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Approach and Avoidance Food Craving: A Dual Cue Reactivity Investigation

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Approach and Avoidance Food Craving: A Dual Cue Reactivity Investigation

by

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy Department of Psychology College of Arts and Sciences University of South Florida

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ABSTRACT

Recent research suggests that food craving is a motivational process underlying the full spectrum of disordered eating behaviors. The ambivalence model of craving, originally applied to substance use craving, provides a framework through which the push-pull motivational process of food craving and its relation to the range of disordered eating behaviors can be understood. In this perspective, food craving is a multi-dimensional motivational process that involves an individual’s competing desires to both consume (i.e., approach) and not consume (i.e., avoid) certain food. Building on previous literature, the current studytested whether behavioral measures of approach and avoidance food craving (i.e., reaction time) differentially and more strongly predicted the spectrum of disordered eating behaviors compared to traditional self-report measures. Participants ($N = 240; 67\%$ female, age $M = 19.79$ years) were recruited from the University of South Florida SONA participant pool and completed a dual food cue-reactivity paradigm and self-report measures of hunger, food craving, and disordered eating in an online environment. Inconsistent with hypotheses, reaction time data from Go/No-Go and Approach-Avoidance Tasks were not predictive of self-reported disordered eating behaviors; however, self-reported measures of food craving were associated with the spectrum of self-reported disordered eating behaviors. Findings highlight that the subjective experience of food craving may be more salient to disordered eating behaviors than objective experiences of food craving.
INTRODUCTION

Disordered eating behaviors encompass a spectrum of unhealthy and maladaptive weight control behaviors (i.e., restrictive eating, overeating, compensatory behaviors) that are potent risk factors for clinically diagnosable eating disorders (e.g., anorexia nervosa, bulimia nervosa, and binge eating disorder; Reel, 2018). Historically weak treatment outcomes coupled with high dropout (Wallier et al., 2009) and relapse rates (Berends et al., 2018) highlight the need to investigate novel processes underlying the spectrum of disordered eating behaviors. To improve treatment outcomes, processes that contribute to the development and maintenance of disordered eating behavior patterns are of particular interest. Borrowing from the substance use literature, the motivational process of craving represents a potentially effective treatment target for both pharmacological (Monterosso et al., 2001) and behavioral interventions (Carroll, 1999). Emerging research suggests that food craving represents a motivational process underlying the full spectrum of disordered eating behaviors that warrants consideration as a potential eating disorder treatment target (Moreno et al., 2009; Ng & Davis, 2013).

Historically, food craving has been defined as a strong motivational state characterized by an intense desire or urge to consume a certain food (e.g., chocolate), or specific types of food (e.g., salty; Gendall et al., 1999; Gendall et al., 1997; Hormes & Rozin, 2010). Importantly, food craving is distinguished from the biological deficit of hunger by both its degree of intensity (Cepeda-Benito et al., 2000) and specificity (Pelchat, 2002). In the 1980’s, researchers began investigating food craving as a unique
predictor of specific disordered eating behaviors (e.g., binge eating: Gendall et al., 1998; dietary restraint: Weingarten & Elston, 1991), while more recent literature supports food craving as a transdiagnostic factor of both eating disorders and the full spectrum of disordered eating behaviors (Cartwright et al., 2007; Rancourt et al., 2019; Verzijl et al., 2018). Review of this literature underscores the importance of food craving as a potentially modifiable process relevant to enhancing eating disorder treatment outcomes.

**Food Craving and Eating Disorder Diagnoses**

Food craving is linked with clinically significant eating disorder diagnoses and can distinguish those with versus without a disorder, as well as individuals with different eating disorder psychopathologies. Food cravings are often reported as more intense and frequent among individuals with eating disorder symptoms (e.g., binge eating, purging behaviors, and night eating) compared to those who do not report any eating disorder symptomatology (Jarosz et al., 2007). For example, individuals with bulimia nervosa (BN) report elevated food cravings, compared to individuals who do not meet criteria for the diagnosis (Van den Eynde et al., 2012). Additionally, numerous studies indicate higher levels of reported food cravings among individuals with binge eating disorder (BED) compared to those without the diagnosis (Innamorati et al., 2014; Ng & Davis, 2013; White & Grilo, 2005). Further, individuals diagnosed with purging and non-purging types of BN can be distinguished from individuals diagnosed with anorexia nervosa (AN) based on food craving ratings (Moreno et al., 2009), as individuals with AN report the lowest levels of food craving across the two eating disorder diagnoses. Collectively, accumulating evidence supports the role of food craving in the development and maintenance of different eating disorder psychopathology, suggesting that the
inclusion of food craving as a screening or treatment target may benefit eating disorder identification and treatment outcomes.

A substantial limitation of work supporting food craving as a transdiagnostic factor of eating disorders is its focus on approach food craving – i.e., the desire to consume – which represents a potent risk factor for overeating/binge eating behaviors (Neumark-Sztainer et al., 2007; Van den Eynde et al., 2012). Such a narrow focus on the desire to consume limits our understanding of food craving as a complex motivational process that may both promote and discourage food consumption (Breiner et al., 1999; Stritzke et al., 2007). Therefore, it is essential to consider the multidimensionality of food craving and how it may contribute to the full range of disordered eating behaviors from restrained eating to overeating.

**Conceptual Limitations of the Food Craving Literature**

Despite advances in the appreciation of food craving as an influential process in the development and maintenance of diagnostic eating disorders, existing literature continues to show conceptual limitations. First, the numerous combinations of disordered eating behaviors across different diagnoses (e.g., overeating in BED; binge eating and compensatory behaviors in BN; undereating and compensatory behaviors in AN) paired with weak treatment outcomes suggests that concentrating on clinically significant eating disorder diagnoses may be less informative than examining the role of food craving on disordered eating behavior patterns. Consistent with data that dimensional approaches provide the most accurate conceptualizations of disordered eating behaviors (Forbush et al., 2018; Luo et al., 2016), food craving and associated motivational models may
contribute to a shift in the current understanding of eating disorders to be transdiagnostic and improve treatment outcomes.

Second, the majority of the food craving literature is historically atheoretical; however, recent advances explaining the relationships between food craving and different behavioral patterns have tested models borrowed from the substance use literature (e.g., ambivalence model of craving: Breiner et al., 1999; elaborated intrusion theory: Kavanagh et al., 2005; May et al., 2012; cognitive processing model: Tiffany, 1990; Verzijl et al., 2018). In the alcohol use literature, motivational models of craving provide theoretical underpinnings of the relationship between alcohol craving and consumption behaviors. Most relevant to the current study, the ambivalence model of craving (e.g., ambivalence model of craving: Breiner et al., 1999) explicitly recognizes that an individual’s craving for alcohol is determined by the relative strength of two competing inclinations – the desire to consume and the desire to not consume. This model posits that the integration of these competing motivational inclinations either promote or discourage the consumption of alcohol. This multidimensional approach aligns well with a transdiagnostic understanding of food craving promoting or discouraging the consumption of food. Thus, the ambivalence model of craving may represent a particularly relevant model to apply to food craving and its conceptualization as a motivational process underlying the full spectrum of disordered eating behaviors from undereating to overeating/binge eating (Verzijl et al., 2021).

The Ambivalence Model of Craving

The ambivalence model of craving (AMC; Breiner et al., 1999; McEvoy et al., 2004; Stritzke et al., 2004) defines craving as the relative activation of response
inclinations that operate on two independent dimensions: an individual’s desire to use a substance and their desire to not use a substance. Within this framework, an individual’s inclination to use alcohol represents approach craving, while the inclination to not use alcohol represents avoidance craving. The strength of an individual’s approach and avoidance inclinations determine the ‘craving points’ that fall in one of four quadrants: (1) approach; (2) avoidant; (3) ambivalent (i.e., co-activation of relatively high intensity of approach and avoidance inclinations); or (4) indifferent (i.e., weak activation of both approach and avoidance inclinations; Breiner et al., 1999; see Figure 1). Analogous to the definitional improvements seen with the AMC when defining alcohol craving, the AMC provides numerous advantages to understanding the push-pull motivational process of food craving and its relation to the range of disordered eating behaviors.

