such decision making measures could divide into groups based on the idea of Type I and Type II decisions (Kahneman, 2011). Type I decisions are viewed as emotion-centered, motivated by gut-reactions to stimuli (Kahneman, 2011). By contrast, Type II decisions are more calculated and deliberative, removed from emotions and motivated by methodical, costs versus benefits processes (Kahneman, 2011). Behavioral tasks such as the BART and DDT, as well as the early IGT trials, have been linked with Type I decision making, whereas tasks such as the GDT and later IGT trials instead utilize Type II decision making. The present results support this distinction in a DE sample. Higher DE was associated with riskier decision making on both the BART and DDT, which may reflect a tendency of individuals self-reporting DE behaviors to rely on gut feelings to guide decisions. Real-world evidence exists of this decision making process, as many DE behaviors can reflect emotion-based evaluative properties rather than concern for long-term consequences (i.e., preference for short-term, immediate gains). That DE was associated with riskier decisions on the later IGT trials might indicate that emotion-based decision making (Type I) impaired initiation of Type II decision making on this task. To perform well on the IGT, individuals much replace Type I decisions with more strategic, Type II decision, following a period in which the participant learns the relative risks and benefits of each deck (Brand et al., 2007). This process was disrupted in individuals reporting higher DE behaviors.

Finally, it was hypothesized that performance on other executive functioning tasks would be impaired in a DE population, and this hypothesis was also partially supported. Significant correlations were observed between Restraint, Shape Concern, and Weight Concern subscales from the EDE and time to complete and overall performance on the TOL. These findings are consistent with previous research that found impaired executive functioning among individuals
with diagnosed eating disorders (Juarascio et al., 2015). Additional analyses in the present study revealed significant correlations between the Weight Concern subscale of the EDE and ability to maintain set on the WCST. Collectively, the results with the TOL and WCST reveal opposing stories. Results with the TOL support the notion that higher DE behaviors are associated with greater difficulties planning ahead for long-term outcomes and examining the effects of a current choice (a “move” on the task). This finding is similar to our result with the DDT, in that there is a short-sighted focus on immediate gains over long-term consequences. However, results with the WCST revealed greater DE behaviors were associated with a greater ability to maintain set on the WCST. Maintaining set on the WCST occurs when individuals are able to respond to multiple items in a row in a consistent and correct manner (i.e., response consistency). It is possible that such response consistency could reflect a type of obsessive-compulsive tendency in a DE population, a clinical feature that has been documented in some eating disorder samples (Garcia-Soriano, Roncero, Perpina, & Belloch, 2014; Pollack & Forbush, 2013). More specifically, obsessive-compulsive tendencies in a DE population may make such individuals acutely aware of changes in their environment, which could lead to an improved ability to moderate responses to consistently follow a new rule.

The present study is the first to examine decision making and executive functioning in a DE population. In general, results reveal that risky decision making and impaired executive functions may occur prior to the diagnosis of a clinical eating disorders. More specifically, in the present study individuals with greater DE behaviors showed a preference for short-term, immediate gains over long-term outcomes. Such a decision making strategy is seen in both DE and eating disorder behaviors, as such behaviors function to maximize immediate gains as accessed with weight loss goals, as one example. As such, it could be the case that these
executive impairments may lead to the development of such disorders, thereby revealing a potential avenue of prevention and intervention. However, this is a preliminary study and additional research is needed before making this conclusion. Considering the preliminary nature of the present study, future research should expand on these findings by increasing the number and type of assessment measures and utilizing clinical assessment of eating disorder pathology by a clinical practitioner.

