Exploring the Impact of Mood States on Motivation to Consume Food and Non-Food Rewards in Individuals with Loss of Control Eating

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A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Psychology

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Abstract

**Introduction.** Loss of control (LOC) eating episodes are eating episodes in which an individual feels they cannot control what or how much they are eating, regardless of the amount of food consumed. These episodes are associated with significant psychological distress, psychiatric comorbidity, and reduced quality of living. Both negative affect and heightened reward processing of food have been posited as mechanisms that contribute to LOC eating. However, few studies have investigated whether negative affect influences reward processing of food and/or non-food rewards in individuals with LOC eating. Understanding how purported mechanisms of LOC work *in conjunction* may help to identify more accurate risk states for LOC eating and better inform treatment targets. **Methods.** Participants (*N* = 46) with LOC eating underwent either a negative or a neutral mood induction prior to performing two behavioral tasks assessing motivation to consume food and non-food rewards. Specifically, the tasks measured the amount of effort participants were willing to expend to receive either chocolate candies or a leisure reward (i.e., the opportunity to play the Angry Birds game on a computer for one minute). Mixed ANOVAs were conducted to assess whether participants with LOC eating would expend more effort (i.e., in the form of greater number of keyboard presses) for food rewards relative to leisure rewards and whether this effect would be greater when participants were in a negative (vs. neutral) mood state. **Results.** We failed to find main effects of mood condition or reward type or an interaction between mood and reward type on the amount of effort expended *F*(1,44) = 0.4, *p* = 0.53, *η*^2^ = .01. **Conclusion.** Results suggest that mood states may not increase
motivation for food in individuals with LOC eating; however, limitations with sample size prohibit strong conclusions from being drawn.

**Key Words**

Loss of control over eating, binge eating, eating disorders, affect, reward
Summary For Lay Audiences

Loss of control (LOC) eating occurs when an individual feels as if they do not have control over their eating, regardless of the amount of food they are eating. The experience of LOC can be distressing and contribute to the development of other eating disorder behaviors. Individuals who report LOC-eating episodes report lower quality of life and are more likely to have other mental health disorders. Thus, it is important to understand factors that contribute to LOC eating.

Some researchers have proposed that being in a negative mood increases the likelihood of binge eating (a phenomenon when an individual has loss of control over their eating and eats a very large amount of food). Other researchers have proposed that how rewarding an individual finds food versus other types of rewards (e.g., leisure rewards) can contribute to binge eating. The purpose of the current study was to investigate whether individuals with LOC-eating episodes find food rewards more rewarding than leisure rewards and whether this difference is greater when individuals are in a negative mood state. These questions were assessed by examining how hard individuals with LOC eating worked on a computer task to receive either food rewards (i.e., M&M candies) or leisure rewards (i.e., the opportunity to play the Angry Birds game). Half of the participants completed the computer tasks in a negative mood while the other half completed the tasks in a neutral mood.

Despite strong theoretical support for our hypotheses, we did not find a significant difference in how rewarding people found food versus leisure rewards. Moreover, negative mood states did not increase how rewarding participants found the food or leisure rewards. These results imply that negative mood may not increase motivation for
food in individuals who experience LOC-eating episodes. This study adds to the literature on factors that contribute to LOC eating by investigating the role of multiple mechanisms at once (reward and mood).
Acknowledgements

First and foremost, I would like to thank my supervisor, Dr. Lindsay Bodell, for her mentorship both on this project and more broadly in my career. Without her guidance, patience, and insight, this project would be a fraction of what it came to be. I am lucky to have a mentor that is both brilliant and kind — graduate school would not be the same endeavor without her support! Thank you also to Dr. Elizabeth Hayden, Dr. Jodie Culham, Dr. Paul Tremblay, Dr. David Dozois, and Dr. Leora Schwartzman for their recommendations and feedback as this project evolved. Thank you also to Dr. David Dozois, Dr. Blair Evans, and Dr. Shannon Stewart for serving on my thesis defense committee. Thank you to all of my RAs who made this study possible, and to the participants who gave their time to this study!

I would also like to thank my family for their perpetual love and support. To my parents, thank you for inspiring my love of asking questions and for supporting me at every step of my education; to my sisters, thank you for being one of my life’s greatest joys. It is hard to articulate how much you all have contributed to my life and to this milestone.

Thank you to my loving, supportive partner and to my wonderful friends. I feel extremely lucky to love and be loved by you all. Near or far, you make my life exciting. I would especially like to thank my cohort for your friendship these past two years. From our first escape room, I have cherished our joyful chaos.

In addition, I would like to thank the other members of the PEAR lab not only for their friendship, but also their informal mentorship. Graduate school has been exponentially easier with your support and shared curiosity. Some of my favorite days in grad school are when we chat about research over lunch in our shared office. That home base was a safe place to explore ideas and learn, and for that I am grateful.
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Background

Binge eating is a prevalent eating behavior that is associated with significant impairment and medical and psychiatric morbidities (Goldschmidt, 2017; Grucza et al., 2007). The defining feature of binge eating in both the Diagnostic and Statistical Manual (DSM-5-TR; American Psychiatric Association, 2022) and the International Classification of Diseases (ICD-11; 2019) is the subjective experience of being out of control during food consumption (c.f., loss of control over eating). Although the DSM-5-TR requires binge-eating episodes to involve the consumption of a ‘large’ amount of food, the ICD-11 only requires that binge episodes involve eating ‘more’ or ‘differently’ than usual. Recurrent binge-eating episodes are a defining symptom of binge eating disorder (BED) and bulimia nervosa (BN) and are often present in other eating disorder diagnoses such as anorexia nervosa.

Many researchers argue that the loss of control (LOC) component of binge eating is the most significant aspect, given that LOC eating more broadly is related to various forms of psychosocial impairment in individuals with eating disorders (Goldschmidt, 2017). Indeed, LOC eating, which is defined as feeling a sense of LOC over eating regardless of the amount of food consumed, is associated with increased eating pathology, anxiety, depression, and decreased quality of life (Colles et al., 2008; Dalle Grave et al., 2012; Elder et al., 2008; Jenkins et al., 2012; Palavras et al., 2015; Vannucci et al., 2013). Further, LOC eating is highly prevalent; one study found that nearly half of their sample of young adult women reported LOC eating at least once in the past three months (Vannucci et al., 2013).
Despite its prevalence, LOC eating is poorly understood. Explicating factors that contribute to LOC eating may have implications for treatment and prevention of eating disorders. Two factors thought to be important in the etiology and maintenance of binge eating are affect and reward; however, the ways in which affect and reward may interact to influence LOC eating is unclear. The aims of the current study were to further understand processes involved in LOC eating, namely, whether negative affect increases reward responses to food (vs. non-food rewards) in individuals who report LOC-eating episodes. In the sections below, I outline the relation between negative affect and LOC eating and then discuss the role of reward processing in LOC eating. Finally, I discuss how and why negative affect may be interrelated with reward processing, and in turn, how this relation may increase propensity for LOC eating.

**Differences in Affect between Individuals with and without LOC Eating**

Compared to healthy controls (HC), individuals with BN and BED self-report higher baseline levels of sadness, negative emotions, and depression symptoms (Danner et al., 2013; Zeeck et al., 2010). In higher weight individuals, those with BED report higher levels of depression and anxiety relative to non-BED controls in semi-structured clinical interviews (Schulz & Laessle, 2010). Moreover, continuous measures of LOC severity demonstrate moderate to large correlations with distress and depressive symptoms (Blomquist et al., 2014; Latner et al., 2014; Vannucci et al., 2013). There also is evidence that individuals who report LOC-eating episodes that are too small to meet DSM criteria for full or “objective” binge-eating have comparable or even greater levels of depressive symptoms compared to individuals who do report objectively large binge-eating episodes (Brownstone et al., 2013; Fitzsimmons-Craft et al., 2014). Further, one
study found that individuals who engage in binge eating but did not qualify for a BED diagnosis reported being in worse moods than those without an eating disorder and better moods than those with BED. These findings suggest that mood may be increasingly relevant to LOC eating behaviors as pathology worsens (Greeno et al., 2000).

In addition to high general co-occurrence of internalizing symptoms (e.g., depression, anxiety), negative affective states also have been linked in close temporal proximity to LOC eating episodes. In interviews and self-report questionnaires, participants report that negative affect precedes their binge episodes, with one study finding anger as the most commonly reported antecedent emotion (Zeeck et al., 2010). Meta-analytic findings imply that guilt may be a particularly important emotional state preceding LOC eating (Berg et al., 2013; Stevenson et al., 2018). Additionally, negative emotions in response to negative social interactions may be more likely to predict binge episodes than negative emotions in response to other life events (Zeeck et al., 2010).

Given associations between negative affect and LOC eating, the affect regulation model of binge eating has been proposed. This model posits that negative affect increases before binge-eating episodes and decreases following binge-eating episodes, reinforcing maladaptive coping behaviors and entrenching binge-eating symptoms (Hawkins & Clement, 1984). This model has been tested using ecological momentary assessment (EMA) methods, wherein participants report on their affect and eating behaviors many times throughout the course of the day. One meta-analysis of EMA studies (N=36) found that negative affect preceded binge-eating episodes but that negative affect did not decrease after binge-eating episodes, providing partial support for the affect regulation model. Notably, the authors only included studies with objective (i.e., large) binge-eating
episodes and excluded studies where participants reported on LOC eating more broadly. Further, many of the earlier studies included in this meta-analysis obscured important facets of binge eating or used potentially biased timelines for assessing affective outcomes (Haedt-Matt & Keel, 2011b). For example, most of these studies used non-random sampling methods when assessing post-binge affect. As is common to EMA methodology, participants were prompted to report their affect at random times throughout the day, and they were asked to record when binge-eating episodes occurred. Due to the randomized nature of EMA sampling methods, measures of pre-binge affect would have been recorded at random intervals of time before binges occurred. By design, measurements of affect following binges were not timed randomly. It is possible that prompting participants immediately following binge episodes captures negative affect too close to its peak, obscuring the true slope of negative affect in relation to binge-eating episodes, potentially biasing results. Taken together, this meta-analysis provides evidence that negative affect reliably precedes binge-eating episodes, supporting the first half of the affect regulation model.

More recent research has used EMA to assess the link between negative affect and LOC-eating episodes more broadly. In higher-weight community-recruited adults ($n = 50$) with ($n = 5$) and without ($n = 45$) BED, LOC-eating episodes were associated with greater ratings of pre- and post-eating negative affect compared to non-LOC-eating episodes where a normative amount of food was consumed (Goldschmidt et al., 2014). This relationship may be attenuated or enhanced based on individual characteristics. For example, EMA studies examining the link between LOC eating and negative affect in children and adolescents have not found significant associations between pre-meal
negative affect and LOC-eating episodes (Hilbert et al., 2009; Ranzenhofer et al., 2014). Further, among both pre- \((n = 14)\) and post-operative \((n = 17)\) bariatric surgery patients, negative affect was associated with subsequent LOC ratings; however, this finding was stronger among individuals who were post-operative (Williams-Kerver et al., 2020). In post-operative participants, the relation between negative affect and LOC ratings was moderated by the percent of total body weight individuals lost since surgery. Specifically, within individuals who lost relatively low percentages of their total body weight, there was a stronger relation between high momentary negative affect and subsequent LOC-eating episodes. It is possible that falling short of participant expectations about weight loss post-bariatric surgery may potentiate the relation between negative affect and LOC eating. Together these findings imply that there may be developmental or cognitive characteristics that influence the strength of the association between affect and LOC eating.