Figure 1. Ambivalence Model of Craving (adapted from Briener et al., 1999)

A substantial limitation of food craving literature has been the failure to capture the competing motivations of the desire to eat and the desire to not eat, which in turn fail to account for the influence of food craving on undereating and compensatory behaviors.
(Rancourt et al., 2019). Additionally, traditional concentrations of approach motivations to consume food, without the competing desire to avoid or not consume food, may misrepresent the motivational process of food craving. As was shown in the alcohol use literature (Stritzke et al., 2007), omission of the avoidance inclination may be incorrectly capturing a motivational process that truly includes some combination of both approach and avoidance food craving. In fact, data indicate that the presentation of different food stimuli can activate both approach and avoidance responses across eating disorder samples (Leehr et al., 2016; Paslakis et al., 2017). These data underscore the importance of applying a motivational model of craving that explicitly identifies both the desire to consume and the desire to not consume. Thus, the AMC provides a framework through which the approach and avoidance inclinations of food craving can be understood as predictors of the full spectrum of disordered eating behaviors.

Applications of the AMC to food craving provide a foundation for understanding the construct as a motivational process underlying disordered eating behavioral patterns. Specifically, the AMC has been applied to food craving to explain chocolate consumption (Cartwright et al., 2007) and the full spectrum of disordered eating behaviors (Ahlich et al., 2020; Rancourt et al., 2019). Cartwright and colleagues (2007) tested a modified version of the AMC specific to chocolate among both adults and youth. They determined that chocolate craving is most adequately explained by the combination of three components: (1) avoidance inclinations; (2) approach inclinations; and (3) the experience of guilt (e.g., three-factor model of chocolate craving). Data from adults indicate that increases in approach chocolate craving are associated with increases in individuals’ risk for overeating chocolate (Cartwright & Stritzke, 2008). The
development of a more general food approach and avoidance questionnaire based on the AMC (Rancourt et al., 2019) replicated these findings and revealed that approach food craving was related to overeating/binge eating behaviors across community (Rancourt et al., 2019), undergraduate (Ahlich et al., 2020; Rancourt et al., 2019), and treatment-seeking populations (Verzijl et al., 2018). Thus, investigations of the multiple dimensions of food craving reinforce approach food craving as an influential process that may be targeted to improve eating disorder treatment outcomes. As work exploring applications of the AMC specifically to food is limited, a general literature focusing on the approach dimension of food craving, and avoidance food craving as available, will be discussed in the following sections.

**Food Craving and Overeating/Binge Eating**

Approach food craving represents a unique predictor of overeating and binge eating behaviors. A core diagnostic feature of both BN and BED, binge eating is defined as eating an amount of food that is objectively larger than what most people would eat in a similar period of time coupled with a sense of lack of control (American Psychiatric Association, 2013). In contrast, overeating is defined as eating an objectively large amount of food without experiencing a loss of control (Fairburn & Wilson, 1993). Both theoretical (McManus & Waller, 1995) and experimental (Waters et al., 2001) data suggest that approach food craving represents an immediate trigger for binge eating and overeating behaviors.

Approach food craving is often reported as an antecedent of binge eating/overeating behaviors in both clinical (Innamorati et al., 2014; Moreno et al., 2009) and community samples (Chao et al., 2016; McManus & Waller, 1995). Among females
diagnosed with an eating disorder, the association between approach food craving and binge eating is strongest among those diagnosed with BN (Waters et al., 2001) and BED (Greeno et al., 2000; Jarosz et al., 2007). In individuals who do not meet diagnostic criteria for any eating disorder, the majority of reported approach food cravings lead to the consumption of craved foods (Lafay et al., 2001; Weingarten & Elston, 1991), which often results in eating an excess of calories and subsequent weight gain (Buscemi et al., 2017). Taken together, approach food craving represents a common antecedent of overeating/binge eating behaviors across individuals with both a diagnosed eating disorder, as well as among the general population. Thus, approach food craving may represent an important target process for individuals seeking treatment for BN, BED, or problematic overeating/binge eating behaviors more broadly.

**Food Craving and Restrained Eating**

Less intuitive than the relationship between approach food craving and overeating/binge eating is the association between approach food craving and undereating or restrained eating. Restrained eating, defined as a deliberate restriction of food intake with the intention to maintain or reduce body weight (Lowe, 2002), is consistently linked with the experience of approach food craving (Burton et al., 2007). In particular, data indicate that individuals restricting their food intake often engage in restrained eating as a means of (1) controlling their approach food cravings and (2) reducing subsequent overeating behaviors (Abdella et al., 2019). Compared to non-dieters, individuals restricting their food intake report approach food cravings as stronger and less resistible (Massey & Hill, 2012). Therefore, approach food craving may also represent an
important eating disorder treatment target for individuals engaging in undereating behaviors.

For individuals restricting their food intake, fewer approach food cravings often lead to greater dieting success (Batra et al., 2013; Meule, Westenhöfer, et al., 2011). In treatment studies, dietary restriction is associated with reductions in reported approach food cravings, but only after conditioned associations with craved foods are broken (see meta-analysis by Kahathuduwa et al., 2017). Thus, if individuals engaging in restrained eating continue to consume craved foods, even in small quantities, the experience of approach food cravings for those specific foods will continue. Unfortunately, current eating disorder treatments do not explicitly aim to break this classically conditioned process (Reas & Grilo, 2014), highlighting an area of possible treatment improvement. Evidence supports that approach food craving represents an important underlying motivation that maintains disordered eating behaviors and targeting this motivation may improve treatment outcomes.

Not surprisingly, preliminary research suggests that avoidance food craving – i.e., the desire to not consume – is also related to restrictive eating behaviors. Specifically, avoidance food craving is positively associated with higher levels of restrained eating (Ahlich et al., 2020; Rancourt et al., 2019; Verzijl et al., 2018). Similarly, avoidance food craving is related to an increased likelihood of meeting self-reported diagnostic criteria for AN (Rancourt et al., 2019), of which restrained eating is a core diagnostic feature (American Psychiatric Association, 2013). Taken together, data indicate that both approach and avoidance food craving may represent effective eating disorder treatment targets for individuals engaging in undereating behaviors.
Food Craving and Compensatory Behaviors

In addition to undereating and overeating, compensatory behaviors are included in the spectrum of disordered eating behaviors. Individuals engage in compensatory behaviors to prevent weight gain and compensate for unwanted calorie consumption, with behaviors including self-induced vomiting, use of laxatives, diuretics, or excessive exercise (American Psychiatric Association, 2013). Compensatory behaviors have largely been neglected in the food craving literature and little is known about the relationship between food craving and stand-alone compensatory behaviors. However, preliminary data from an eating disorder treatment-seeking sample suggests that avoidance food craving is associated with a greater likelihood of engaging in compensatory behaviors including vomiting, use of laxatives or diuretics, and compensatory exercise (Verzijl et al., 2019). While avoidance food craving seems to show counteracting benefits (e.g., breaking the classically conditioned response to craved foods in individuals engaging in overeating/binge eating), the association between avoidance food craving and compensatory behaviors highlights that the desire to not consume food may also contribute to the maintenance of maladaptive disordered eating behaviors.

Taken together, a broad literature suggests that food craving represents a transdiagnostic construct related to the full spectrum of disordered eating behaviors (e.g., overeating, undereating, and compensatory behaviors), with potential to be a modifiable motivational process that may help to improve historically weak treatment outcomes.

A Methodological Limitation of Current Literature

While investigations of approach and avoidance food craving have made important contributions to our conceptualization of the motivational process, the current
literature continues to demonstrate one considerable methodological limitation. Specifically, research on the ambivalence model of food craving has been limited to self-reports of approach and avoidance food craving (Ahlich et al., 2020; Rancourt et al., 2019; Verzijl et al., 2019). Although self-report data are informative, they may also be susceptible to bias. Self-report measures of food craving may be influenced by demand characteristics and/or stigma. Data suggest that food cravings have historically been viewed as (1) problems experienced by individuals diagnosed with a variety of health conditions (e.g., eating disorders: Bruch, 1973; premenstrual disorder: Morton et al., 1953; obesity: Randolph, 1956; mood disorders: Wurtman, 1988); (2) negative side effects of medications (Garland et al., 1988); and (3) barriers to adherence of medically prescribed diets (Doyle et al., 2011). Thus, behavioral measurements of approach and avoidance food craving may decrease concern of biased self-reporting due to social desirability (Banks et al., 2016).