**Limitations**

The present study had several limitations. First, we relied on self-report measures to assess DE behaviors. In general, self-report measures could underestimate the actual prevalence of behaviors if individuals are uncomfortable sharing such information with a researcher. Future research should attempt to better assess DE behaviors with the use of more thorough measures and a structured clinical interview. It could also be the case that social desirability factors influenced responses, particularly among men. As maladaptive eating patterns are often regarded as “feminine” issues, accurate disclosure of DE behaviors could be withheld among men due to societal pressures to conform to normative masculine behavior. Third, the present study used a limited span of executive functioning measures to assess potential higher-order cognitive impairment among DE populations. Future research should attempt to include more measures of executive functions, such as the Frontal Systems Behavior Scale (FrSBe; Grace & Malloy, 2001), which specifically examines features such as executive dysfunction and disinhibition. In addition, measures of emotional processing would be useful in assessing the degree to which individuals with DE can successfully regulate emotions (e.g., negative, positive, and neutral emotions). Including psychophysiological recordings, such as heart rate variability, could help elucidate the relationships between DE, executive functions, and emotional processing.
Moreover, such research could better our understanding of higher-order impairment that could potentially serve as risk factors for the development of DE behaviors.

**Conclusion**

The present study had two general study aims: to assess overall prevalence rates of DE behaviors in a college population, and to assess decision making and executive functioning processes in a DE population. Overall DE rates were higher than for eating disorders, but gender differences were maintained in this non-clinical population. Risky decision making was observed with the BART, DDT, and later trials of the IGT in individuals with higher reported DE behaviors. Impairments in executive functioning were observed with the TOL in terms of planning ability, but the opposite was seen on a measure of problem solving (WCST). Future research should seek to expand on potential decision making and executive functioning impairments, as such variables could potentially predict the development of clinical eating disorders. Such findings could reveal a potential avenue for eating disorder prevention and intervention efforts.
References


doi:10.1016/j.brat.2015.01.007


Appendix A

Disordered Eating and Health Questionnaire

1. Do you know your current weight?
   Yes _____ No _____
   If yes, please indicate your current weight: _____
   If no, please make your best guess of your current weight: _____

2. What was your highest weight (excluding pregnancy)? _______

3. What was your lowest adult weight? ________

4. What is your ideal weight? __________

5. What is your current height? _____ feet _____ inches

6. How many times a week do you weigh yourself? ______

7. Do you feel you are overweight?
   Yes _____ No _____
   If yes, what is your goal weight? _____

8. Have you ever dieted to lose weight?
   Yes _____ No _____
   If yes, how many times have you dieted to lose weight in the past year? _____
   If yes, how many times have you dieted to lose weight in your lifetime? _____

9. Have you ever exercised to lose weight?
   Yes _____ No _____
   If yes, please describe a typical exercise session. __________________________

10. How many times per week do you exercise? ______
    How often do you engage in aerobic exercise (such as running, playing tennis, bicycling)? _____
    How often do you engage in anaerobic exercise (such as strength training/lifting weights)? _____

11. When you exercise, how long is your exercise session? _____
12. Have you ever taken diet pills to lose weight?
   Yes _____  No _____
   If yes, which diet pills have you tried? ____________________________
   When did you use these diet pills? ________________________________

13. Have you ever taken laxatives to lose weight?
   Yes _____  No _____
   If yes, which laxatives have you tried? ____________________________
   When did you use these laxatives? ________________________________
   How many laxatives would you usually take at one time? ______________

14. Have you ever felt like you could not stop eating?
   Yes _____  No _____

15. Have you ever vomited after eating?
   Yes _____  No _____
   If yes, how often do you vomit after eating currently? ________________
   How often did you vomit after eating in the past? ____________________

16. Have you ever deprived yourself of food so as to lose weight?
   Yes _____  No _____
   If yes, please describe this behavior. ________________________________
   How often do you deprive yourself of food to lose weight? ______________

17. Have you ever deprived yourself of food for other reasons (NOT to lose weight)?
   Yes _____  No _____
   If yes, what were those reasons? _________________________________
   How often do you engage in this behavior? _________________________

18. Do you feel dissatisfied with your current weight?
   Yes _____  No _____

19. Does the thought of gaining weight make you anxious?
   Yes _____  No _____
20. Do you find it hard to balance your weight in the midst of your daily routine?
   Yes _____ No _____

21. Do you think about your weight or losing weight often?
   Yes _____ No _____
   If yes, how often do you think about your weight or losing weight? __________
   If daily, how many times per day? __________