Among those for whom pre-meal negative affect is related to LOC eating, the literature has identified facets of negative affect and LOC eating that may be more distinctly related. As noted, there is evidence that guilt, in particular, rises before LOC-eating episodes (Stevenson et al., 2018). Work by Goldschmidt and colleagues (2012) implies that pre-meal negative affect is more strongly related to subjective feelings of LOC than it is to the amount of food consumed during eating episodes. For example, in their study of higher weight adults with \((n = 9)\) and without \((n = 13)\) BED, pre-meal negative affect was associated with greater feelings of LOC during the eating episode \((t = 4.61)\) but not with the number of kilocalories consumed \((t = 0.81)\). These findings held in a sample of individuals with and without BED, implying that negative affect is a relevant
predictor of LOC eating in individuals with varying degrees of eating pathology (Goldschmidt et al., 2012). Taken together, these studies provide evidence that negative affect is a relevant cue preceding LOC-eating episodes, regardless of the amount of food consumed.

**Experimental Differences in Negative Affect and LOC Eating**

In addition to naturalistic self-report studies relating negative affect to LOC eating, researchers also have investigated the influence of experimental inductions of negative affect on food intake and subjective feelings of LOC in individuals with LOC eating. These studies have used both negative mood inductions and stress-inductions. Pre-eminent measures of negative affect include items such as “distress” and “upset” as facets of negative affect (Thompson, 2007). Moreover, models of emotion regulation specific to LOC eating have conceptualized negative affect from both specific negative emotional states (e.g., sadness, guilt, etc.) and general negative affective states (i.e., generalized feelings of stress) (Leehr et al., 2015). Therefore, both types of manipulations are discussed here as ‘negative affect’ inductions.

There is evidence that individuals who report LOC eating are more sensitive to the effects of negative affect inductions. Some researchers have found that negative mood inductions increase sadness in individuals with BED moreso than they do in healthy comparison groups (Svaldi et al., 2014). On the other hand, some studies have found that individuals with BN and BED report similar changes in momentary sadness and feelings of stress following lab-based mood and stress inductions (Danner et al., 2013; Schulz & Laessle, 2012). Interestingly, Danner and colleagues (2013) found that, following an increase in sadness, women with BN and BED were more impulsive in a gambling task,
whereas women without an eating disorder were not. Following lab-based stress inductions, self-reported anxiety and stress have been positively correlated with urge to binge and cravings for sweet food in those with BED, but not in comparison groups (Rosenberg et al., 2013). These data imply that individuals with binge-type eating disorders may be particularly susceptible to experiencing cravings or impulse-related behaviors in response to negative affective states.

Negative mood inductions also have been shown to change eating behavior in individuals with LOC eating. Stress inductions that increase social stress have been shown to increase both the rate of food consumption and the acceleration of this rate (i.e., faster eating) in individuals with BED compared to individuals without an eating disorder (Laessle & Schulz, 2009; Schulz & Laessle, 2012). Moreover, daily caloric intake following lab-based stress inductions has been related to depression scores in individuals with BED, but not in non-eating disorder controls (Schulz & Laessle, 2010). These findings imply that spikes in negative affect promote factors relevant to LOC eating.

Although negative affect seems to be an important predecessor to LOC-eating episodes, there is limited evidence that binge eating is reinforced by reductions in negative affect. The lack of evidence supporting the full affect regulation model of binge eating has led some researchers to posit that binge eating may be reinforced by changes in positive affect as opposed to decreases in negative affect (Haedt-Matt & Keel, 2011b; Mason et al., 2021). Indeed, binge eating typically involves the consumption of highly palatable/rewarding foods, which may elevate momentary positive affect or hedonic states. In turn, negative affect may serve as a learned cue that increases motivation to consume these highly palatable “binge” foods. Thus, alternate models of binge eating
that emphasize reward processing may further explain processes relevant to the maintenance of LOC eating.

_models of reward and loc eating_

reward is a broad construct comprised of several facets, including (but not limited to) wanting, liking, and reward learning (Berridge, 2009; Leenaerts et al., 2022; Morales & Berridge, 2020). In short, ‘wanting’ refers to craving or “motivation that promotes approach toward and consumption of rewards” (Berridge et al., 2009). ‘Liking’ refers to the pleasurable or hedonic experience of consuming a reward. ‘Reward learning’ refers to the “process by which organisms acquire information about stimuli, actions, and contexts that predict positive outcomes, and by which behavior is modified when a novel reward occurs, or outcomes are better than expected” (National Institute of Mental Health (NIMH), 2023). Impairment in these domains of reward processing has been implicated in eating disorders (Harrison et al., 2010). Although all three subconstructs may be relevant to risk for and acquisition of LOC eating, ‘wanting’ is posited to be most relevant to the maintenance of LOC eating.

Scientific conceptions of reward have shifted over time, but there remains theoretical overlap between older and newer frameworks. More recent conceptualizations of reward from the National Institutes of Health Research Domain Criteria (RDoC), include the constructs of reward responsiveness, valuation, and learning, each of which is broken down into three smaller subconstructs. Notably, RDoC facets of reward valuation and reward responsivity (e.g., valuation-effort, valuation-delay, and reward anticipation) map onto the broader construct of ‘wanting’, whereas other facets of reward responsivity (i.e., initial response to reward, reward satiation) map onto the concept of ‘liking’. Given
theoretical overlap, it is possible to integrate older and newer findings. For simplicity, this review will focus on constructs that map onto conceptualizations of ‘liking’ and ‘wanting’, including reward anticipation, reward valuation-delay discounting, and reward valuation-effort, and how they relate to eating behaviors. Notably, research and theories on reward alterations in relation to binge eating overlap with research and theories on substance addiction (Berridge & Robinson, 2016; Bodell & Racine, 2022; Morales & Berridge, 2020). Below, I describe leading theories of reward as they relate to LOC-eating behaviors and the important facets of the larger construct of reward.

Some researchers advocate for a Food Addiction (FA) model: a variant of drug addiction in which ultraprocessed or highly processed foods such as potato chips, ice cream, and carbonated soft drinks act as the addictive substance (Gearhardt & Schulte, 2021). These models explain why the current food climate, which is saturated with ultra-processed, ultra-palatable, calorie-dense foods interacts with our evolutionary food-reward processes to create pathological overeating (or ‘food addiction’). These models note key similarities in physiological mechanisms and risk factors between substance abuse and food addiction. Further, models of FA overlap with models of binge eating in that they share the symptoms of overconsumption and the concept of LOC via compulsion. Within FA models there are two main schools of thought. First, some models suggest that highly palatable foods have “addictive” properties and exert changes to the neural circuits pertaining to reward processes, similar to the way that psychotropic substances may alter these circuits en route to phenotypic substance addiction (Davis & Carter, 2009; Gearhardt & Schulte, 2021). Another school of thought within FA models posits that behavioral patterns in food addiction mimic patterns of LOC over substance
use and identify shared compulsive consumption of the addictive substance despite negative consequences. Indeed, reward circuitry in the brain, including areas in the prefrontal cortex and striatum has been implicated in FA (Ziauddeen et al., 2015). Although there is mixed evidence to support FA as a distinct syndrome from BED (Fletcher & Kenny, 2018; Gearhardt & Hebebrand, 2021), this framework lays out a biobehavioral model of compulsive consumption in which reward processing is a central focus and may be helpful to our understanding of LOC eating. Further, the FA literature identifies BED as a useful phenotype of FA, but suggests that binge eating in other eating disorders (e.g., BN) may be driven by other cues and behavioral patterns (Davis & Carter, 2009). This nuance begs the question of whether the FA syndrome of dysregulated reward processing and compulsive consumption relates to the broader phenomenon of LOC eating or whether it is disorder-specific.

Whereas FA models posit that FA is distinct, but related to BED, other models are specific to reward alterations across all binge-type eating disorder presentations (i.e., all eating disorders that involve binge-eating episodes). One such model incorporates a leading theory of substance use addiction and identifies evidence that this process may explain binge-type eating behaviors. Bodell and Racine (2022) identify the incentive sensitization theory of addiction as relevant to the entrenchment of binge eating and distinguish which facets of reward may be relevant at different stages of the eating disorder. Incentive sensitization is a theory originally proposed for substance addiction, whereby repeated exposure to an addictive substance promotes alterations in the mesolimbic dopamine systems in the brain (Berridge & Robinson, 2016). These alterations heighten subjective ‘wanting’, or motivation to receive that substance,
especially in response to learned cues for that substance. Notably, this model identifies subjective ‘liking’, or hedonic enjoyment or pleasure, of the addictive substance as a separate facet of reward and suggests that liking of the substance does not increase as incentive sensitization progresses. Bodell and Racine (2022) posited that the process of incentive sensitization maps on to etiological processes for binge eating. Further, these authors link subjective liking of various rewarding stimuli as a risk factor for beginning binge eating. In line with the seminal incentive sensitization model, Bodell and Racine (2022) posit that subjective liking may not be relevant to progression of the disorder once binge eating has begun. Therefore, the ‘wanting’ facet of reward emerges as a key construct driving binge eating, specifically the ‘wanting’ of food rewards. Given that ‘wanting’ and the process of reward sensitization seem to drive entrenchment of binge eating behaviors, this construct may be most relevant to studying the “compulsive” aspect of LOC eating. Below, I briefly describe key facets of reward and summarize their relevance to binge-type eating behaviors. The evidence supports Bodell and Racine’s theoretical model and highlights the need to study reward processes pertaining to wanting in relation to LOC eating.

**Evidence for the Role of Reward in LOC Eating**

The evidence to date suggests that individuals with disordered eating differ from non-eating disorder controls in ‘liking’ and ‘wanting’ of rewards; however, such responses may vary by reward type (i.e., food versus non-food stimuli) and by progression of disease (Bodell & Racine, 2022). Accurately measuring these separate constructs at the self-report, behavioral, and physiological levels and distinguishing reward response by type of reinforcer may help disentangle the complex role of reward in
predicting LOC eating. In particular, studying individual differences in wanting may be critical to understanding maintenance factors for LOC eating.

**Wanting.**

The construct of ‘wanting’ can be understood as the psychological process by which a stimulus and its cues are associated with a rewarding meaning. This process allows an individual to develop desire and motivation for a stimulus based on either presentation of the stimulus itself or its associated cues. This “motivation” may be linked to the compulsivity of LOC seen in behavioral models of FA and has been operationalized as reward valuation. Reward valuation itself can be broken down into reward anticipation, reward valuation-delay discounting, and reward valuation-effort.

*Reward anticipation.* To assess reward anticipation of food rewards, researchers commonly present participants with food images (Geliebter et al., 2016; Schienle et al., 2009) or food smells (Jiang et al., 2019). In these paradigms, individuals with binge eating report experiencing higher arousal towards foods cues but no difference in self-reported desire to eat high energy-dense foods compared to individuals without binge eating (Geliebter et al., 2016; Schienle et al., 2009). Further, when exposed to olfactory food cues, individuals with binge eating demonstrate greater activation of brain regions associated with motivational salience than individuals who do not binge eat (Jiang et al., 2019).

Monetary incentive delay (MID) tasks are measures commonly used to assess reward anticipation more broadly (Knutson et al., 2000). In these tasks, participants respond to a target in order to gain or to avoid losing monetary rewards. They are cued to know which trials represent opportunities to win rewards, opportunities to lose rewards,
and opportunities where their performance does not impact reward receipt. Brain activity in reward regions is assessed during the period of time in which participants anticipate gaining/winning rewards. Murao and colleagues (2017) found no differences in brain activity during anticipation of monetary rewards in individuals with binge-purge subtype anorexia nervosa versus patients with anorexia nervosa who did not binge eat or healthy controls. Moreover, work by Balodis and colleagues found decreased activity of the ventral striatum in BED relative to higher-weight controls but not compared to average-weight controls (Balodis et al., 2013). Additionally, among a sample of adolescent girls with and without binge eating, Bodell and colleagues (2018) found that there were no differences in neural activity in reward regions of the brain during reward anticipation on potential win trials between those that reported binge eating versus those who did not. However, in the total sample, reward anticipation was associated with greater activity in multiple reward regions in the brain.