In addition to the stigma associated with food craving, self-reported food craving may also be biased by the interruption of automatic responses associated with verbal reporting or labeling. Similar to data indicating that self-report assessments of emotions can disrupt the experience of the emotion itself and lead to verbal overshadowing effects (Creswell et al., 2018; Schooler et al., 2003), food craving may also be more accurately represented via behavioral measures that do not disrupt the experience of food craving. Theoretical work (e.g., automotive theory of non-conscious goal pursuit; Bargh, 1994) suggests that in the context of a history of a strong connection between stimuli (i.e., food) and target behaviors (i.e., approach or avoidance inclinations), specific stimuli induce approach and avoidance behaviors automatically and in the absence of consciousness. To
overcome the methodological limitations of self-report, cue-reactivity paradigms (e.g., Go/No-Go, Joystick, and Approach-Avoidance Tasks) have been used to investigate the motivational processes of food approach and avoidance that occur at an automatic and implicit level. Cue-reactivity designs of Go/No-Go, Joystick, and Approach-Avoidance tasks provide measures of latency to response via reaction time that may (1) be less influenced by social desirability or verbal overshadowing effects and (2) occur automatically.

**Go/No-Go Paradigms**

Based on the stop-signal paradigm (Lappin & Eriksen, 1966; Logan & Cowan, 1984; Ollman, 1973), Go/No-Go tasks represent a gold standard measure of inhibitory control, or the ability to inhibit a planned or ongoing action. The complex stop-signal paradigm involves two concurrent tasks: (1) a go task and (2) a no-go or stop task. The inhibitory control of a given impulse depends on the latency of the response (e.g., reaction time) to the go signal and the latency of the response to the no-go signal. Applied to a food context, studies have implemented the Go/No-Go paradigm to investigate individuals’ inhibitory control toward high- and low-calorie foods across undergraduate (Meule, Lukito, et al., 2011), adolescent (He et al., 2019), community (Carbine et al., 2017), and binge eating samples (Lyu et al., 2017).

Investigations using healthy samples indicate that young adults show a longer latency of response, or longer reaction time, when responding to high-calorie foods relative to low-calorie foods (Carbine et al., 2017; Meule, Lukito, et al., 2011). Thus, data suggest that a healthy brain may process high- and low-calorie foods differently with respect to inhibitory control. Still, reaction times may look different or be exacerbated for
individuals engaging in disordered eating behavioral patterns. Preliminary research shows a shorter latency of response for both high-calorie (Lyu et al., 2017) and food-specific stimuli (Schag et al., 2013; Schmitz et al., 2015) in individuals engaging in binge eating, compared to weight-matched controls.

Across food-based Go/No-Go studies, go trial reaction times have been conceptualized as automatic approach biases associated with the motivational process of incentive salience, or unconscious ‘wanting’ (Meule et al., 2012). Through the lens of the AMC, latency of response may also represent an unbiased measure of approach (i.e., shorter reaction time) and avoidance (i.e., longer reaction time) food craving. In recent literature, shorter latency of response to high-calorie food stimuli has been linked to post-task calorie intake among women engaging in binge eating (Lyu et al., 2017), highlighting the possible link between latency of response to high-calorie foods and food craving. Therefore, the current study aims to examine the AMC through a Go/No-Go paradigm, measuring individuals’ reaction times to go tasks in response to high- and low-calorie food images. An important design limitation of the Go/No-Go paradigm is that only approach behaviors are measured (via button pressing), neglecting the measurement of avoidance behavior. Thus, joystick and approach-avoidance task paradigms provide methods to fully capture both approach and avoidance behavior.

**Joystick and Approach-Avoidance Task Paradigms**

Dual-process models suggest that perceiving a stimulus as positive facilitates approach behavior, while perceiving a stimulus as negative facilitates avoidance behavior (Chen & Bargh, 1999; Solarz, 1960). Two methods used to investigate this stimulus-response compatibility effect are the measure of approach-avoidance behavior (MAAB)
via a joystick (Krieglmeyer & Deutsch, 2010) and up/down arrow keys (De Houwer et al., 2001). Across undergraduate (joystick: Brockmeyer et al., 2015; arrow keys: Havermans et al., 2011) and community samples (arrow keys: Brignell et al., 2009; joystick: Piqueras-Fiszman et al., 2014), emerging literature has measured general approach and avoidance behavior by asking participants to (1) pull or push a joystick or (2) push up and down arrow keys in response to food images, respectively.

Data from Krieglmeyer and Deutsch (2010) suggest that manikin tasks, whereby participants are instructed to move a manikin figure on the screen towards or away from stimuli, are slightly more sensitive to valence-induced activation of approach and avoidance behavior in response to word and animal stimuli. Other literature, however, suggests that joystick tasks more accurately measure approach and avoidance movements in response to food stimuli (e.g., moving joystick towards or away from participant, respectively; Piqueras-Fiszman et al., 2014; Seibt et al., 2008). The increased accuracy is established when the participant acts as their own reference point, moving the food stimuli toward or away from their own body, as opposed to moving the manikin figure toward or away from the food stimuli on the screen. Thus, joystick tasks represent the most accurate and appropriate measure of approach and avoidance motivations to move toward or away from food stimuli.

Data suggest that non-clinical individuals reporting high levels of trait food craving show stronger automatic approach tendencies (e.g., shorter reaction time) when approaching food cues via a joystick compared to individuals reporting low levels of food craving (Brockmeyer et al., 2015). However, this approach bias toward food cues was not replicated in a sample of patients with AN (Paslakis et al., 2016). Additionally, patients
with BED showed an avoidance bias (e.g., shorter reaction times) when avoiding low-calorie foods via a joystick, compared to individuals without the diagnosis (Paslakis et al., 2017). Applying the AMC to the joystick paradigm, latency to response of approach and avoidance behavior toward high- and low-calorie food images may provide additional unbiased, automatic measurements of approach and avoidance food craving. The current study aims to investigate the application of the AMC to food craving using a joystick paradigm and measuring individuals’ reaction times when asked to approach and avoid high- and low-calorie food images.

**Current Study**

As outlined, literature has provided a strong foundation for understanding the approach-avoidance compatibility effect via food-based stop-signal and joystick paradigms, whereby positive perceptions facilitate approach behavior and negative perceptions facilitate avoidance behavior. Still, substantial gaps in the literature remain. Investigations of the multi-dimensional motivational process of food craving and its relation to the full spectrum of disordered eating behaviors are limited, both in the evaluation of approach and avoidance inclinations, as well as the use of behavioral measures of approach and avoidance food craving. A test of the AMC theoretical framework using Go/No-Go and joystick paradigms may provide less biased and automatic measures of approach and avoidance food craving as they relate to the full spectrum of disordered eating behaviors.

**COVID Modifications**

Due to the COVID-19 pandemic and associated closures, the current study was modified to be conducted in a fully online format (e.g., Pavlovia.org; Bridges et al., 2020;
Sauter et al., 2020) using Go/No-Go and arrow key press (De Houwer et al., 2001) methodologies. In consideration of previous literature using arrow key presses in response to food images across a variety of populations (community: Brignell et al., 2009; undergraduate: Havermans et al., 2011; eating disorder treatment seeking adolescents: Neimeijer et al., 2015) arrow key presses measuring approach-avoidance behavior act as appropriate proxies for responses via the joystick (see Appendix M for original study design and methods).

In the modified study, food craving was defined a multi-dimensional motivational process that involves an individual’s competing desires to both consume and not consume certain food or certain types of food. The proposed study tested whether automatic, behavioral measures of approach and avoidance food craving differentially and more strongly predicted the spectrum of disordered eating behaviors compared to traditional self-report measures using Go/No-Go and approach-avoidance task (AAT) via arrow key pressing methodologies. Go/No-Go and the AAT capture participants’ motivationally driven behavior to approach and avoid high- and low-calorie foods without interrupting the automatic experience of food craving that may occur with verbal reporting or labeling of the food craving experience. Reaction time (RT) represents a straightforward assessment of the underlying motivational processes of approach and avoidance food craving. How RT were anticipated to reflect the AMC-described approach and avoidance food craving dimensions varied based on experimental task (see below).