22. Please describe your food intake today, including: what meal, what time of day, the food eaten, the amount of food eaten, and how you felt after eating.
   Is this a typical day in terms of what/how much you ate?
   Yes _____ No _____

23. Please describe your food intake yesterday, including: what meal, what time of day, the food eaten, the amount of food eaten, and how you felt after eating.
   Is this a typical day in terms of what/how much you ate?
   Yes _____ No _____

24. Do you count calories as you eat?
   Yes _____ No _____

25. Do you count calories after you eat?
   Yes _____ No _____

26. Do you have a set number of calories that you consume on a daily basis?
   Yes _____ No _____
   If yes, please indicate the number of calories. __________

27. On average, how many servings of fruits do you eat per day? __________

28. On average, how many servings of vegetables do you eat per day? __________

29. On average, how many servings of grains do you eat per day? __________

30. On average, how many servings of protein (both plant and animal based) do you eat per day? __________

31. On average, how many servings of dairy products do you eat per day? __________
32. On average, how many servings of caffeinated beverages do you drink per day?  

33. On average, how many servings of sugary or processed foods do you eat per day?  

34. Do you have any dietary restrictions due to allergies or religious reasons?  
   Yes _____  No _____  
   If yes, what restrictions do you have? ____________________  

35. On average, how many times per week do you eat at fast food restaurants? _______  

36. Have you ever been diagnosed with an eating disorder?  
   Yes _____  No _____  
   If yes, which disorder? _______  
   When were you diagnosed? _______  
   Have you received treatment for this disorder?  
      Yes, currently _______  
      Yes, in the past _______  
      No _______
## Eating Attitudes Test-26 (EAT-26)

Check a response for each of the following statements:

<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Usually</th>
<th>Often</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Am terrified about being overweight.</td>
<td></td>
<td></td>
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<tr>
<td>2. Avoid eating when I am hungry.</td>
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<tr>
<td>3. Find myself preoccupied with food.</td>
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<td>4. Have gone on eating binges where I feel that I may not be able to stop.</td>
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<td>5. Cut my food into small pieces.</td>
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<tr>
<td>6. Aware of the calorie count of foods that I eat.</td>
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<td>7. Particularly avoid food with a high carbohydrate content (i.e., bread, rice, potatoes, etc.).</td>
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<td>8. Feel that others would prefer if I ate more.</td>
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<td>9. Vomit after I have eaten.</td>
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<td>10. Feel extremely guilty after eating.</td>
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<td>11. Am preoccupied with a desire to be thinner.</td>
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<td>12. Think about burning up calories when I exercise.</td>
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<td>13. Other people think that I am too thin.</td>
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<tr>
<td>14. Am preoccupied with the thought of having fat on my body.</td>
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<td>15. Take longer than others to eat my meals.</td>
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<tr>
<td>16. Avoid foods with sugar in them.</td>
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<td>17. Eat diet foods.</td>
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<td>18. Feel that food controls my life.</td>
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<td>19. Display self-control around food.</td>
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<td>20. Feel that others pressure me to eat.</td>
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<td>21. Give too much time and thought to food.</td>
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<tr>
<td>22. Feel uncomfortable after eating sweets.</td>
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<tr>
<td>23. Engage in dieting behavior.</td>
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<td>24. Like my stomach to be empty.</td>
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<td>25. Have the impulse to vomit after meals.</td>
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</tbody>
</table>
In the past 6 months, have you:

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>1x per month or less</th>
<th>2-3x per month</th>
<th>1x per week</th>
<th>2-6x per week</th>
<th>1x per day or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Gone on eating binges where you feel that you may not be able to stop? *</td>
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<tr>
<td>B. Ever made yourself sick (vomited) to control your weight or shape?</td>
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<tr>
<td>C. Ever used laxatives, diet pills, or diuretics (water pills) to control your weight or shape?</td>
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<td></td>
</tr>
<tr>
<td>D. Exercised more than 60 minutes a day to lose or to control your weight?</td>
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<tr>
<td>E. Lost 20 pounds or more in the past 6 months?</td>
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</tbody>
</table>

*Defined as eating much more than most people would under the same circumstances and feeling that eating is out of control.
Appendix C

Eating Disorder Examination Questionnaire (EDE-Q)

The following questions are concerned with the past four weeks (28 days) only. Please read each question carefully. Please answer all questions.