Researchers have used food incentive delay (FID) variants of the MID to assess food-reward processing, which may be more relevant to individuals with eating disorders (Leenaerts et al., 2022). Simon and colleagues (2016), compared anticipatory brain responses to both food rewards and monetary rewards across individuals with BN or BED and controls without an eating disorder. The FID task provided food rewards in the form of “snack points”, a representation of a future ability to exchange points for sweet, salty, or other food rewards. In this study, individuals with binge-type eating disorders responded faster to more food rewards; however, these participants did not respond faster to more monetary rewards. Moreover, there were no differences in neural activation of reward regions during anticipation of reward receipt. Together, these findings imply that
reward anticipation may be sensitive to type of reward, but information on reward anticipation to food rewards is nascent. Comparisons between lab-based measures of reward may require methodological honing before strong conclusions can be made. For example, food is considered a primary reinforcer, because it is directly consumable, and motivation for food is driven by physiological needs. On the other hand, money is a secondary reinforcer, meaning that individuals come to view money as rewarding through behavioral learning (Morales & Berridge, 2020). This distinction may be important when operationalizing reward paradigms, particularly when comparing motivation to receive two different kinds of rewards (Epstein et al., 2010). Therefore, contrasting effort on MID and FID may index processes that hinge upon distinct behavioral motivators.

*Reward valuation-delay.* Reward valuation-delay is the process by which the value of a reinforcer is computed as a function of its magnitude and the anticipated amount of time prior to reward receipt (National Institute of Mental Health, 2023). It is measured behaviorally by delay discounting paradigms that ask participants to choose between receipt of immediate rewards versus a different amount of a reward at a later time. Steeper delay discounting, represented as “choosing smaller more immediate rewards over larger, more delayed rewards” is associated with greater impulsivity and impairment across a range of disorders (Manwaring et al., 2011). Use of these paradigms has yielded mixed evidence on whether individuals with LOC eating or BED demonstrate steeper discounting of delayed rewards than control participants (Kekic et al., 2020; McClelland et al., 2016). One study found that individuals with BED demonstrated steeper delay discounting of many types of rewards (money, food, sedentary activity, and massage time) than average-weight and higher-weight controls (Manwaring et al., 2011).
Notably, Manasse and colleagues (2014) found no differences in temporal discounting when the clinical group consisted of individuals with any LOC-eating episodes in the preceding three months. In addition, these studies investigated delay discounting in higher-weight samples; the role of delay discounting in LOC eating among individuals of non-higher weights is less clear (McClelland et al., 2016). Lastly, data from neuroimaging studies imply no differences in neurological functioning during delay discounting tasks in BED relative to healthy controls (Haynos et al., 2021; Miranda-Olivos et al., 2021). Thus, delay discounting may be less relevant to individuals who report LOC-eating episodes but do not meet diagnostic criteria for BED.

*Reward valuation-effort.* Reward valuation-effort is defined as the tendency to overcome response costs to obtain a reinforcer and is typically quantified as the amount of effort an individual will expend to receive rewards (National Institute of Mental Health, 2011). This “motivation” may relate to the compulsivity of food consumption, making it a key behavioral measure of reward processes that may be relevant during LOC-eating episodes. Reward valuation-effort has been measured in non-human animals using progressive ratio tasks, which require progressively more effort on behalf of the subject to receive fixed rewards. These tasks have been adapted from the animal literature, wherein a human participant must produce a number of responses (effort) to receive rewards; as the individual moves through trials, the amount of effort required increases relative to a fixed amount of reward (Hodos, 1961).

In the context of eating behaviors research, several tasks have been developed to assess reward valuation-effort, in which the amount of effort participants will expend to receive food rewards is quantified as their “motivation” (Bodell & Keel, 2015; Epstein et
al., 2010; Racine et al., 2019; Schebendach et al., 2013). This literature consistently suggests that individuals with binge-type eating disorders perform differently from comparison samples on these tasks. In these paradigms, individuals elevated on binge eating account for food reward magnitude more in their decision-making than individuals low on binge eating symptoms (Racine et al., 2019). Women with BN work harder for chocolate candies than healthy controls (Bodell & Keel, 2015). Further, individuals with binge eating work harder for food rewards than controls when both groups are told to binge (Schebendach et al., 2013). This latter study highlights the relevance of reward valuation-effort to LOC eating because it demonstrates that individuals who experience LOC-eating episodes emphasize effort when they are attempting to behaviorally recreate LOC episodes. Therefore, greater reward valuation may be relevant during LOC-eating episodes and not just a global difference between individuals with and without LOC-eating.

Given the pronounced relation of reward valuation-effort to binge eating in the literature and its alignment with theories of reward and LOC, it is a clear target for investigating mechanisms of LOC eating more broadly. Thus, in this study, I examine whether reward valuation or ‘motivation,’ a specific aspect of reward processing, is relevant to eating behaviors in individuals with LOC eating. Because motivation is thought to increase over time once LOC-eating episodes begin (Bodell & Racine, 2022), and much of this work has been conducted in individuals with threshold binge-type eating disorders, it is pertinent to assess reward valuation-effort in individuals across a span of severity of LOC eating behaviors.
Until recently, rigorous research comparing reward valuation-effort in the context of food-reward paradigms to non-food reward paradigms has been limited (Berner et al., 2017; Keel et al., 2022). The development of a progressive ratio task assessing reward valuation of leisure-based primary reinforcers comparable to the task developed by Bodell & Keel (2015) allows for a rigorous comparison of reward valuation across reward domains (Keel et al., 2022). However, research on the extent to which individuals with binge eating will work for food versus other types of primary reinforcers (e.g., leisure reinforcers) has only begun to be examined (Keel et al., 2022). As mentioned, such knowledge is essential to better understand which aspects of reward functioning are altered in individuals with LOC eating and in which contexts.

**Influence of Mood on Reward Processing**

Together, the literature implicates both heightened ‘wanting’ for foods and negative affect as proximal risk factors for LOC-eating episodes. Individuals with LOC eating may present with generally elevated and more frequent negative affect relative to healthy controls, and spikes in negative affect relative to baseline may act as specific risk states for the occurrence of LOC eating. When in these heightened negative affective states, ‘wanting’ for food may increase, driving LOC eating. This process may be driven by incentive sensitization, whereby stress-sensitive physiological changes to mesolimbic dopamine systems increase cravings (Berridge & Robinson, 2016; Bodell & Racine, 2022). Alternately, the affect regulation model would posit that negative affect acts as a cue to positively alter or stabilize affect states; therefore, individuals may seek out hedonic stimuli when in these states (Haedt-Matt & Keel, 2011b; Mason et al., 2021). Although there is some evidence that negative affect may increase motivation to consume
food rewards in those with BED (Laessle & Schulz, 2009; Rosenberg et al., 2013; Schulz & Laessle, 2010, 2012), little is known about whether negative affect increases motivation to consume food rewards relative to non-food rewards, particularly in individuals who engage in LOC eating more broadly. This information may help us understand why individuals engage in binge eating versus other rewarding activities during negative mood states and may elucidate reward-processing alterations that may be contributing to the entrenchment of these behaviors. Reward valuation is a promising area of research, given that reward valuation-effort seems to map onto subjective binge states (Schebendach et al., 2013), and this construct may be relevant to maintaining LOC behaviors once they have begun (Bodell & Racine, 2022). Further, there are rigorous methodologies that allow us to compare reward valuation-effort across primary reinforcers, allowing for tight control and stronger conclusions to be drawn (Keel et al., 2022). Thus, in this study I examined whether mood-related alterations to reward valuation-effort are specific to reward types (i.e., food vs. non-food rewards) among individuals with LOC eating.

**Research Objectives**

In this study, I investigated whether negative mood selectively modulates reward valuation for food versus leisure rewards in individuals with LOC eating. Participants were induced into either a negative or a neutral mood state before undergoing repeated behavioral paradigms. All participants completed progressive ratio tasks assessing reward valuation, or ‘wanting’ of food and nonfood (leisure) rewards. I hypothesized that 1) across both mood states, participants would demonstrate greater motivation for food rewards relative to leisure rewards (i.e., main effect for task). I also hypothesized that 2)
the difference between motivation for food and leisure rewards would be greater in the negative mood condition (i.e., interaction between task and mood condition). These hypotheses are visually depicted in Figure 1.

**Figure 1**

*Depiction of Hypothesized Interaction*

![Hypothesized Task Performance Across Conditions](image)

*Note.* Figure 1 depicts hypothesized performance on reward tasks. All participants complete both the game and food tasks. Therefore, differences in total presses within mood condition clusters pictured are within person effects, whereas differences across conditions are between-person effects.

**Methods**

**Participants**

Forty-nine participants completed the study. These participants were recruited via the Western University SONA system, mass email recruitment, and flyers posted on
social media and in community spaces around London, Ontario (e.g. local cafes, museums, gyms, etc.). Flyers stated the following: “The PEAR Lab at Western University is looking for female volunteers (17-35 years of age) who experience a loss of control over their eating to participate in a study on mood and feelings of reward.” Some information about study procedures and a link to a brief online screening survey were included on the flyer (see Appendix A). After completing the screening survey, eligible individuals indicated whether they would like to participate. Inclusion criteria were as follows: 1) identified as women between the ages of 17 and 35; 2) reported LOC eating at least two times a month over the past three months; 3) endorsed liking chocolate a moderate degree (at least a five on a ten-point scale); 4) endorsed liking video games or phone games to a moderate degree (at least five on a ten point scale). The LOC inclusion criteria for this study falls short of diagnostic thresholds for BED and BN (American Psychiatric Association, 2022). Therefore, this sample included individuals with a range of threshold and subthreshold eating pathology. Individuals who identified as male or fell outside of the stated age range were excluded. To ensure that the progressive ratio tasks were assessing motivational reward processes (i.e., ‘wanting’), individuals who did not endorse liking chocolate or phone games to a moderate degree were excluded.

Overview of Procedures

The full study procedures are depicted in Figure 2. Before participants arrived, they were assigned to a mood condition (negative or neutral) and the order in which they would complete behavioral progressive ratio tasks. To minimize order effects, task order was counterbalanced across participants. Self-report and anthropometric measures (i.e., height, weight) were assessed at the beginning of the study visit. Participants completed a
mood induction protocol, matching the mood state to which they were assigned (i.e.,
negative or neutral). Then, participants completed one of the two progressive ratio tasks
(described below). Following the initial mood induction protocol and progressive ratio
task, participants underwent a second mood induction to reinstate the target affective
state. For the second mood induction, participants were asked to recall a different
memory to minimize interference from emotional processing or spontaneous self-
compassion that occurred during the first recall task. Following the second mood
induction protocol, participants completed the second progressive ratio task. Self-report
ratings of momentary affect, feelings of reward, and eating disorder cognitions were
taken before each mood induction (T1), after each mood induction (T2), and after each
progressive ratio task (T3). After completing all study procedures, participants were
provided with a debriefing form, including local mental health resources. SONA
participants were compensated with two research credits. Community participants were
compensated with $25 cash. All participants consented to study procedures at the
beginning of their visit. All protocols were approved by the University of Western
Ontario’s Non-medical Research Ethics Board (See Appendix B).
Figure 2

Study Procedure Flowchart

Note. Half of participants completed the M&M task first, and half of participants completed the tasks in counterbalanced order (i.e. Angry Birds task first, then the M&M task).
Measures

*Mood Induction Protocol*

Participants were assigned to either a negative or a neutral mood condition and underwent an autobiographical mood induction protocol. Participants in the negative mood condition were asked to recall a time in which they felt sad, guilty, or rejected for three minutes, followed by a period of four minutes in which they wrote about that memory. Participants in the neutral mood condition were asked to recall and write about an everyday chore for an equivalent amount of time. Autobiographical mood induction protocols are valid and reliable methods for inducing affective changes in both clinical and non-clinical samples (Baker & Guttfreund, 1993; Joseph et al., 2020). However, there is evidence that these mood states are relatively short-lasting. One study comparing the efficacy of negative mood inductions found that, following sad memory mood inductions, negative mood spikes remain significantly elevated from pre-mood induction levels for 10 minutes (Gillies & Dozois, 2021). Notably, the magnitude of this change was not considered very large for that entire interval (with the absolute change in negative affect falling short of literature standards), nor did it significantly differ from the neutral comparison condition past the four minute mark (Gillies & Dozois, 2021).