It was hypothesized that (1) high self-reported approach food craving would be associated with

(a) shorter RT on go stimuli of high-calorie foods;
(b) shorter RT when approaching high-calorie foods via the up arrow key;
(c) high levels of self-reported binge eating behaviors and uncontrolled eating;
and
(d) higher likelihood of self-reported binge eating disorder.

It was hypothesized that that (2) high self-reported avoidance food craving would be associated with

(a) longer RT on go stimuli of high-calorie foods;
(b) shorter RT when avoiding high-calorie foods via the down arrow key;
(c) high levels of restrained eating; and
(d) greater likelihood of self-reported anorexia nervosa.

It also was hypothesized that (3) high self-reported approach and high self-reported avoidance food craving would be associated with equal likelihood of self-reported bulimia nervosa; (4) behavioral measures of approach food craving (i.e., RT on go stimuli of high-calorie foods, RT when approaching high-calorie foods via arrow up key) would more strongly predict self-reported binge eating behaviors, uncontrolled eating, and likelihood of binge eating disorder compared to self-report measures of approach food craving; and (5) behavioral measures of avoidance food craving (i.e., RT when avoiding high-calorie foods via the down arrow key) would more strongly predict restrained eating and likelihood of anorexia nervosa compared to self-reports of avoidance food craving.
Method

Participants

The study received approval from the University of South Florida’s Institutional Review Board. Participants aged 18-65 were recruited through the Psychology Department research participant pool. To identify the appropriate sample size for the planned analyses requiring the most power, a power analysis was conducted in G*Power (v3.1) based on Carbine and colleagues’ (2017) observed effect of condition across high- and low-calorie Go/No-Go tasks ($\eta^2 = .02$, which was converted into an $F$ effect size of .14). Correlations among repeated measures was set to a conservative .4, number of groups was set to 4, and number of measurements was set to 4. To detect the small sized effect of condition as seen in previous literature, with power .80, the total sample size required was 120. To account for 20% data loss, an additional 30 participants were recruited, leading to an anticipated recruited sample of 150. Since the study was moved to online data collection and online response data collection is less reliable than in-person data, the desired sample size was doubled to 320 participants. Due to established sex differences in the eating disorder and food craving literatures (Burton et al., 2007; Konttinen et al., 2010; Opwis et al., 2017), efforts were made to recruit 50% males, but testing for sex differences was outside the scope of the current project. Following completion of the online experiment, participants were compensated with partial course credit.
Data cleaning procedures included two steps: 1) data cleaning based on the survey data and 2) data cleaning based on the reaction time data (see Figure 2). In terms of survey data cleaning, of the original 411 individuals who consented to participate, 40 individuals were excluded from analyses for completing the survey outside of a reasonable duration (i.e., below the 5th and greater than the 95th percentile for the overall sample time to complete; Meade & Craig, 2012; Piqueras-Fiszman et al., 2015). Additionally, 32 individuals were removed for discontinuing the survey after providing informed consent. Fifteen participants did not provide sufficient information to calculate body mass index and 22 were duplicates, leaving 302 individuals with complete survey data. Participants with complete survey data were 68% women ($n = 206$) and ranged in age from 18 to 40 years ($M = 19.85, SD = 2.77$). Participants’ mean body mass index (BMI) was 24.11 ($SD = 5.42$), which is in the healthy weight range. Seventy-eight
percent (77.8%; $n = 235$) identified as non-Hispanic, Spanish, or Latinx (22.8% Hispanic, Spanish, or Latinx, 0.3% unknown). Of those who identified as non-Hispanic, Spanish, or Latinx, 62.4% identified as White, 13.2% as Black, 16% as Asian, 1.6% as American Indian or Alaskan Native, and 6.8% as other/multiracial. Of those who identified as Hispanic, Spanish, or Latinx, 71.6% identified as White, 5.4% as Black, 1.4% as Asian, 2.7% as American Indian or Alaskan Native, and 18.9% as other/multiracial.

Reaction time data quality was also evaluated in multiple ways. Based on previous literature, data with an error percentage of 35% or greater was indicative of participants having difficulty with task instructions and not a valid representation of craving motivations. Thus, these data were classified as poor and excluded (Brockmeyer et al., 2015). To remove outliers, reaction times were excluded per participant and per trial type if they were under 300 ms or over 2000 ms (Piqueras-Fiszman et al., 2015). Fifty-three individuals were removed for not completing the experiment (see Table 1) and nine individuals were removed for having all reaction time coded as poor or outside a reasonable duration. Attrition analyses indicated that participants with quality data and participants with poor data did not significantly differ by sex ($\chi^2 (1, 302) = .18, p = .668$), ethnicity ($\chi^2 (1, 302) = .76, p = .383$), age ($p = .787; d = 0.04$), BMI ($p = .481; d = 0.10$), hunger ratings ($p = .877; d = 0.02$), approach food craving ($p = .960; d = 0.01$), avoidance food craving ($p = .843; d = 0.03$), restrained eating ($p = .805; d = 0.04$), uncontrolled eating ($p = .948; d = 0.01$), or ED symptom count ($p = .391; d = 0.12$; see Table 2).

The final sample for data analyses included 240 individuals with both quality survey and reaction time data (67% female; $n = 161$). Participants ranged in age from 18 to 40 years ($M = 19.79$, $SD = 2.93$) and had a mean body mass index (BMI) of 24.24 ($SD$
= 5.33), which is in the healthy weight range. Seventy-six percent (76.7%; \( n = 184 \)) identified as non-Hispanic, Spanish, or Latinx (23.3% Hispanic, Spanish, or Latinx). Of those who identified as non-Hispanic, Spanish, or Latinx, 61.9% identified as White, 11.9% as Black, 16.4% as Asian, 2.2% as American Indian or Alaskan Native, and 7.6% as other/multiracial. Of those who identified as Hispanic, Spanish, or Latinx, 67.9% identified as White, 7.2% as Black, 1.7% as Asian, 3.6% as American Indian or Alaskan Native, and 19.6% as other/multiracial.

**Experimental Procedure**

After electronically providing informed consent, participants completed an online survey of questionnaires via Qualtrics assessing hunger, food craving, eating disorder symptomatology, restrained eating, and uncontrolled eating. After completing online measures, participants were automatically re-directed to the experiment via Pavlovia.org (Anwyl-Irvine et al., 2020; Bridges et al., 2020; Sauter et al., 2020). Once the experiment fully loaded (approximately 30-45 seconds), participants were shown an automatized slide show of home décor magazine covers to washout priming effects (Gellatly & Meyer, 1992). Magazines were verified to not include body image, dieting, or food-related content (e.g., home decor magazines).

Next, participants completed a series of Go/No-Go and approach-avoidance tasks that were adapted from previous research (e.g., Go/No-Go: Carbine et al., 2017; Joystick: Krieglmeier & Deutsch, 2010). There were two control blocks (office supply stimuli) and eight mini experimental blocks (either low- or high-calorie food stimuli; see Figure 3). All participants completed all 10 blocks. With four potential starting conditions (i.e., arrow key low calorie, Go/No-Go low calorie, arrow key high calorie, Go/No-Go high
calorie), initial order of conditions was balanced using a diagram-balanced Latin Square. This design guaranteed that every condition occurred in each position exactly once and each condition preceded and followed every other exactly once for each participant. The two dependent variables of interest were reaction times (RT) for both high- and low-calorie food tasks across Go/No-Go and arrow key tasks.

**Figure 3. Experimental Design Flow**

**Practice Trials**

The experiment began with two practice trials (2 blocks of 25 trials) that had neutral pictures (e.g., office supplies; Brodeur et al., 2010) not used elsewhere in the task to ensure that participants understood the task instructions. For the Go/No-Go practice trial, participants were instructed to press the space bar when they saw office supplies (e.g., scissors; go stimulus) and inhibit a response when they saw non-office related images (e.g., soap dispenser; no-go stimulus). Each Go/No-Go practice cue was
presented for 750 ms, followed by a blank screen for 500 ms, followed by a fixation point for 500 ms (see Appendix G).