0 = No days 3 = 13-15 days 5 = 23-27 days
1 = 1-5 days 4 = 16-22 days 6 = Every day
2 = 6-12 days

On how many of the past 28 days…

1. Have you been deliberately **trying** to limit the amount
   of food you eat to influence your shape or weight
   (whether or not you have succeeded)?

2. Have you gone for long periods of time (8 waking hours or more) without eating anything at all in order to influence your shape or weight?

3. Have you **tried** to exclude from your diet any foods that you like in order to influence your shape or weight (whether or not you have succeeded)?

4. Have you **tried** to follow definite rules regarding your eating (for example, a calorie limit) in order to influence your shape or weight (whether or not you have succeeded)?

5. Have you had a definite desire to have an **empty** stomach with the aim of influencing your shape or weight?
6. Have you had a definite desire to have a ___
   totally flat stomach? 0 1 2 3 4 5 6

7. Has thinking about food, eating, or calories made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)? 0 1 2 3 4 5 6

8. Has thinking about shape or weight made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)? 0 1 2 3 4 5 6

9. Have you had a definite fear of losing control over eating? 0 1 2 3 4 5 6

10. Have you had a definite fear that you might gain weight? 0 1 2 3 4 5 6

11. Have you felt fat? 0 1 2 3 4 5 6

12. Have you had a strong desire to lose weight? 0 1 2 3 4 5 6
Please fill in the appropriate number. Remember that the questions only refer to the past four weeks (28 days).

**Over the past four weeks (28 days)…**

13. How many times have you eaten what other people would regard as an unusually large amount of food (given the circumstances)? __________

14. On how many of these times did you have a sense of having lost control over your eating (at the time that you were eating)? __________

15. On how many days have such episodes of overeating occurred (i.e., you have eaten an unusually large amount of food and have had a sense of loss of control at the time)? __________

16. How many times have you made yourself sick (vomit) as a means of controlling your shape or weight)? __________

17. How many times have you taken laxatives as a means of controlling your shape or weight? __________

18. How many times have you exercised in a “driven” or “compulsive” way as a means of controlling your weight, shape, or amount of fat, or to burn off calories? __________
Please circle the appropriate number. Please note that for these questions the term “binge eating” means eating what others would regard as an unusually large amount of food for the circumstances, accompanied by a sense of having lost control over eating.

0 = No days  
1 = 1-5 days  
2 = 6-12 days  
3 = 13-15 days  
4 = 16-22 days  
5 = 23-27 days  
6 = Every day

19. Over the past 28 days, on how many days have you eaten in secret (i.e., furtively)? Do not count episodes of binge eating.

0 1 2 3 4 5 6

20. On what proportion of the times that you have eaten have you felt guilty (felt that you’ve done wrong) because of its effect on your shape or weight? Do not count episodes of binge eating.

0 1 2 3 4 5 6

21. Over the past 28 days, how concerned have you been about other people seeing you eat? Do not count episodes of being eating.

0 1 2 3 4 5 6
Please circle the appropriate number on the right. Remember that the questions only refer to the past four weeks (28 days).