Despite this short window, the effects of suddenly-elevated negative affect should be present when participants begin both progressive ratio tasks, emulating how individuals may begin reward-seeking behaviors in day-to-day life to up-regulate mood. Further, as individuals engage with rewarding stimuli, we would expect there to be natural increases in positive affect or decreases in negative affect; therefore, the duration of the induced state is relevant so long as it lasts until the reward task begins.
Progressive Ratio Tasks

In this study, reward motivation (i.e., ‘wanting’) was quantified as total button presses on two progressive ratio tasks – one with a food reward and one with a leisure reward. Participants were asked to press a keyboard button to earn chocolate candies or to earn the opportunity to play the computer game Angry Birds. Throughout the task, participants had to exert progressively more effort (increasing number of button presses) to receive a fixed amount of reward (M&M candy or Angry Birds playtime). In both tasks, the first trial consisted of 50 button presses. Each subsequent trial involved an increase in 200 button presses, with a total of 9500 potential presses per task. When a participant completed a trial, an image of M&Ms or Angry Birds would appear on the screen. In the food reward task, a bag of 10 M&Ms was automatically dispensed from a machine for participants to consume (Bodell & Keel, 2015). In the leisure reward task, participants received one minute of playtime of the Angry Birds game, which appeared on the progressive ratio task computer and then disappeared 60 seconds later (Keel et al., 2022). Throughout the task, the reward amounts for completed trials (10 M&Ms or 1 minute of Angry Birds playtime) stayed constant. Before a participant could continue tapping on the keyboard, they were instructed to eat all 10 M&Ms or complete their minute of game play time. To ensure that participants followed the instructions for consumption of the M&Ms, video recordings of task performance were inspected after participation. Both tasks had a maximum of ten potential trials that participants could complete. Participants were instructed to continue pressing on the keyboard for as long as they wanted more chocolate candies or Angry Birds playtime. Given that the ‘wanting’ facet of reward is sensitive to reward-specific cues, a static image of Angry Birds or
M&Ms were displayed to participants on the device where that reward would be delivered (Bodell & Racine, 2022). Further, to discourage response bias in task participation, participants were told that there were no right or wrong answers and that performance on the task was not a competition. Participants completed both tasks, in counter-balanced order.

These tasks were previously developed and validated to examine reward valuation-effort in individuals with and without binge eating (Bodell & Keel, 2015; Keel et al., 2022). For example, in prior studies, self-reported ratings of ‘liking’ and ‘wanting’ M&Ms and the Angry Birds task were related to task performance in university samples (Keel et al., 2022). Additionally, self-report ratings of how rewarding participants found the M&Ms and the Angry Birds game were related to measures of effort on the respective tasks (Keel et al., 2022). Performance on the two tasks were correlated in that participants who worked harder on the M&M task also tended to work harder on the Angry Birds task (Keel et al., 2022). Given these properties and the similarities of the tasks, total presses on the tasks were used as a continuous outcome measures of food and non-food reward valuation-effort.

**Self-Report Measures**

Before engaging in the behavioral protocols (mood inductions and progressive ratio tasks), participants completed a battery of self-report questionnaires assessing eating and related psychopathology symptoms, including loss of control eating (described below). Additionally, momentary ratings of participant affect, liking and wanting of the rewards, urge to binge, and hunger state were assessed throughout the study visit in the form of visual analog scales (VAS). These VAS measures were assessed directly before
and after each mood induction and directly after each progressive ratio task. Two measures of eating pathology and the VAS were included in analyses for this project. Measures of depressive symptoms, personality features, alcohol use, and clinical impairment were collected but not used in this thesis. These additional measures are described in Appendix C.

**Momentary Ratings of Affect, Reward, and Eating (VAS Scales).** The VAS were collected before and after mood induction protocols, as well as after each progressive ratio task. VAS have been used to collect repeated measures of momentary reward and interoceptive states (Bodell & Keel, 2015; Keel et al., 2022; Sherdell et al., 2012). This methodology prevents interference from recall biases associated with assessing subjective states across temporal sequences, especially when ratings are expected to change across certain timepoints (Shiffman et al., 2008). These types of ratings also have demonstrated convergent validity to eating-related psychophysiological outcomes in eating disorder samples (Keel et al., 2018). In the initial validation of the Angry Birds task, self-reported feelings of reward were associated with effort displayed in both the M&M and Angry Birds tasks (Keel et al., 2022).

For the momentary affective measures, I measured positive and negative affect using items derived from the Positive and Negative Affect Scales (Watson et al., 1988) and consistent with findings from EMA studies in the field of eating disorders (Berg et al., 2013). Given the burden of repeated measures, I selected specific items from these scales, which were presented in the form of VAS. I used the following five items to assess for momentary negative affect: sad, tense, angry, anxious, and upset. The following four items were used to assess momentary positive affect: happy, excited,
satiated/satisfied, enthusiastic. Past research has found good internal consistency among PANAS subscales when select items were used for repeated momentary ratings (Berg et al., 2015). Response options ranged on a scale from zero to 100, as indicated by moving a bar along a sliding scale. Participants completed these measures on the computer via Qualtrics. Internal consistencies of the positive affect items ($\alpha$’s = .81 - .84) and the negative affect items ($\alpha$’s = .72 - .80) were calculated at the pre-mood induction timepoint for both tasks.

Other VAS items assessed subjective states related to eating behaviors (i.e., how hungry, how full, how strong they feel an urge to binge, how strong they feel an urge to restrict) and reward processing (i.e., how much they liked the M&Ms, how much they wanted the M&Ms, how rewarding they found the M&Ms). Each VAS item asked participants to indicate how much they felt each subjective state right now. In the VAS measures taken before, during, and after the M&Ms task, the reward items focused on M&Ms. In the timepoints surrounding the Angry Birds progressive ratio task, VAS reward items focused on the Angry Birds game. These items (3 per task) were used as single-item momentary measures of liking, wanting, and general reward.

**Loss of Control Over Eating Scale.** I used the Loss of Control over Eating Scale (LOCES) to assess features and severity of LOC eating (Latner et al., 2014). The LOCES is a twenty-four item measure assessing three features of LOC eating: behavioral, cognitive/dissociative, and positive/euphoric facets of LOC. This measure has demonstrated good validity and reliability in university populations (Latner et al., 2014). The LOCES is sensitive to differences in eating pathology across a range of LOC-eating
episode frequencies and in non-clinical samples (Stefano et al., 2016). In the current study, the LOCES demonstrated excellent internal consistency ($\alpha = .91$).

**Eating Disorder Examination Questionnaire – Short Form.** The Eating Disorder Examination Questionnaire Short Form (EDE-Q-SF) (Gideon et al., 2016) was used to assess severity of eating disorder symptoms over the preceding week. This twelve-item measure has demonstrated good validity and reliability in a variety of samples, including university students, individuals with probable eating disorders, and community participants (Gideon et al., 2016; Jordan et al., 2021; Prnjak et al., 2020). In this sample, the EDEQ-SF demonstrated good internal consistency ($\alpha = .84$).

**Data Analytic Plan**

Statistics were conducted in SPSS or in R and Rstudio, using the tidyverse, psychstats, and rstatix packages (Kassambara, 2023; Wickham & RStudio, 2023). As a manipulation check, state ratings of negative affect were compared using one-way ANOVAs probing for main effects of mood condition and timepoint. Post-hoc t-tests were conducted to assess for differences in negative affect at each timepoint across mood conditions and across timepoints within each condition, respectively.

The model for assessing the main hypotheses was a between- and within-groups design with comparable continuous outcome variables. As such, a mixed ANOVA was employed to test study hypotheses. As an intermediate step, this model probed for main effects of both task (Hypothesis 1) and mood condition on total presses. Further, the model assessed for the interacting effects of mood (between group) and reward type (within group) on total presses (Hypothesis 2). Greenhouse-Geisser sphericity correction was applied to within-subject factors violating the assumption of sphericity. Significant
mixed model ANOVAs would be further interpreted using post-hoc one-way ANOVAs to probe significant main effects and post-hoc paired t-tests.

To confirm reliability of the reward task paradigms and to assess for relevant associations with clinical correlates, supplemental Pearson’s correlations were calculated for task total presses, LOCES, and EDE-Q. Further, measures of state liking, wanting, feelings of reward, urge to binge, and urge to restrict from the post-mood induction timepoint were correlated with performance on each task. Finally, order effects were assessed using linear regressions wherein task order predicted total presses on each task and on change in negative affect following the mood induction protocols.

I conducted an a priori power analysis to determine the sample size needed to detect a small-to-medium main effect of task on total presses and a small-to-medium effect size of the interaction term. Given that the population value for these effects was not known, I chose to be conservative and use a small to medium effect size as my estimate ($f = .15$). As all participants completed both progressive ratio tasks, a power analysis for a repeated measures within-between interaction with two groups and two measurements was conducted. Parameters were set to $\alpha = .05$ and power set to .80, where the repeated measures are correlated at ($r = .51$) (Keel et al., 2022). The power analysis indicated that a sample size of $n = 88$ individuals was needed to detect an effect size of $f = .15$. To account for potential missing data (e.g., due to task malfunction), I intended to recruit a total of $N = 100$ participants (50 per condition [negative vs. neutral mood]).
Results

Participant Characteristics

In total, 579 individuals completed our screening survey. Of those individuals, 115 (19.5%) met the study criteria. Of those eligible, 54 (47%) chose to participate after receiving more information. After participation, seven participants had to be excluded for the following reasons: misunderstanding the progressive ratio task instructions (n = 3); mechanical malfunction of the Angry Birds task (n = 2); choosing to end or skip the task for reasons unrelated to rewarding value of the task (i.e., eye strain from the computer screen, dairy allergy) (n = 2). Thus, the final sample included 46 eligible participants. Of the 46 participants who completed the study, 59% (n = 27) were white, 13% (n = 6) were South Asian, 11% (n = 5) were East Asian, 9% (n = 4) were multiple ethnic or racial groups, 4% (n = 2) were Middle Eastern, 2% (n = 1) were a racial group not listed, and 2% (n = 1) were Black. Participants were mostly single and never married 72% (n = 33). Additionally, 59% (n = 27) of participants were students, 30% (n = 14) were employed, 4% (n = 2) were self-employed, and 7% (n = 3) were unemployed. Mean age of participants was 23.3 (SD = 5.23; range 18-35) years old.

Manipulation Check

Prior to testing my hypotheses, I assessed the impact of the mood induction protocol on participant ratings of negative affect. Descriptive information on negative affect across study timepoints is included in Table 1 and depicted in Figure 3.
### Table 1

*Means and Standard Deviations for Negative Affect Across All VAS Measurements*

<table>
<thead>
<tr>
<th>Timepoint</th>
<th>Negative Mood Condition</th>
<th>Neutral Mood Condition</th>
<th>Total Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 21)</td>
<td>(n = 25)</td>
<td>(n = 46)</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>AB T1</td>
<td>23.36</td>
<td>20.93</td>
<td>20.27</td>
</tr>
<tr>
<td>AB T2</td>
<td>35.71</td>
<td>23.42</td>
<td>18.71</td>
</tr>
<tr>
<td>AB T3</td>
<td>22.01</td>
<td>17.67</td>
<td>17.55</td>
</tr>
<tr>
<td>M&amp;M T1</td>
<td>21.29</td>
<td>15.83</td>
<td>19.76</td>
</tr>
<tr>
<td>M&amp;M T2</td>
<td>40.22</td>
<td>20.28</td>
<td>14.90</td>
</tr>
<tr>
<td>M&amp;M T3</td>
<td>20.11</td>
<td>20.08</td>
<td>17.22</td>
</tr>
</tbody>
</table>

*Note.* Table 1 describes mean negative affect scores at each timepoint across both mood conditions and in the total sample. P-values denote significance of pairwise comparisons of mean negative affect levels for the Negative and Neutral Mood at each timepoint. All p-values are Bonferroni-corrected. AB = Angry Birds, T1 corresponds to pre-mood induction timepoint, T2 corresponds to post-mood induction timepoint, and T3 corresponds to post-progressive ratio task timepoint. Due to participant exclusions, there are n = 4 more participants in the neutral condition than in the negative condition.
Note. Mean variability in negative affect is displayed over time and by task type. Participant data for individuals in the negative mood condition is displayed on the top row, with individuals in the neutral condition lower on the y-axis. AB = Angry Birds, T1 corresponds to pre-mood induction timepoint, T2 corresponds to post-mood induction timepoint, and T3 corresponds to post-progressive ratio task timepoint. Task type is indicated by labels on the x-axis and by color.