For the AAT practice trial, participants were instructed to push the up arrow key when they saw office supplies (e.g., scissors; approach) and push down arrow key when they saw non-office related images (e.g., soap dispenser; avoid). The arrow key in which participants were asked to press (up or down arrow) was indicated by an isosceles triangle (height: 1 cm; base: 20 cm; Piqueras-Fiszman et al., 2014) that appeared above (pointing upward; push up arrow) or below (pointing downward; push down arrow) the image, respectively. Based on previous literature (Piqueras-Fiszman et al., 2014), the visual indicators of triangles provided un-biased instructions. The practice trial instructions included the wording, “Please press the arrow key matching the direction in which the triangle is pointing.” This phrasing has been shown to eliminate positive or negative connotations assigned to particular motor response in the instructions of a task (i.e., negative valence associated with “push” and “away” when used in reference to oneself, and positive valence associated with “pull” and “towards”; see Eder & Rothermund, 2008; Kraus & Hofman, 2013). For the AAT task practice trials, three asterisks were presented for 200 ms to direct participants’ attention to the center of the screen, followed by a blank screen for 100 ms. Then, the image appeared in the center of the screen. After participants responded to all stimuli, the screen was blank. The inter-trial interval was 1000 ms (see Appendix H).

Following practice trials, all participants completed the Go/No-Go and AAT high- and low-calorie tasks. Similar to the initial ordering of practice trials, initial order of experimental conditions was balanced using a diagram-balanced Latin Square.
**Food Go/No-Go Tasks**

The Go/No-Go task captured participants’ motivationally driven behavior to approach and avoid high- and low-calorie foods. Based on prior literature (Carbine et al., 2017; Price et al., 2016; see Figure 2) participants completed four blocks of food Go/No-Go tasks to assess inhibitory control toward high- and low-calorie foods. On the food Go/No-Go high-calorie task, participants were instructed to quickly, but accurately, press the spacebar when they saw high-calorie food pictures (e.g., donut; *go* stimulus; approach; see Appendix I) and inhibit responses when they saw low-calorie food pictures (e.g., celery; *no-go* stimulus; avoidance). In the low-calorie task, participants were instructed to do the opposite and press the space bar when they saw low-calorie food (*go* stimulus) and inhibit when they saw high-calorie food (*no-go* stimulus).

For each task, there were four blocks of 50 trials, 25 of which were *go* trials and 25 of which were *no-go* trials. Pictures were presented for 750 ms, followed by a blank screen for 500 ms, which were followed by a fixation point for 500 ms (see Appendix I). Thirty-eight high-calorie and 38 low-calorie food pictures were provided by Carbine and colleagues (2017), who have used the pictures in a Go/No-Go task after they were accurately categorized as high- or low-calorie foods 95% of the time or better by 26 separate undergraduate participants. The pictures were provided to Carbine and colleagues (2017) by Killgore and colleagues (2013), who have used the images in multiple experiments (e.g., Killgore et al., 2013; 2010; Killgore & Yurgelun Todd, 2005). The high-calorie food images include 15 dinner meals (e.g., cheeseburger), 16 images of desserts (e.g., ice cream), and 7 breakfast meals (e.g., waffles). The low-calorie food images include 25 fruits (e.g., cantaloupe) and 13 vegetables (e.g., celery). A noted
limitation of the Go/No-Go paradigm is that the design is limited to measuring only approach behaviors (via button pressing) since avoidance behaviors would be represented through inhibiting of approach behaviors. Therefore, RT measured through the arrow key pressing paradigm is essential to fully capture both approach and avoidance inclinations toward high- and low-calorie food stimuli.

**Food Approach-Avoidance Task**

The approach-avoidance task (AAT) via arrow key presses provided information on both approach and avoidance food craving motivations, yielding incremental validity beyond the traditional Go/No-Go task. On the AAT high-calorie task, participants were instructed to move towards high-calorie food by pressing the up arrow key (i.e., approach), and to move away from low-calorie food by means of pressing the down arrow key (i.e., avoid; De Houwer et al., 2001; Havermans et al., 2011). In the low-calorie task, participants were instructed to do the opposite and move towards low-calorie food by pressing the up arrow key (e.g., approach), and to move away from high-calorie food by pressing the down arrow key (e.g., avoid).

At the beginning of each trial, three asterisks were presented for 200 ms to direct participants’ attention to the center of the screen, followed by a blank screen for 100 ms. Then, a food image appeared in the center of the screen and isosceles triangles were shown above (pointing upward) or below the stimulus (pointing downward). After participants respond to all stimuli, the screen was blank (see Appendix J). The inter-trial interval was 1000 ms. The dependent variable measured was the time between the onset of the food stimulus and when the participants press the specified arrow key (e.g., reaction time).
The same high- and low-calorie images included in the Go/No-Go tasks were used for AAT. All stimuli were presented on a blank background. Completion of the full study took approximately 45 minutes. Upon completion of the study, participants were compensated with 2 SONA points.

**Measures**

**Demographics.** Demographic data including age, sex, race, ethnicity, height, and weight were collected via self-report during the initial online questionnaire. Body Mass Index (BMI) was used as an index of body weight adjusted for participant height and calculated by using the equation BMI = Weight (kg)/Height (m)^2. Literature suggests a high degree of agreement between self-reported and objectively measured BMI (Ahlich et al., 2020; Himes et al., 2005); thus, self-reported results are likely an accurate estimate of the current sample’s BMI.

**Hunger.** Hunger levels were assessed by averaging across six visual analog scales (VAS): (1) current levels of hunger; (2) fullness (reverse scored); (3) desire to eat; (4) how much could you eat; (5) urge to eat; and (6) preoccupation with thoughts of food. Each VAS consisted of a 100-mm (10 cm) line, anchored from 0 (not at all) to 10 (extremely; Blundell et al., 2010; Carbine et al., 2017). Literature suggests that VAS measurements of hunger consistently and reliably predict meal initiation, amount of food consumed, and are sensitive to experimental manipulation (Stubbs et al., 2000). The average hunger score demonstrated adequate internal consistency in the current sample (women $\alpha = .66$; men $\alpha = .74$).

**Approach and Avoidance Food Craving.** Food craving was assessed using the approach and avoidance subscales of the 12-item Food Approach and Avoidance
Questionnaire (FAAQ; Rancourt et al., 2019). The 6-item approach subscale reflects an individual’s motivation to consume a particular food or type of food. A sample item is “If I eat when I am craving, I often lose control and eat too much” with responses ranging from 0 (not at all) to 8 (very strongly). The 6-item avoidance subscale measures the competing desire to avoid or not consume a particular food or food type. A sample item is “I do things to take my mind off my food cravings” with responses ranging from 0 (not at all) to 8 (very strongly). For both subscales, higher values indicate more food craving motivations. Both the approach (α = .90) and avoidance (α = .84) subscales demonstrated acceptable reliability in the development and validation study with mixed-sex adult samples, as well as in the current sample (approach women α = .87; approach men α = .81; avoidance women α = .87; avoidance men α = .83).

**Eating Disorder Symptoms.** Eating disorder symptomatology, including binge eating, was assessed using the Eating Disorder Diagnostic Scale - DSM-5 Version (EDDS-5; Stice, n.d.). The EDDS-5 is a 23-item questionnaire generates an ED symptom count, an ordinal binge eating variable, and preliminary diagnoses for anorexia nervosa (AN), bulimia nervosa (BN), and binge eating disorder (BED), low frequency AN, low frequency BN, low frequency BED, purging disorder, and night eating syndrome to fit the diagnostic changes in the DSM-5. An example item is “Over the past 3 months, have you felt fat.” Symptom count scores are computed via the sum of all raw scores or average of z-scores of all items when items are positively skewed. Binge eating scores are computed using three questions assessing presence and frequency of objective binge eating episodes. Scores include 0 (no binge eating), 1 (binge eating 2-3 times per month over past 3 months), or 2 (binge eating 4+ times per month over past 3 months). Higher
symptom count scores indicate greater ED symptomatology and higher binge eating scores indicate greater frequency of binge eating. When compared with clinical interviews, the EDDS-5 demonstrates accuracy of diagnosis, such that the proportion of individuals for whom the diagnosis generated by the EDDS-5 matched the proportion generated by the clinical interview (Sysko et al., 2015). The EDDS-5 has also demonstrated excellent internal consistency with a mixed-sex adult community sample (α = .91; Becker et al., 2017) and acceptable internal consistency in the current sample (women α = .82; men α = .71).