<table>
<thead>
<tr>
<th>Question</th>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Markedly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over the past 28 days...</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>22. Has your <strong>weight</strong> influenced how you think about (judge) yourself as a person?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>23. Has your <strong>shape</strong> influenced how you think about (judge) yourself as a person?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>24. How much would it have upset you if you had been asked to weigh yourself once a week (no more, or less, often) for the next four weeks?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>25. How dissatisfied have you been with <strong>weight</strong>?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>26. How dissatisfied have you been with <strong>shape</strong>?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>27. How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath/shower)?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>28. How uncomfortable have you felt about <strong>others</strong> seeing your shape or figure (for example, in communal changing rooms, when swimming, or wearing tight clothes)?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 1. Means, standard deviations, and ranges for eating behavior questionnaires.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$n$</th>
<th>Min</th>
<th>Max</th>
<th>$M$</th>
<th>$SD$</th>
<th>$M$</th>
<th>$SD$</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAT</td>
<td>412</td>
<td>0</td>
<td>63</td>
<td>10.10</td>
<td>8.54</td>
<td>7.85</td>
<td>6.44</td>
<td>11.95</td>
<td>9.57</td>
</tr>
<tr>
<td>EAT-2</td>
<td>412</td>
<td>0</td>
<td>13</td>
<td>2.61</td>
<td>2.69</td>
<td>2.47</td>
<td>2.64</td>
<td>2.73</td>
<td>2.73</td>
</tr>
<tr>
<td>EDE-1</td>
<td>412</td>
<td>0</td>
<td>70</td>
<td>12.50</td>
<td>15.21</td>
<td>7.02</td>
<td>10.66</td>
<td>16.90</td>
<td>16.84</td>
</tr>
<tr>
<td>EDE-2</td>
<td>412</td>
<td>0</td>
<td>84</td>
<td>8.27</td>
<td>14.37</td>
<td>7.17</td>
<td>13.30</td>
<td>9.02</td>
<td>15.15</td>
</tr>
<tr>
<td>EDE-3</td>
<td>412</td>
<td>0</td>
<td>15</td>
<td>1.30</td>
<td>2.67</td>
<td>.69</td>
<td>1.67</td>
<td>1.80</td>
<td>3.19</td>
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<tr>
<td>EDE-4</td>
<td>412</td>
<td>0</td>
<td>42</td>
<td>11.47</td>
<td>12.10</td>
<td>6.08</td>
<td>8.69</td>
<td>15.76</td>
<td>12.68</td>
</tr>
</tbody>
</table>

*Note: Min = minimum score; Max = maximum score; EAT = Eating Attitudes Test; EDE = Eating Disorder Examination (1 = Restraint; 2 = Eating Concern; 3 = Shape Concern; 4 = Weight Concern)*
Table 2. Correlations between study variables.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>EAT</td>
<td>86</td>
<td>10.88</td>
<td>8.50</td>
<td>--</td>
<td>.556***</td>
<td>.696***</td>
<td>.337***</td>
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<tr>
<td>2.</td>
<td>EAT-2</td>
<td>86</td>
<td>2.67</td>
<td>2.61</td>
<td>--</td>
<td>.526***</td>
<td>.380***</td>
<td>.499***</td>
</tr>
<tr>
<td>3.</td>
<td>EDE-1</td>
<td>86</td>
<td>13.19</td>
<td>16.09</td>
<td>--</td>
<td>.451***</td>
<td>.703***</td>
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</tr>
<tr>
<td>4.</td>
<td>EDE-2</td>
<td>86</td>
<td>8.28</td>
<td>16.47</td>
<td>--</td>
<td></td>
<td>.399***</td>
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<tr>
<td>5.</td>
<td>EDE-3</td>
<td>86</td>
<td>1.53</td>
<td>2.81</td>
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<td>6.</td>
<td>EDE-4</td>
<td>86</td>
<td>11.99</td>
<td>12.41</td>
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<td>7.</td>
<td>BART</td>
<td>85</td>
<td>22.28</td>
<td>11.02</td>
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<tr>
<td>8.</td>
<td>GDT</td>
<td>84</td>
<td>10.90</td>
<td>4.94</td>
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*p < 0.05; **p < .01; ***p < .001

Note: Min = minimum score; Max = maximum score; EAT = Eating Attitudes Test; EDE = Eating Disorder Examination (1 = Restraint; 2 = Eating Concern; 3 = Shape Concern; 4 = Weight Concern); BART = Balloon Analogue Risk Task, average adjusted pumps per balloon; GDT = Game of Dice Task, net score; CCT = Columbia Card Task cold, average selections per trial; DDT = Delay Discounting Task, $k$-value; IGT = Iowa Gambling Task, net score by 20-card block of trials; WCST = Wisconsin Card Sort Task, total errors (E), total perseverative errors (PE), and failures to maintain set (FMS); TOL = Tower of London, total latency (time) and overall performance (score).
Table 2. Correlations between study variables (continued).

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