Mood condition had a statistically significant effect on negative affect ($F[1, 274] = 17.40, p < .01, \eta_p^2 = 0.06$). Follow-up pairwise comparisons revealed that mean negative affect scores were significantly different between the negative and neutral mood
conditions at the timepoints immediately following the mood inductions (Table 1),
highlighting that the mood induction was ‘successful’. Likewise, there was a significant
main effect of time on negative affect \( (F[3.46, 155.65] = 4.57, p < .01, \eta_p^2 = 0.09) \). When
examined within each condition, the effect of time was statistically significant only for
the negative mood induction condition \( (F[2.76, 55.17] = 12.89, p < .01, \eta_p^2 = 0.39) \)
(Appendix D). In this condition, post-hoc pairwise comparisons revealed that negative
affect was significantly different across timepoints. Specifically, negative affect at the
post-mood induction timepoint for the Angry Birds task was significantly higher than the
Angry Birds pre-mood timepoint \( (p = .005) \), the Angry Birds post-task timepoint \( (p =
.005) \), and the M&M post-task timepoint \( (p = .045) \). Negative affect at the post-mood
induction timepoint for the M&M task was significantly higher than negative affect at the
M&M pre-mood induction timepoint \( (p = .004) \), the M&M post-task timepoint \( (p = .002) \),
the Angry Bird pre-mood timepoint \( (p = .007) \), and the Angry Bird post-task timepoint \( (p < .001) \). All p-values noted above were Bonferroni-corrected to control for multiple
comparisons.
Main Analyses

Descriptive statistics on participant trait measures and total presses on behavioral tasks are reported in Table 2. Assumptions for a two-way, mixed model ANOVA were probed prior to testing hypotheses. A Shapiro-wilk test revealed that the number of total presses on each task for both conditions was not normally distributed (all p’s < .05), and further testing revealed that the total presses variable for both the M&M task and the Angry Birds task were leptokurtic. Box’s M-test demonstrated homogeneity of covariances in the behavioral data. As such, these variables were log-transformed before analyses were run. Further, Levene’s test revealed homogeneity of variance in Angry Birds task total presses (p = 0.62) and M&M task total presses (p = 0.52) between mood conditions. There was no main effect of mood condition on total presses (F[1,44] = 2.06, p = 0.16, ηp² = 0.05) nor was there a main effect of task on total presses (F[1,44] = 0.34, p = 0.56, ηp² = .01) (Hypothesis 1). The two-way mixed-model ANOVA assessing for hypothesis 2 revealed that there was no significant difference in total presses based on reward type (food vs. leisure) and mood condition (F[1,44] = 0.4, p = 0.53, ηp² = .01) (Table 3). This result is visually depicted in Figure 4.
Table 2

*Means and Standard Deviations of Trait Eating Pathology Measures and Behavioral Tasks*

<table>
<thead>
<tr>
<th></th>
<th>Negative Mood Condition</th>
<th>Neutral Mood Condition</th>
<th>Total Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 21)</td>
<td>(n = 25)</td>
<td>(n = 46)</td>
</tr>
<tr>
<td><strong>M (SD)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trait Measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOCES</td>
<td>3.70 (0.60)</td>
<td>2.82 (0.66)</td>
<td>2.78 (0.64)</td>
</tr>
<tr>
<td>EDEQ-SF</td>
<td>1.32 (0.52)</td>
<td>1.40 (0.56)</td>
<td>1.39 (0.54)</td>
</tr>
<tr>
<td><strong>Behavioral Tasks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M&amp;M Total Presses</td>
<td>1752.43 (2321.89)</td>
<td>1815.80 (1559.13)</td>
<td>1810.14 (1951.52)</td>
</tr>
<tr>
<td>AB Total Presses</td>
<td>1803.28 (1397.53)</td>
<td>1815.80 (1559.13)</td>
<td>1839.09 (1566.60)</td>
</tr>
</tbody>
</table>

*Note. AB = Angry Birds, T1 corresponds to pre-mood induction timepoint, T2 corresponds to post-mood induction timepoint, and T3 corresponds to post-progressive ratio task timepoint. LOCES = Loss of Control Over Eating Scale, EDEQ-SF = Eating Disorder Examination Questionnaire- Short Form.*
Figure 4

Effort Expended by Reward Type and Mood Condition

*Note.* Participant effort on the Angry Birds and M&M progressive ratio tasks is broken down by task and mood condition.
Table 3

Mixed Analysis of Variance Probing Interaction of Mood Condition and Task on Total Presses

<table>
<thead>
<tr>
<th>Predictors</th>
<th>$Df$</th>
<th>$F$</th>
<th>$p$</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between-subjects Effect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mood Condition</td>
<td>$1, 44$</td>
<td>2.06</td>
<td>0.158</td>
<td>0.045</td>
</tr>
<tr>
<td><strong>Within-subjects Effect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>$1, 44$</td>
<td>0.34</td>
<td>0.565</td>
<td>0.008</td>
</tr>
<tr>
<td>Mood x Task</td>
<td>$1, 44$</td>
<td>0.40</td>
<td>0.529</td>
<td>0.009</td>
</tr>
</tbody>
</table>

*Note.* Results of between-within ANOVA assessing interaction of mood condition and task on total presses. Degrees of freedom and $p$-values may be affected by Greenhouse-Geisser sphericity correction.

**Supplemental Correlations**

As supplementary analyses, correlations between the total presses, LOCES, EDEQ-SF, and momentary measures of affect, hunger, liking, wanting, feelings of reward, urge to binge, and urge to restrict at the post-mood induction VAS ratings are presented in Tables 4 and 5. Correlations were in expected directions. LOCES scores were positively associated with performance on the M&M task ($r = .32$), but not on the AB task ($r = .21; p > .05$). Scores on the EDEQ-SF were not significantly associated with performance on either task ($r$'s = .02 - .17). Total presses in the M&M task was strongly associated with total presses on the Angry Birds task ($r = .53$). Liking and wanting of
M&Ms as well as the rewarding value of M&Ms had large, positive associations with each other (r’s = .75-.89), as did momentary ratings of liking, wanting, and the rewarding feeling of the Angry Birds game (r’s = .84-89). Immediately following the M&M task mood induction, momentary ratings of liking (r = .33), wanting (r = .36), how rewarding the M&Ms were (r = .31), and self-reported urge to binge (r = .29) were correlated with total presses on the M&M task. Total presses on the Angry Birds task was associated with momentary ratings of wanting Angry Birds immediately after the Angry Birds mood induction (r = .37).
Table 4

Correlations among Task Performance, Clinical Variables, and Momentary Affective Ratings Post M&M Mood Induction Protocol

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
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<td>[.39, .77]</td>
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<tr>
<td>3. M&amp;M T2 Urge to Binge</td>
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<td>.19</td>
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<td>[.53, .41]</td>
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<tr>
<td>5. M&amp;M T2 Like</td>
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<td>.49**</td>
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<td>.44**</td>
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<td>.75**</td>
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<td>.47**</td>
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<td>.76**</td>
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<td>.29*</td>
<td>-.11</td>
<td>.33*</td>
<td>.36*</td>
<td>.31*</td>
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<td>[.00, .54]</td>
<td>[.39, .44]</td>
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<td>[.02, .05]</td>
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<td>.13</td>
<td>.07</td>
<td>.03</td>
<td>.08</td>
<td>.06</td>
<td>.53**</td>
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Table 5

Correlations among Task Performance, Clinical Variables, and Momentary Affective Ratings Post Angry Birds Mood Induction Protocol

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
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<td>2. EDEQ-SF</td>
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<td>Urge to Binge</td>
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<td>Urge to Restrict</td>
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<td>6. AB T2</td>
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<tr>
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<td>7. AB T2</td>
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<td>.03</td>
<td>-.02</td>
<td>.85**</td>
<td>.89**</td>
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<td>[-.27, .31]</td>
<td>[-.31, .27]</td>
<td>[.75, .92]</td>
<td>[.80, .94]</td>
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<td>8. M&amp;M Total Presses</td>
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<td>.17</td>
<td>.15</td>
<td>.01</td>
<td>.16</td>
<td>.05</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>9. AB Total Presses</td>
<td>.21</td>
<td>.02</td>
<td>.13</td>
<td>.26</td>
<td>.15</td>
<td>.13</td>
<td>.15</td>
<td>.53**</td>
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Note. Values in square brackets indicate the 95% confidence interval for each correlation. * indicates \( p < .05 \). ** indicates \( p < .01 \).

Order Effects
Lastly, exploratory linear regression analyses were conducted to examine whether the order that participants completed the M&M and Angry Birds tasks affected change in negative affect preceding each task as well as whether order impacted total presses (i.e., reward valuation effort) on the tasks. Task order was included as the predictor and coded as a dichotomous variable where 0 = participants who completed the Angry Birds task first and 1 = participants who completed the M&M task first. For examination of order effects on negative affect, change in negative affect was included as the dependent variable and calculated as a simple difference score where pre-mood induction negative affect was subtracted from post-mood induction negative affect. Positive values on this difference score connote an increase in negative affect following the mood induction, whereas negative values connote a decrease in negative affect after the mood induction. For examination of order effects on task performance, total presses on the M&M task or Angry Birds task was included as the dependent variable.

Results for order effect on change in negative affect are organized by mood condition and task to examine whether order effects were consistent across tasks within each mood condition. Task order did not predict change in negative affect prior to playing Angry Birds for participants in the negative mood condition ($R^2 = .10, F[1, 19] = 2.21, p = .15$), but task order did predict change in negative affect prior to playing Angry Birds for participants in the neutral mood condition ($R^2 = .16, F[1, 23] = 4.45, p = .046$). In the neutral condition, participants who engaged in the Angry Birds task first ($n = 12$) had a decrease in negative affect following the Angry Birds mood induction ($M = -5.37, SD = 10.30$), whereas participants who engaged in the M&M task first ($n = 13$) had an
increase in negative affect following the Angry Birds mood induction ($M = 1.95, SD = 6.86$).

For the M&M tasks, task order did not predict change in negative affect prior to the M&M task in the neutral mood condition $R^2 = .06, F[1, 23] = 1.42, p = .25$. However, task order did predict negative affect changes prior to the M&M task in the negative mood condition ($R^2 = .22, F[1, 19] = 5.47, p = .03$). Participants who engaged in the M&M task second ($n = 8$) had a larger increase in negative affect following the M&M mood induction ($M = 29.15, SD = 20.26$) than participants who engaged in the M&M task first ($n = 13, M = 12.65, SD = 12.30$).

Finally, two linear regressions were conducted in the total sample (N=46) to assess whether the task order affected participant effort (i.e., total presses) on the Angry Birds or M&M task, respectively. Results indicated that task order was not associated with total presses on either the Angry Birds task ($R^2 = .05, F[1, 44] = 2.50, p = .12$) or the M&M task ($R^2 = .03, F[1, 44] = 1.40, p = .24$), suggesting that behavioral performance was not related to the order in which the tasks were completed.