**Restrained eating.** The restrained eating subscale of the Dutch Eating Behavior Questionnaire (DEBQ; Van Strien et al., 1986) was used to assess restrained eating. The subscale consists of 10-items rated on a five-point scale from 1 (never) to 5 (very often). Items are summed for a total score, with higher scores indicating a greater degree of food restriction. An example item is “Do you deliberately eat less in order not to become heavier?” The restraint scale demonstrated excellent internal consistency in past research (women: α = .94; men: α = .94; Rancourt et al., 2019) and in the current sample (women α = .96; men α = .93).

**Uncontrolled eating.** Uncontrolled eating behaviors were captured using the uncontrolled eating subscale of the Three Factor Eating Questionnaire (TFEQ-R18V2; Cappelleri et al., 2009). The 9-item scale reflects difficulty in regulation or loss of control while eating. A sample item is “I’m always so hungry that it’s hard for me to stop eating before finishing all of the food on my plate” with responses ranging from 1 (definitely true) to 4 (definitely false). Higher values indicate more uncontrolled eating behavior. This scale has demonstrated acceptable internal consistency in previous research.
(women: $\alpha = .89$; men: $\alpha = .89$; Verzijl et al., 2018) and in the current sample (women $\alpha = .89$; men $\alpha = .86$).

**Data Analytic Plan**

Preliminary analyses include basic descriptives and were conducted in SPSS (version 25; IBM, 2016). Due to noted sex differences in both disordered eating behaviors and food craving (Burton et al., 2007; Konttinen et al., 2010; Opwis et al., 2017), independent samples $t$-tests and chi-square tests were conducted to test whether males and females significantly differed on any baseline characteristics (EDDS symptom count, ED diagnoses, approach and avoidance food craving) or other demographic variables. No additional tests of sex differences were pursued.

To examine hypotheses that individuals high in approach and individuals high in avoidance food craving would show differential RT on high- and low-calorie food tasks (Hypotheses 1a, 1b, 2a, and 2b), RT data for both Go/No-Go and AATs were examined via multilevel modeling (MLM; Hoffman & Rovine, 2007). Of note, MLM represents the most appropriate analytic strategy for Go/No-Go and AAT data, compared to traditional ANOVA, since data are hierarchically structured (i.e., trial nested within individual; Field & Wright, 2011). Additionally, MLM: (1) provides increased flexibility to address dependencies among observations with random effects, or effects of variables that are specified as varying across participants (i.e., approach food craving, age, sex, etc.); (2) permits simultaneous tests of main effects and interactions of categorical (i.e., high-calorie or low-calorie) and continuous (i.e., approach and avoidance food craving) independent variables; and (3) allows data from participants with only partial responses to be included because listwise deletion is not required (Hoffman & Rovine, 2007).
Lastly, MLM has fewer and less strict data assumptions than traditional ANOVAs (Wright & London, 2009).

To test both Go/No-Go (hypothesis 1a and 2a) and AAT hypotheses (hypothesis 1b and 2b), RT data points for correct responses were analyzed via analogous multilevel models in SPSS (IBM, 2016). Multilevel models were estimated using maximum likelihood and the Satterthwaite method (see Fitzmaurice et al., 2004) was implemented in the presence of incomplete data. Individual RT data points were natural log-transformed to reduce skewness (Faust et al., 1999). Across hypotheses, models were specified in an iterative fashion, such that fixed and random factors were individually added to the baseline (or null) model to ensure that the final model showed improved goodness of fit compared to the baseline model (Hoffman & Rovine, 2007; Wright & London, 2009). Model 1 represented the baseline model, with time as a fixed and repeated effect. Model 2 was a main effects model with homogeneous variances where task (level 1; high-calorie or low-calorie) was modeled as a fixed and repeated effect. For all analyses task was dummy coded (1 = high-calorie, 0 = low-calorie). Model 3 was a main effects model with added self-reported FAAQ food craving (level 2; e.g., approach food craving for hypotheses 1a and 1b; avoidance food craving for hypotheses 2a and 2b), which was modeled as a fixed and random effect. Model 4 additionally included a task*self-reported FAAQ food craving interaction, which was modeled as a fixed and random effect (Field & Wright, 2011). Given substantial literature supporting sex (Burton et al., 2007; Opwis et al., 2017), age (Abdella et al., 2019; Pelchat, 1997), BMI (Franken & Muris, 2005; Striegel-Moore & Bulik, 2007), and hunger (Reichenberger et al., 2018) as significant correlates and/or predictors of a range of disordered eating behaviors and
food craving, all full models (Model 5) included these variables as covariates. Across
approach-avoidance analyses, RT dependent variables were dummy coded. When
examining RTs for approaching food images via the up arrow, the dependent variable
was coded as up arrow RT (1 = up arrow RT, 0 = down arrow RT). When examining RTs
when avoiding food images via the down arrow, the dependent variable was coded as
down arrow RT (0 = up arrow RT, 1 = down arrow RT). Dummy coding provided
separate parameter estimates for the effects of independent variables (i.e., approach and
avoidance food craving) for each outcome (i.e., up arrow RT, down arrow RT). Due to
the high number of comparisons across multilevel models, p-values were adjusted
controlling for false discovery rate (FDR; Benjamini & Hochberg, 1995).

Associations between self-reported measures of approach and avoidance food
craving and disordered eating behaviors (Hypotheses 1c, 1d, 2c, 2d, and 3) were examined
via stepwise linear regressions (continuous outcomes), logistic regressions (ED diagnoses
binary outcomes), and ordered logistic regressions (ordinal outcome), controlling for age,
sex, BMI, and hunger. Stepwise linear regressions (continuous outcomes), logistic
regressions (binary outcomes), and ordered logistic regressions (ordinal outcome) also
examined whether behavioral measures of approach and avoidance food craving (i.e.,
approach: average RT on go stimuli of high-calorie foods, average RT when approaching
high-calorie foods via arrow up key; avoidance: RT when avoiding high-calorie foods via
the down arrow key) would more strongly predict disordered eating behaviors
(Hypotheses 4 and 5) above and beyond self-reported food cravings, controlling for age,
sex, BMI, and hunger. For Hypotheses 4 and 5, the predictor variables represented means
calculated across all the RT data within person.
Results

Descriptive statistics

Zero-order correlations, means, and standard deviations of all relevant variables are presented in Table 3. Results indicated that men and women did not significantly differ in their hunger ratings ($p = .853; d = 0.02$), avoidance food craving ($p = .098; d = 0.23$), restrained eating ($p = .432; d = 0.11$), uncontrolled eating ($p = .322; d = 0.14$), BMI ($p = .401; d = 0.12$), or age ($p = .387; d = 1.09$). Women reported significantly more approach food craving than men ($p = .007, d = 0.40$; see Table 4).

Means and standard deviations of all reaction time variables are presented in Table 5. Both raw Go/No-Go RT data, $D(46353) = .03, p < .001$, and AAT RT data were not normally distributed, $D(91353) = .15, p < .001$; thus, raw RT data were natural log-transformed (Faust et al., 1999). For hypotheses 4 and 5, mean natural log-transformed RT for correct responses when 1) going on high-calorie foods, 2) approaching high-calorie foods via up arrow, and 3) avoiding high-calorie foods via down arrow were calculated for each participant.

Hypothesis 1a: Approach Food Craving and Go Reaction Time on High-Calorie Foods

It was hypothesized that higher self-reported FAAQ approach food craving would be associated with shorter RT on go stimuli of high-calorie foods. Model parameters are presented in Table 6. In the empty Model 1, the fixed intercept was -0.72, the expected natural log-transformed RT in seconds for an average participant on an average go trial
(i.e., the grand mean), regardless of task (high- or low-calorie). The random intercept variance was .004, which represents the magnitude of the difference in overall go RT across participants. The trial-to-trial variance in go RT not accounted for by individuals is represented by the residual variance, which was .021. All estimates were statistically significant.

Including task as a fixed and repeated effect, Model 2 demonstrated improved model fit based on AIC and BIC values compared to Model 1. Model 2 included a significant main effect of task (high- or low-calorie; $\beta = -.033$, $SE = .001$, $p = .003$), suggesting a significant expected linear rate of decline in go RT on high-calorie food images compared to low-calorie food images. Therefore, participants showed shorter go RT when responding to high-calorie foods images compared to low-calorie food images.