**Discussion**

**Summary**

This thesis assessed the impact of negative affect on reward valuation of multiple types of rewards in individuals with LOC eating. Prior studies have linked negative affect to LOC eating and to food craving and increased food intake. Additionally, other studies have demonstrated baseline differences in global reward processing among individuals with LOC eating. However, this study is the first to examine whether negative affect heightens motivation for both food and non-food rewards in a sample of individuals with
I hypothesized that individuals with LOC eating would work more to receive chocolate candies than they would to play Angry Birds. However, this main effect was not observed in my sample. Indeed, there was no difference in effort between the M&M and the Angry Birds tasks across the sample. Further, I hypothesized that the difference in effort for food versus leisure rewards would be greater in the negative mood condition, with greater motivation (effort) for M&M candies. The data failed to support this hypothesis as well; there was no significant interaction nor a visual trend in the data.

**Discussion**

Despite the vast literature on negative affect and binge eating in adults (Haedt-Matt & Keel, 2011b; Leehr et al., 2015), we did not find a main effect of mood on motivation to eat (total presses). We also failed to support our second hypothesis that a negative affect induction would increase motivation to consume food rewards but not motivation to play Angry Birds. Notably, this is the first study to examine how negative affect impacts reward valuation for food versus leisure rewards. Although I theorized that negative affect may lead to LOC eating via increased motivation to consume palatable foods, it is possible that different mechanisms may be at play. For example, hunger may moderate the relation between negative affect and LOC eating. One meta-analysis of EMA studies found that self-reported hunger prior to binge eating episodes was elevated compared to individuals’ average hunger ratings, but significantly lower than hunger ratings taken prior to non-LOC eating episodes (Haedt-Matt & Keel, 2011a). Therefore, eating in response to negative affect while experiencing relatively low levels of hunger may increase likelihood for the subjective experience of LOC. Alternately, researchers have proposed that individuals may engage in binge eating as a way to “escape” from
states of negative self-awareness or as a means of self-punishment (Heatherton & Baumeister, 1991; Muehlenkamp et al., 2019; O’Loghlen et al., 2023). These motives may be induced by acute negative affective states.

An alternative interpretation for why there was not a main effect of mood or a significant interaction of mood and reward type on participant effort could be that the mood induction procedure was insufficient to mimic the conditions likely to potentiate affect-related reward responses in the participants. Notably, the increases in negative affect following the M&M and Angry Birds mood induction met the literature’s criterion of at least a 10-point increase in negative affect as measured on a scale of 0-100 (Gillies & Dozois, 2021). However, it may be important to contextualize this spike in affect with the overall affective experience of the sample population. Individuals with LOC eating experience negative affect fairly regularly and report greater negative mood symptoms; therefore, the experimentally-induced negative affect may not have been salient relative to their higher baseline negative affect. In other words, the mood inductions may have been insufficient to create the context needed for increased motivation for food rewards.

Indeed, there is mixed evidence from meta-analyses of lab-based mood inductions on the impact of negative mood states on eating behaviors in individuals with eating disorders (Cardi et al., 2015; Evers et al., 2018), with some individual studies reporting decreased eating following negative mood inductions (Haynes et al., 2003). Therefore, despite meeting literature standards for efficacy, the mood inductions may not be sufficient tools for replicating the relation between negative affect and increased eating-related behaviors observed in self-report and EMA studies. Alternately, these mixed findings may be dependent on unobserved differences in associated eating disorder
symptoms (e.g., dietary restraint, disinhibition, etc.), which are washed out in large meta-analytic studies. That is, there may be personality or behavioral characteristics that influence whether an individual tends to eat more versus less when they are in a negative mood. Individual studies examining the relation between negative affect may not account for or control for these individual differences, leading to inconsistent findings. Given these considerations, future research should be conducted to identify factors that may predict greater versus reduced eating in negative affective states. Research should also focus on whether the broader standards for mood induction procedures mimic naturalistic experiences of negative affect in those with LOC eating.

Moreover, the null effect of task (reward type) on motivation (total presses) raises questions of whether food reward valuation is as relevant to individuals with sub-clinical LOC eating as it is to individuals with binge-type eating disorders. Indeed, participants engaged with both the M&M and Angry Birds tasks equally, suggesting that they may not favor food over other types of reward. This interpretation is somewhat consistent with Bodell and Racine’s (2022) mechanistic staging model of binge eating, which posits that differences in ‘wanting’ of food and non-food rewards emerge with longer duration of binge eating. It is possible that the current sample was less entrenched in their LOC eating than typical samples recruited to assess binge-type eating pathology.

Although recruitment of individuals with a range of LOC-eating severity was intentional, it is possible that this recruitment strategy captured both individuals for whom incentive salience has been deeply entrenched and individuals at earlier stages of illness who experience high levels of ‘wanting’ for many kinds of rewards. Therefore, hypothesized effects could be muddied by a large range in LOC eating duration. The
study did not collect data on duration of LOC-eating pathology; however, mean scores on the LOCES and EDEQ-SF suggest that my sample included individuals with distressing levels of LOC eating but without other kinds of significant eating pathology. This observation supports the idea that this sample may be more aligned with samples considered “high risk” for developing an eating disorder, which according to Bodell and Racine’s mechanistic staging model of reward alterations in binge eating (2022), would demonstrate heightened ‘wanting’ to both food and non-food rewards.

Furthermore, similar to delay-discounting, it is not known whether, or to what extent, food reward valuation predicts maladaptive eating behaviors in individuals with sub-threshold LOC eating. Differences in reward valuation-effort for food versus leisure rewards may be much smaller than anticipated, resulting in smaller effect sizes. Indeed, observed effect sizes were even smaller than predicted. Future studies investigating reward mechanisms in samples that span eating disorder severity may need to anticipate smaller effect sizes and recruit larger samples.

Although it is possible that the non-significant effects found in this study may be ‘true’ null findings, there are several alternative reasons I may have failed to find support for our hypotheses. First, the current sample size fell short of the recruitment goals established by our a priori power analyses. Post-hoc sensitivity analyses indicate that the current sample size would have been able to detect a main effect size of \((f = .20)\). This is larger than our hypothesized effect size \((f = .15)\), and much larger than our observed effect of task \((f = .09)\). Therefore, it remains possible that the hypothesized effect would be observed in a larger sample.
Although the majority of studies suggest enhanced reward valuation for food in binge-type eating disorders, the only other study that used the Angry Birds task found that individuals in the eating disorder group had slightly higher breakpoints for the Angry Birds task than they did for the M&M task (Keel et al., 2022). This difference was reported descriptively, so no conclusions were drawn about whether this difference was statistically significant. Given that the authors did not test this difference and that theories of binge eating imply that individuals with LOC eating would work harder for food rewards than other rewards, I hypothesized that participants would work harder for M&Ms than Angry Birds playtime. However, the Angry Birds task may be a more salient reward stimulus in the progressive ratio paradigm (for those with or without LOC eating).

In addition to the considerations described above, a methodological deviation of note is that I included two individuals in analyses who chose not to play one of the progressive ratio tasks because they did not want to. Prior studies using these identical tasks have only included individuals who completed at least one full trial (Bodell & Keel, 2015; Keel et al., 2022). However, given that I was hypothesizing a difference in motivation between two tasks, excluding individuals who wanted to play one task but did not want to play another task may have biased the data. Therefore, I included individuals who reported a “true zero” of wanting for one progressive ratio task (i.e., not wanting to play) but excluded individuals who represented false zeros (e.g., individuals who could not play the M&M task due to a food allergy). Notably, removing these two participants from analyses did not impact the results.
Study Limitations

There are several study limitations, some of which may have contributed to null fundings. First and foremost was the insufficient sample size. Importantly, although I screened a sufficient number of eligible individuals, less than half of those individuals decided to participate. The disinterest in the study may be related to eating disorder behaviors and cognitions that could interfere with individuals being willing to play a task to consume M&M candies. Namely, individuals with LOC eating often present with dietary restraint. Dietary restraint is a broad term that refers to the cognitive efforts an individual takes to eat less than their body needs, for the purpose of controlling their body shape or weight (Schaumberg et al., 2016). As seen in the supplementary correlation tables, participant ratings of urge to restrict their eating immediately before beginning the M&M progressive ratio task was negatively associated with how much participants endorsed wanting the M&Ms. Thus, some individuals may have chosen not to participate, in part, due to high dietary restraint. In order to understand the role of reward processing mechanisms in eating disorders, the field needs valid measures of reward constructs in which individuals with a broad range of symptoms will participate. As an offshoot of this study, my lab also attempted to recruit individuals who present with clinically significant food restriction and related cognitions but no LOC eating. In line with the statements above, I found it exceptionally hard to recruit this sample. Over the course of nine months, I successfully recruited and ran only eight individuals who presented with restriction without LOC eating. This information further speaks to the difficulties in recruiting individuals with eating disorders to engage with food-related behavioral tasks, as well as to the difficulty of isolating transdiagnostic mechanisms in this field.
The use of repeated mood inductions also may be considered a methodological weakness. In this study, order effects seemed to have some impact on the effectiveness of the mood induction protocols. Participants in the neutral mood condition that were assigned to participate in the M&M task first had, on average, a mild increase in negative affect following their second neutral mood induction. Likewise, among participants in the negative mood condition, those who were randomized to participate in the Angry Birds task first had greater changes in negative affect during their second mood induction protocol (prior to the M&M task). Therefore, having a second mood induction itself may increase negative affect by increasing participant annoyance or burden. Some authors have cautioned against repeated use of negative mood inductions, given that subsequent inductions may have less pronounced effects than the first induction (Richell & Anderson, 2004). It is also possible that repeated probing of participant mood states can promote spontaneous emotion regulation, thus, interfering with experimental effects (Gillies & Dozois, 2021; Torre & Lieberman, 2018). However, the repeated use of autobiographical memories to induce negative moods has been demonstrated to be consistent when administered repeatedly over the course of days (as opposed to being administered more than once in a single day) (Hernandez et al., 2003). Additionally, one study found that repeated negative mood inductions within one experimental visit successfully increased negative affect both times (Mata et al., 2013). Within this study, our negative mood induction significantly increased negative affect relative to baseline levels, increased negative affect relative to a neutral mood induction control, and increased negative affect by absolute minimum standards (10-20 points on a 100 point scale). Therefore, although this methodology should be employed cautiously, my
manipulation checks imply that it met field standards of success. Further, the use of repeated mood inductions increased feasibility by decreasing the number of study visits participants needed to attend.

This study will continue with recruitment before findings can be meaningfully interpreted. If the hypotheses are not supported with an adequate sample size, findings would imply that reward valuation for food may not be altered compared to non-food rewards in individuals who report LOC eating broadly. Instead, those data would imply that alterations to reward processes may occur in more severe or more developed cases, such as individuals with threshold binge-type eating disorders. Alternately, these data might imply that, in individuals who binge eat, the amount of food consumed during LOC-eating episodes may be more closely linked to reward valuation.

On the other hand, if hypotheses are supported in the full sample, then this study would support that reward valuation may be an important mechanism for understanding when and why individuals engage in LOC eating, particularly in relation to negative affect. Further, these findings might inform the development or adaptation of interventions for LOC eating that focus on the link between negative affect and reward. For example, it may be relevant for individuals to identify alternative activities to LOC eating that are comparably rewarding. Expanding coping behaviors for negative affect may both decrease propensity for LOC eating in the moment and halt the further entrenchment of LOC-eating behaviors over time.

**Strengths of the Current Study**

Despite the stated limitations, this study had several notable strengths. I used progressive ratio tasks that were previously established as comparable, valid, and reliable
measures of ‘wanting’ for rewards. Further, these tasks have been used in both non-clinical and eating disorder samples, making them ideal for assessing these constructs in samples with a range in severity of eating disorder symptoms. All individuals included in the study were screened for baseline levels of liking of both types of rewards (chocolate and computer games) to ensure that participants would be at least moderately interested in the reward stimuli. This decision allowed for the comparison of motivation between conditions. As noted, the sample included individuals with low levels of eating pathology, as assessed by the EDE-Q-SF self report. This may be considered a strength, given the need to study LOC eating across a range of severities of eating disorder symptoms. Much of the research in this field has investigated the role of affect or reward processing in individuals with clinical levels of binge eating; therefore, this study expands the literature by examining the role of these mechanisms in a sub-clinical sample. Further, this study attempts to bridge information across multiple literatures and theories of LOC eating, adding to our understanding of the psychobiological mechanisms that interact dynamically to predict LOC eating.

**Future Directions**

A noteworthy direction for future research is to examine how reward processing and negative affect interact to predict LOC eating as individuals age, and over the course of illness. Understanding the dynamic interaction between these facets along explicit trajectories may provide a stronger picture of their role in binge-type eating disorders. Another option for future research is to explore whether, in individuals with LOC eating, different reward mechanisms (e.g., delay discounting) have a stronger relation to affect than reward valuation. For example, one EMA study found that greater delay discounting
heightened the relation between self-reported negative affect and binge eating in adult women (Smith et al., 2019). Lastly, future research might investigate the role of specific negative emotional states in promoting (food) reward-seeking behaviors. There is evidence that guilt in particular precedes LOC eating episodes (Stevenson et al., 2018). Therefore, motivation for food rewards may be more sensitive to guilt versus other types of negative affect. Research on the affect-regulation model of binge eating might explore the use of guilty mood inductions or even personalized mood inductions to best emulate conditions that naturalistically precede LOC-eating episodes.

In sum, this study used an experimental design to examine the impact of negative affect on motivation for different types of rewards in individuals with LOC eating. Despite the strong theoretical rationale for the study, study hypotheses were not supported. Additional participants will be recruited to ensure adequate sample size and allow for more concrete conclusions with the hope of informing future research on the prevention and treatment of LOC eating.
References


https://doi.org/10.1016/j.appet.2009.05.018

https://doi.org/10.1016/j.eatbeh.2008.04.003


https://doi.org/10.1016/j.neubiorev.2018.05.028


https://doi.org/10.1038/oby.2011.286

https://doi.org/10.1023/B:JOBA.0000007455.08539.94


https://doi.org/10.1016/j.psychres.2009.06.010


https://doi.org/10.1002/eat.22806


Psychiatry and Clinical Neurosciences, 71(9), 647–658.

https://doi.org/10.1111/pcn.12537


https://www.nimh.nih.gov/research/research-funded-by-nimh/rdoc/positive-valence-systems-workshop-proceedings


Appendices

Appendix A: Study Recruitment Flyer

SEEKING PARTICIPANTS
Do you feel a loss of control over your eating?

The PEAR Lab at Western University is looking for female volunteers (17–35 years of age) who experience a loss of control over their eating to participate in a study on mood and feelings of reward.

Participants will be compensated for their participation.

This study involves:
- A 2 hour visit to Westminster Hall or the Western Interdisciplinary Research Building
- Answering online questionnaires
- Completing 2 short mood and memory tasks
- Completing 2 simple computer tasks

This study will be conducted under the supervision of Dr. Lindsay Bodei. If you have any questions, contact:

(Redacted)
Appendix B: Research Ethics Board Approval Letter

Dear Dr. Lindsay Bedell,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals and mandated training must also be obtained prior to the conduct of the study.

Documents Approved:

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Document Type</th>
<th>Document Date</th>
<th>Document Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task References</td>
<td>Other Data Collection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debriefing Form April 11 2022</td>
<td>Debriefing document</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M&amp;M VAS</td>
<td>Online Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A VAS</td>
<td>Online Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 April Mood Specificity Questionnaire</td>
<td>Online Survey</td>
<td></td>
<td></td>
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<tr>
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<td>angry_birds_game_image</td>
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<td>M&amp;M stimulus</td>
<td>Other Data Collection</td>
<td></td>
<td></td>
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<tr>
<td>PR Task Instructions June 1 22</td>
<td>Other Data Collection</td>
<td></td>
<td></td>
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<tr>
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<td>Other Data Collection</td>
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<tr>
<td>Flyer_1_June_1_22</td>
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<td>01/Jan/2022</td>
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<td>Recruitment Materials</td>
<td>01/Jan/2022</td>
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<td>Recruitment Materials</td>
<td>01/Jan/2022</td>
<td></td>
</tr>
<tr>
<td>PROTOCOLS_BUMMARY Mood and Reward Specificity June 6 2022</td>
<td>Protocol</td>
<td>07/Jan/2022</td>
<td>1</td>
</tr>
<tr>
<td>Email_script_June 6_22</td>
<td>Recruitment Materials</td>
<td>07/Jan/2022</td>
<td>1</td>
</tr>
<tr>
<td>SONA script June 6_22</td>
<td>Recruitment Materials</td>
<td>07/Jan/2022</td>
<td>1</td>
</tr>
</tbody>
</table>
No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Ms. Zoe Levi, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

*Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).*
Appendix C: Description of Measures of Psychopathology Collected in Study Protocol that are not used in current study’s analyses.

**Eating Disorder Symptoms**

**Eating Pathology Symptoms Inventory.** The Eating Pathology Symptoms Inventory (EPSI) is a forty-five item self-report questionnaire (Forbush et al., 2013). The EPSI contains eight scales, corresponding to different eating disorder symptoms and associated features: body dissatisfaction, binge eating, cognitive restraint, purging, excessive exercise, restricting, muscle building, and negative attitudes toward obesity. These scales demonstrate good internal consistency and validity in college as well as eating disorder samples (Forbush et al., 2013, 2014). This measure was not included in analyses for this project. In the total sample, this measure displayed excellent internal consistency ($\alpha = .90$).

**Clinical Impairment Assessment.** The Clinical Impairment Assessment (CIA) is a three-factor measure of impairment and disruptions to quality of life specific to eating disorder symptoms. The sixteen items assess personal, cognitive, and social impairment over the preceding twenty-eight days. This measure has good internal consistency, which has replicated across samples (Bohn & Fairburn, 2008; Jenkins, 2013). Further, this measure displays sensitivity to changes in impairment following treatment while also displaying high test-retest reliability. This measure is preferable to other measures of quality of life in eating disorders as it emphasizes psychosocial impairment secondary to eating disorder symptoms themselves, and it includes impairment due to heightened concerns about body shape (Bohn & Fairburn, 2008). High scores on the CIA are related to overall eating pathology as well as binge eating frequency (Jenkins, 2013). The CIA is elevated in individuals without eating disorders who were referred to an eating disorder
specialty service, indicating that it may be a good indicator of clinical impairment among those with subthreshold eating disorder symptoms (Jenkins, 2013). This measure was not included in analyses. In this sample, the CIA demonstrated excellent internal consistency ($\alpha = .92$).

**Personality Features**

**UPPS-P Impulsive Behavior Scale.** All five subscales from the UPPS-P Impulsive Behavior Scale (negative urgency, (lack of) premeditation, (lack of perseverance), sensation-seeking, positive urgency) were collected in this study. In particular, the negative urgency subscale was included to assess the degree to which participants endorse impulsive behaviors specific to negative affective states (Whiteside & Lynam, 2001). This measure was selected over other measures of impulsivity as negative urgency is particularly relevant to eating disorder symptoms (Fischer et al., 2008). This subscale has good construct and discriminant validity from other measures of impulsivity, and it has been demonstrated to predict clinical psychopathology when other forms of impulsivity are controlled for (Whiteside et al., 2005). In this sample the negative urgency subscale had excellent internal consistency ($\alpha = .91$).

**Difficulties with Emotion Regulation Scale.** The Difficulties in Emotion Regulation scale (DERS) was developed to assess emotional awareness, understanding and acceptance of emotions, emotional modulation abilities, and the ability to act in desired ways regardless of emotional state (Gratz & Roemer, 2004). This forty-one item measure has adequate construct and predictive validity, as well as test-retest reliability. Further it demonstrates good to excellent internal consistency in college and eating disorder samples (Gratz & Roemer, 2004; Ruscitti et al., 2016; Svaldi et al., 2012). There
is evidence that individuals with different eating disorders report differences in emotion regulation. Specifically, individuals with BED report greater acceptance of negative emotions than those with AN, greater emotional clarity than those with BN, and more access to emotion regulation strategies than individuals in either group (Svaldi et al., 2012). Given shared emotion regulation deficits, the DERS is associated with both eating disorder and personality psychopathology. In this sample the DERS had excellent internal consistency ($\alpha = .90$).

**Depressive Symptoms**

**Center for Epidemiologic Studies of Depression Scale.** The Center for Epidemiologic Studies of Depression Scale (CES-D) is a twenty item measure assessing the following components of depression: depressed mood, feelings of guilt and worthlessness, feelings of hopelessness, psychomotor disturbances, loss of appetite, and sleep disturbances (Radloff, 1977). Among both community and clinical samples, this measure has good to excellent internal consistency and acceptable test-retest reliability (Orme et al., 1986; Radloff, 1977). Although related to cognitive symptoms of eating pathology, the CES-D shows good discriminant validity from behavioral measures of eating disorder symptoms (Espelage et al., 2003). In this sample, the CES-D demonstrated good internal consistency ($\alpha = .74$).

**Dimensional Anhedonia Rating Scale.** The Dimensional Anhedonia Rating Scale (DARS) is a seventeen-item measure that assesses anhedonia, or the loss/lack thereof hedonic pleasure (Rizvi et al., 2015). This measure and its subscales demonstrate good to excellent internal consistency, good content validity, and high convergence with other measures of anhedonia. A strength of the DARS is that it taps into desire,
motivation, effort, and enjoyment of activities. Participant responses are tailored to their favorite hobbies, foods, social activities, and sensory experiences, which are elicited during administration of the questionnaire. Resultantly, this measure is a better indicator of reward functioning in individuals with major depressive disorder than the competing “good standard” measure of anhedonia (Rizvi et al., 2015). The DARS had good internal consistency in this sample ($\alpha = .80$).

**Other Psychopathology**

**Alcohol Use Disorders Identification Test.** The Alcohol Use Disorders Identification Test (AUDIT) was developed as a screening instrument for problematic and harmful alcohol use. Its ten items measure drinking behaviors as well as their cognitive, emotional, and physical consequences (Saunders et al., 1993). The AUDIT total score as well as its subscales have good to very good internal reliability, and perform well across international samples. The AUDIT has been used to identify problematic alcohol use in individuals seeking bariatric surgery, and scores of this measure are associated with higher risk for BED in this population (Mitchell et al., 2015). In this sample, the AUDIT demonstrated good internal consistency ($\alpha = .84$).
Appendix D: One-Way Analyses of Variance in Negative Affect Across all Mood Conditions

One-Way Analyses of Variance in Negative Affect Across all Mood Conditions

<table>
<thead>
<tr>
<th>Mood Condition</th>
<th>df (1,2)</th>
<th>F</th>
<th>p</th>
<th>ηp²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>2.76, 55.17</td>
<td>12.89</td>
<td>&lt;.001</td>
<td>0.39</td>
</tr>
<tr>
<td>Neutral</td>
<td>5, 120</td>
<td>1.19</td>
<td>0.634</td>
<td>0.05</td>
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</table>

*Note.* One-way post-hoc ANOVA assessing for a main effect of time on negative affect for both conditions. Degrees of freedom and p-values may be affected by Greenhouse-Geisser sphericity correction. All p-values are bonferroni-corrected.
Appendix C: Funding Letter for Paid Participants

April 26, 2022

Dear Kendall Schmidt,

It is my pleasure to inform you that you have been awarded a Graduate Research Award for $525 in support of your research.