Model 3 (AIC = -40,002; BIC = -31,229) included self-reported FAAQ approach food craving (level 2) as a fixed and random effect, but these additions did not improve model fit compared to Model 2. Thus, the self-reported FAAQ approach food craving random effect was removed (AIC = -40,110; BIC = 32,248). The main effect of self-reported FAAQ approach food craving was not significant ($\beta = .001$, $SE = .002$, $p = .952$).

Model 4 (AIC = -40,110; BIC = 32,239) included the main effects of task and self-reported FAAQ approach food craving, as well as the task*self-reported FAAQ approach food craving interaction as a fixed and random effect, but these additions did not improve the model. The random effect was removed. Model 4 did not show improved fit beyond Model 2. In model 4, the task*self-reported FAAQ approach food craving interaction was not significant ($\beta = -.007$, $SE = .004$, $p = .150$).
Model 5 included all covariates and showed equivalent model fit via AIC (AIC = -40,112), but not BIC (BIC = -32,198) compared to Model 2. Thus, it was concluded that model fit was not improved. Collectively, results were inconsistent with hypotheses that high self-reported FAAQ approach food craving would be associated with shorter RT on go stimuli of high-calorie foods.

**Hypothesis 1b: Approach Food Craving and Up Arrow Reaction Time on High-Calorie Foods**

It was hypothesized that high self-reported FAAQ approach food craving would be associated with shorter RT when approaching high-calorie foods via the up arrow. Model parameters are presented in Table 7. In the empty Model 1, the fixed intercept was -0.68, the expected natural log-transformed RT in seconds for an average participant on an average approach via up arrow trial, regardless of task (high- or low-calorie). The random intercept variance was .034, which represents the magnitude of the difference in overall approach via up arrow RT across participants. All estimates were statistically significant.

Including task as a fixed and repeated effect, Model 2 demonstrated improved model fit based on AIC and BIC values compared to Model 1. Model 2 included a significant main effect of task (high- or low-calorie; $\beta = -.009, SE = .003, p = .004$), suggesting the expected linear rate of decline in AAT RT on high-calorie food images compared to low-calorie food images. Participants showed shorter AAT RT when responding to high-calorie foods images compared to low-calorie food images.

Model 3 (AIC = 14,396; BIC = 22,346) included self-reported FAAQ approach food craving (level 2) as a fixed and random effect, but these additions did not improve
model fit compared to Model 2. Thus, the self-reported FAAQ approach food craving random effect was removed (AIC = 14,269; BIC = 22,219). The main effect of self-reported FAAQ approach food craving was not significant ($\beta = .007, SE = .007, p = .317$).

Model 4 (AIC = 14,080; BIC = 22,038) included the main effects of task and self-reported FAAQ approach food craving, as well as the task*self-reported FAAQ approach food craving interaction as a fixed and random effect. Model 4 showed improved fit beyond Model 2. Thus, the task*self-reported FAAQ approach food craving interaction random effect was removed. In model 4, the task*self-reported FAAQ approach food craving interaction was not significant ($\beta = -.003, SE = .011, p = .848$).

Model 5, which included all covariates, showed model improvement via AIC (AIC = 14,075), but not BIC (BIC = 22,077) compared to Model 4. Thus, it was concluded that model fit was not improved. Collectively, results were inconsistent with hypotheses that high self-reported FAAQ approach food craving would be associated with shorter RT when approaching high-calorie foods via the up arrow key.

**Hypothesis 1c: Approach Food Craving, Binge Eating, and Uncontrolled Eating**

It was hypothesized that high self-reported FAAQ approach food craving would be associated with high levels of self-reported binge eating behaviors and uncontrolled eating and results were consistent with hypotheses. Controlling for age, hunger, sex, BMI, and self-reported FAAQ avoidance food craving, higher self-reported FAAQ approach food craving was significantly associated with increased binge eating ($b = .77$, OR = 2.17, 95% CI [1.59, 2.96]) and more uncontrolled eating ($b = .21$, $\beta = .56$, $p < .001$; see Table 8). Specifically, the odds of falling into a higher binge eating category (i.e.,
binge eating 4+ times per month) as opposed to a lower category (i.e., engaging in no
binge eating or engaging in binge eating 2-3 times per month) were 2.17 times higher for
participants with higher approach food craving compared to participants with lower
approach food craving.

**Hypothesis 1d: Approach Food Craving and Binge Eating Disorder**

It was hypothesized that high self-reported FAAQ approach food craving would
be associated with higher likelihood of self-reported binge eating disorder. Only two
participants (0.6% of total sample) met self-reported diagnostic criteria for any BED
diagnosis (i.e., clinical and subclinical BED), thus logistic regression analyses were not
pursued (Moons et al., 2014; Pavlou et al., 2016).

**Hypothesis 2a: Avoidance Food Craving and Go Reaction Time on High-Calorie
Foods**

It was hypothesized that high self-reported FAAQ avoidance food craving would
be associated with longer RT on go stimuli of high-calorie foods. Model parameters are
presented in Table 9. Model 1 and Model 2 are the same as seen in Hypothesis 1a, such
that the fixed intercept was -0.72, the expected natural log-transformed RT in seconds for
an average participant on an average go trial (i.e., the grand mean), regardless of task
(high- or low-calorie). The random intercept variance was .004, which represents the
magnitude of the difference in overall go RT across participants. The trial-to-trial
variance in go RT not accounted for by individuals is represented by the residual
variance, which was .021. All estimates were statistically significant.

Model 3 (AIC = -40,020; BIC = -32,158) included self-reported FAAQ avoidance
food craving (level 2) as a fixed and random effect, but Model 3 did not show model
improvement compared to Model 2. Thus, the self-reported FAAQ avoidance food craving random effect was removed (AIC = -40,111; BIC = 32,249). The main effect of self-reported FAAQ avoidance food craving was not significant ($\beta = -.002, SE = .001, p = .514$).

Model 4 (AIC = -40,145; BIC = -32,274) included the fixed main effect of task and task*self-reported FAAQ avoidance food craving interaction as a fixed and random effect. Model 4 showed improved fit beyond Model 2, but the task*self-reported FAAQ avoidance food craving interaction was not significant ($\beta = -.008, SE = .004, p = .089$).

Model 5, which included all covariates, showed model improvement via AIC (AIC = -40,147), but not BIC (BIC = -32,233), compared to Model 4. Thus, it was concluded that model fit was not improved. Collectively, results were inconsistent with hypotheses that high self-reported FAAQ avoidance food craving would be associated with longer RT on go stimuli of high-calorie foods.

**Hypothesis 2b: Avoidance Food Craving and Down Arrow Reaction Time on High-Calorie Foods**

It was hypothesized that high self-reported FAAQ avoidance food craving would be associated with shorter RT when avoiding high-calorie foods via the down arrow. Model parameters are presented in Table 10. In the empty Model 1, the fixed intercept was -0.59, the expected natural log-transformed RT in seconds for an average participant on an average avoiding via down arrow trial (i.e., the grand mean), regardless of task (high- or low-calorie). The random intercept variance .032, which represents the magnitude of the difference in overall avoidance via down arrow RT across participants.
The trial-to-trial variance in avoiding via the down arrow is represented by the residual variance, which was .07. All estimates were statistically significant.

Model 2 demonstrated improved model fit based on AIC and BIC values compared to Model 1. Model 2 included a significant main effect of task (high- or low-calorie; $\beta = -.022, SE = .002, p = .004$), suggesting a significant expected linear rate of decline in AAT RT on high-calorie food images compared to low-calorie food images. Therefore, participants showed shorter AAT RT when responding to high-calorie foods images compared to low-calorie food images.

Model 3 (AIC = 11,155; BIC = 19,114) included self-reported FAAQ avoidance food craving (level 2) as a fixed and random effect, but it did not show model improvement compared to Model 2. Thus, the self-reported FAAQ avoidance food craving random effect was removed (AIC = 11,017; BIC = 18,976). The main effect of self-reported FAAQ avoidance food craving was not significant ($\beta = .005, SE = .006, p = .311$).

Model 4 (AIC = 10,770; BIC = 18,738) included the main effects of task and self-reported FAAQ avoidance food craving, adding the task*self-reported FAAQ avoidance food craving interaction as a fixed and random effect. Model 4 showed improved fit beyond Model 2. In model 4, the task*self-reported FAAQ avoidance food craving interaction was not significant ($\beta = -.005, SE = .011, p = .721$).