To receive your award you must fill out a University travel form and attach your original receipts. The form should be submitted to your Department’s Administrative Officer or designate. Please note that the monies must be used for the purposes outlined in your application. Upgrades to personal computers are not eligible, but upgrades to University-owned computers are acceptable. If you have any questions or concerns please consult your Department’s Administrative Officer or designate as well as the GRAF Process on the webpage.

Congratulations and best of luck with your studies.

Sincerely,

[Redacted]

Jamie Baxter
Associate Dean (Graduate)

Cc: Graduate Chair
    Administrative Officer
    Graduate Assistant
Appendix D: Negative Mood Induction

Please recall, as vividly as possible, an event in your life that made you feel sad, guilty, or rejected. For the next 3 minutes, try to carefully remember and evoke details about that situation, how you felt, and what your thoughts were at the time. While you are doing this, try to immerse yourself as deeply as possible into the mood that your memories evoke.

After this, you will be asked to write as detailed a description of the event as possible for approximately 4 minutes.
Appendix E: Neutral Mood Induction

Please recall, as vividly as possible, an everyday task, errand, or chore that you completed. For the next 3 minutes, try to carefully remember and evoke details about that situation, such as where you were and what exactly you did.

After this, you will be asked to write as detailed a description of the event as possible for approximately 4 minutes.
Appendix F: M&M Task Instructions

M&M Task Instructions

This computer task consists of 10 opportunities, or trials, to earn M&Ms® by repeatedly pressing the space bar. The number of presses needed to earn 10 M&Ms® will increase as you go through the trials.

After you complete a trial, an image of M&Ms® will appear on the screen, and 10 M&Ms® will automatically be dispensed in a bag for you to consume. After you complete a trial and consume the M&Ms®, you may continue working for more M&Ms® by continuing to tap on the space bar.

Please only continue to tap for as long as you still want more M&Ms®. You must finish the M&Ms® in the bag before you continue to tap on the space bar.

You will have up to 45 minutes to complete the computer task; however, you may stop at any time. There are no right or wrong answers and this is not a competition. To end the task, please press the bell. Note that you only earn 10 M&Ms® for completed trials.
Appendix G: M&M Progressive Ratio Task Stimuli

Instruction Screen:

Screen Displayed During Trials:
Screen Displayed at End of Trials:
Appendix H: Angry Birds Task Instructions

**Angry Birds Task Instructions**

This computer task consists of 10 opportunities, or trials, to earn time playing the Angry Birds™ game by repeatedly pressing the **space bar**. The number of presses needed to earn one minute of Angry Birds™ playtime will increase as you go through the trials.

After you complete a trial, an image of Angry Birds™ will appear on the screen, and you will automatically be able to play Angry Birds™ with the mouse. After you complete a trial and **play Angry Birds™ for one minute**, you may continue working for more Angry Birds™ playtime by continuing to tap on the space bar.

Please only continue to tap for as long as you still want to play Angry Birds™. You must finish the minute of Angry Birds™ playtime before you continue to tap on the space bar.

You will have up to 45 minutes to complete the computer task; however, you may stop at any time. There are no right or wrong answers and this is not a competition. To end the task, please press the bell. Note that you only earn one minute of Angry Birds™ playtime for completed trials.
Appendix I: Angry Birds Task Stimulus

Screen Displayed During Trials:

Screen Displayed at End of Trials:
Screen of Angry Birds Game Being Played:
Appendix J: Post-hoc One-Way Analysis of Variance in Negative Affect Across all Timepoints

One-Way Analyses of Variance in Negative Affect At Each Timepoint

<table>
<thead>
<tr>
<th>Timepoint</th>
<th>$df$</th>
<th>$F$</th>
<th>$p$</th>
<th>$\eta_p^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB T1</td>
<td>1, 44</td>
<td>0.33</td>
<td>1.00</td>
<td>0.01</td>
</tr>
<tr>
<td>AB T2</td>
<td>1, 44</td>
<td>9.12</td>
<td>0.02</td>
<td>0.17</td>
</tr>
<tr>
<td>AB T3</td>
<td>1, 44</td>
<td>0.79</td>
<td>1.00</td>
<td>0.02</td>
</tr>
<tr>
<td>MM T1</td>
<td>1, 44</td>
<td>0.11</td>
<td>1.00</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>MM T2</td>
<td>1, 44</td>
<td>25.09</td>
<td>&lt;.001</td>
<td>0.36</td>
</tr>
<tr>
<td>MM T3</td>
<td>1, 44</td>
<td>0.31</td>
<td>1.00</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note. One-way post-hoc ANOVA assessing for a main effect of mood condition on negative affect at each timepoint. All p-values are bonferroni-corrected. T1 corresponds to pre-mood induction timepoint, T2 corresponds to post-mood induction timepoint, and T3 corresponds to post-progressive ratio task timepoint.
Appendix K: Means and Standard Deviations of Momentary Eating Pathology and Feelings of Reward Toward M&M Candies

Means and Standard Deviations of Momentary Eating Pathology and Feelings of Reward Toward M&M Candies

<table>
<thead>
<tr>
<th>VAS Item</th>
<th>Negative Mood Condition</th>
<th>Neutral Mood Condition</th>
<th>Total Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n = 21$</td>
<td>$n = 25$</td>
<td>$n = 46$</td>
</tr>
<tr>
<td>Urge to Binge</td>
<td>31.19 (36.62)</td>
<td>42.64 (33.54)</td>
<td>37.41 (35.06)</td>
</tr>
<tr>
<td>Urge to Restrict</td>
<td>26.57 (36.38)</td>
<td>28.92 (28.17)</td>
<td>27.85 (31.83)</td>
</tr>
<tr>
<td>Like</td>
<td>58.33 (31.37)</td>
<td>67.36 (26.36)</td>
<td>63.24 (28.79)</td>
</tr>
<tr>
<td>Want</td>
<td>53.48 (35.44)</td>
<td>70.72 (22.41)</td>
<td>62.85 (30.03)</td>
</tr>
<tr>
<td>Rewarding</td>
<td>52.05 (33.96)</td>
<td>66.48 (22.16)</td>
<td>59.89 (28.76)</td>
</tr>
</tbody>
</table>

Note. Values were drawn from the visual analogue scales taken immediately after the M&M task mood induction protocol. VAS = Visual Analogue Scale.
### Appendix L: Means and Standard Deviations of Momentary Eating Pathology and Feelings of Reward Toward Angry Birds

**Means and Standard Deviations of Momentary Eating Pathology and Feelings of Reward Toward Angry Birds**

<table>
<thead>
<tr>
<th>VAS Item</th>
<th>Negative Mood Condition</th>
<th>Neutral Mood Condition</th>
<th>Total Sample</th>
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<tbody>
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<td></td>
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<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>M(SD)</td>
</tr>
<tr>
<td>Urge to Binge</td>
<td>17.38 (23.21)</td>
<td>24.80 (29.65)</td>
<td>21.41 (26.88)</td>
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<tr>
<td>Urge to Restrict</td>
<td>28.43 (35.90)</td>
<td>33.88 (30.59)</td>
<td>31.39 (32.86)</td>
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<tr>
<td>Like</td>
<td>29.86 (28.38)</td>
<td>44.68 (27.37)</td>
<td>37.91 (28.51)</td>
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<tr>
<td>Want</td>
<td>37.57 (32.36)</td>
<td>43.44 (30.28)</td>
<td>40.76 (31.04)</td>
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<tr>
<td>Rewarding</td>
<td>33.43 (30.52)</td>
<td>40.64 (32.29)</td>
<td>37.35 (31.36)</td>
</tr>
</tbody>
</table>

*Note.* Values were drawn from the visual analogue scales taken immediately after the Angry Birds task mood induction protocol. VAS = Visual Analogue Scale.
Curriculum Vita

KENDALL M. SCHMIDT

EDUCATION

2021 - Western University | London, ON, CA
Candidate for Master’s of Science, Clinical Psychology
Advisor: Lindsay Bodell, PhD

2015 - 2019 Yale University | New Haven, CT
Bachelor of Science in Psychology
with Distinction in the Major
GPA: 3.8
Advisor: Eli Lebowitz, PhD

AWARDS AND HONORS

2022-2023 Graduate Research Award Fund (Western University)
2018-2019 Silliman Mellon Forum Scholar (Yale University)
2018-2019 Aurelian Honor Society (Yale University)
2018 Silliman College Richter Summer Fellowship for Research (Yale University)
2017 Silliman College Richter Summer Fellowship for Academic Internship (Yale University)

PUBLISHED MANUSCRIPTS


REGISTERED REPORTS STAGE 1 ACCEPTED


MANUSCRIPTS UNDER REVIEW


**MANUSCRIPTS IN PREPARATION**


**PROFESSIONAL PRESENTATIONS**


**RESEARCH EXPERIENCE**

2019 - 2021 **Research Coordinator | Risk for Anxiety and Depression Lab**
*Florida State University, Tallahassee, FL*

**Supervisor**: Greg Hajcak, PhD
- Coordinated multiphase study on adult depression
Collected and processed psychophysiological data (EEG)

**Research Assistant | Anxiety & Mood Disorders Program**
*Yale Child Study Center, Yale School of Medicine, New Haven, CT*
**Supervisor:** Eli Lebowitz, PhD
- Conducted research visits for an R21 Developmental Research Grant
- Implemented study protocols, collected self-report, behavioral, and psychophysiological data

**Fall 2017 Research Assistant | Applied Cooperation Lab**
*Yale University, Department of Psychology, New Haven, CT*
**Supervisor:** David Rand, PhD
- Conducted literature reviews on individual differences in and individual-difference measures for the acceptance of violent acts and terrorism
- Created experimental materials for studies

**CLINICAL TRAINING AND EXPERIENCE**

**Winter 2021-2022 Clinical Interviewer | Psychobiology of Eating and Related Disorders Lab**
*Western University Psychology Department, London, ON*
**Supervisors:** Drs. Lindsay Bodell and David Dozois
- Administered structured clinical interviews (Eating Disorder Assessment for DSM-5 and Mini-International Neuropsychiatric Interview) for research purposes

**Summer 2019 Clinical Interviewer | Risk for Anxiety and Depression Lab**
*Florida State University Psychology Department, Tallahassee, FL*
**Supervisors:** Drs. Greg Hajcak & Alexandra Meyer
- Administered structured clinical interviews (KSADS) to adolescents

**Fall 2017 Undergraduate Intern | Anxiety and Mood Disorders Clinic**
*Yale Child Study Center, New Haven, CT*
**Supervisors:** Eli Lebowitz, PhD, Dennis Sukhodolsky, PhD, & Fred Volkmar, PhD
- Observed child CBT and parent-based interventions
- Received training on Anxiety Disorders Interview Schedule (ADIS) implementation.
Summer 2016 **Applied Behavioral Analyst Intern | Language and Learning Clinic**  
*Marcus Autism Center*  
Supervisor: Tom Cariveau, PhD  
o Implemented Discrete Trial Teaching Therapy in conjunction with Applied Behavioral Analysis to foster growth in language and behavioral abilities in children with Autism Spectrum Disorder

**PROFESSIONAL SERVICE**

2022 - **Presenter | Advocacy Through Action**  
*London, ON*  
o Created and provided mental health literacy lectures to community members

2022 - **Member | Clinical Psychology Diversity, Equity, and Inclusion Committee**  
*London, ON*  
o Disseminated information on clinical psychology application process to community members  
o Drafted student opinion statements

2020 - **Ad hoc Reviewer | Journal of Psychiatric Research**

2020 - 2021 **Member | Dismantling Systemic Shortcomings in Education and Clinical Training (DiSSECT)**  
o Compiled and disseminate open-access resources to address systemic racism in clinical training programs

**LEADERSHIP AND VOLUNTEER SERVICE**

2022 - **Presenter | Advocacy Through Action**  
*London, ON*  
o Created & provided mental health literacy lectures to community members

**PROFESSIONAL AFFILIATIONS**

- Psi Chi, the International Honor Society in Psychology (Student Member)  
- American Psychological Association (Member)