Model 5, which included all covariates, showed model improvement (AIC = 10,752; BIC = 18,763) compared to Model 4. Sex, BMI, hunger, and self-reported FAAQ approach food craving were not significant predictors of AAT RT ($p$’s > .05). Age ($\beta = .017, SE = .004, p = .021$) was the only covariate that demonstrated a significant main
effect suggesting the expected linear rate of increase in AAT RT (e.g., longer
AAT RT) for a one-unit increase in age. Collectively, results were inconsistent with
hypotheses that high self-reported FAAQ avoidance food craving would be associated
with shorter RT when avoiding high-calorie foods via the down arrow.

**Hypothesis 2c: Avoidance Food Craving and Restrained Eating**

It was hypothesized that higher self-reported FAAQ avoidance food craving
would be associated with high levels of restrained eating. As anticipated, higher self-
reported FAAQ avoidance food craving was associated with more restrained eating ($b = 4.56, \beta = .80, p < .001$; Table 11) when controlling for age, hunger, sex, BMI and self-
reported FAAQ approach food craving.

**Hypothesis 2d: Avoidance Food Craving and Anorexia Nervosa**

It was hypothesized that high self-reported FAAQ avoidance food craving would
be associated with greater likelihood of self-reported anorexia nervosa. Only eight
participants (1.9% of total sample) met self-reported diagnostic criteria for AN, including
clinical and subclinical anorexia nervosa (AN). Therefore, logistic regression analyses
were not pursued (Moons et al., 2014; Pavlou et al., 2016).

**Hypothesis 3: Self-Reported Food Craving and Bulimia Nervosa**

It was hypothesized that high self-reported FAAQ approach and avoidance food
craving would be associated with equal likelihood of self-reported bulimia nervosa. A
total of 12 participants (3.9% of total sample) met diagnostic criteria for bulimia nervosa
(BN), including clinical and subclinical BN. Consistent with hypotheses, controlling for
age, hunger, BMI, and sex, both self-reported FAAQ approach food craving and FAAQ
avoidance food craving were associated with a higher likelihood of meeting self-reported
criteria for BN (approach: $b = 1.20$, OR = 2.99, $p = .002$; avoidance: $b = .79$, OR = 2.19, $p = .004$; see Table 12). Greater approach food craving corresponded with a 2.99 times higher likelihood of meeting criteria for BN (95% CI [1.50, 5.96]), while greater avoidance food craving corresponded with a 2.19 higher likelihood of meeting criteria for BN (95% CI [1.23, 3.91]).

**Hypothesis 4: Behavioral Approach Food Craving Predicting Binge Eating Behaviors, Uncontrolled Eating, and likelihood of Binge Eating Disorder**

It was hypothesized that behavioral measures of approach food craving (i.e., average RT on go stimuli of high-calorie foods, average RT when approaching high-calorie foods via up arrow key) would more strongly predict self-reported binge eating behaviors, uncontrolled eating, and likelihood of binge eating disorder compared to self-report measures of approach food craving. Inconsistent with hypotheses, average RT on go stimuli of high-calorie foods was not significantly associated with binge eating (OR = 8.32, 95% CI [.02, 3869], $p = .499$) or uncontrolled eating (b = .33, $\beta = .04$, $p = .512$; see Table 13) above and beyond self-reported FAAQ approach food craving (binge eating: OR = 2.16, 95% CI [1.58, 2.94], $p < .001$; uncontrolled eating: b = .20, $\beta = .54$, $p < .001$). Similarly inconsistent with hypotheses, average RT when approaching high-calorie foods via the up arrow key was not significantly associated with uncontrolled eating (b = .01, $\beta = .004$, $p = .936$; see Table 13) above and beyond self-reported FAAQ approach food craving (b = .21, $\beta = .56$, $p < .001$).

Before adjusting for false discovery rates (FDR), longer average RT when approaching high-calorie foods via the up arrow key was significantly associated with decreased likelihood of binge eating (OR = .09, 95% CI [.01, .94], $p = .045$) above and
beyond self-reported FAAQ approach food craving (b = .80, OR = 2.22, 95% CI [1.62, 3.05], p < .001). After adjusting for FDR, the association was no longer significant (p = .158). Associations between behavioral measures of approach food craving and likelihood of meeting diagnostic criteria for binge eating disorder could not be assessed due to the small sample of individuals who met diagnostic criteria for clinical and subclinical BED (n = 2). Thus, approach food craving behavioral hypotheses were not supported.

**Hypothesis 5: Behavioral Avoidance Food Craving and Restrictive Behaviors**

In contrast to hypotheses, behavioral measures of avoidance food craving (i.e., average RT when avoiding stimuli of high-calorie foods via down arrow key) were not significantly associated with restrained eating (b = 1.32, β = .01, p < .001; Table 15) above and beyond self-reported FAAQ avoidance food craving (b = 4.33, β = .75, p < .001) when controlling for age, hunger, sex, BMI and self-reported FAAQ approach food craving. Associations between behavioral measures of avoidance food craving and likelihood of meeting diagnostic criteria for anorexia nervosa could not be assessed due to the small sample of individuals who met diagnostic criteria for clinical and subclinical AN (n = 8).
DISCUSSION

The present study addressed a gap in the current food craving literature by examining an application of the ambivalence model of craving (Breiner et al., 1999; McEvoy et al., 2004; Stritzke et al., 2004) to food craving using a dual cue-reactivity experimental design. Research on the ambivalence model of food craving has been limited to self-reports of approach and avoidance food craving (Ahlich et al., 2020; Rancourt et al., 2019; Verzijl et al., 2019). In the present study, it was hypothesized that the Go/No-Go method provided a measure of approach behavior via the latency of response to the go signal. The AAT method provided measures of both approach and avoidance behaviors (Seibt et al., 2008). Consistent with previous literature and hypotheses, self-reported FAAQ approach food craving was associated with overeating behaviors (i.e., binge eating and uncontrolled eating) while self-reported FAAQ avoidance food craving was associated with restrictive eating behaviors. Hypotheses focused on behavioral measures of approach and avoidance food craving, however, were not supported. Behavioral measures of approach food craving and avoidance food craving were not significantly associated with either self-reported FAAQ approach and avoidance food craving nor self-reported disordered eating behaviors. Findings highlight that the subjective, self-reported experience of food craving may be more salient to disordered eating behaviors than objective, implicit experiences of food craving.
Self-Reported Food Craving and Reaction Time

Previous literature examining latency to response toward high- and low-calorie foods is mixed. In the present study, participants showed an approach bias (i.e., shorter go reaction time and shorter AAT reaction time) when responding to high-calorie food images compared to low-calorie food images (Hypotheses 1a, 1b, 2a, 2b). This contrasts with a study that used the same high- and low-calorie pictures as the current study and demonstrated increased accuracy and longer RT (i.e., no approach bias) when going on high-calorie foods (Carbine et al., 2017). The longer reaction time was explained as an increased recruitment of inhibitory control processes when responding to more palatable and appetizing high-calorie food images (Appelhans et al., 2011; Hall, 2012). If this is an accurate understanding of the reaction time process, then participants in the current study unexpectedly showed a stronger desire for, and recruited less inhibitory control processes when responding to, high-calorie food images.

The current study may not have replicated Carbine et al. (2017) results due to multiple factors not measured in the current online data collection. For example, sleep and engagement in physical activity prior to study participation could have impacted the present findings. Carbine and colleagues instructed participants to get at least 7 hours of sleep and refrain from vigorous physical activity before participating. Participants in the current study were not provided such instructions and because it was an online study, there was no way to gather behavioral observations during the study that may have indicated a lack of sleep or recent physical activity. Research using college samples has documented high prevalence of poor sleep (Becerra et al., 2020; Becker et al., 2018), and poor sleep is associated with greater desire for high-calorie foods (i.e., sweets and high-
fat; Spiegel et al., 2004) and poorer inhibitory control when responding to high-calorie foods via Go/No-Go paradigms (e.g., cake, pie, and cookies; Duraccio et al., 2019). It is possible the approach bias observed in the current sample may be due to poor typical sleep patterns of university students. Similarly, approach bias for high-calorie foods via AAT paradigms are known to decrease after participants engage in an exercise session (Li et al., 2022); however, recent investigations with college-age populations show decreases in physical activity during the COVID-19 pandemic (Baceviviene & Jankauskiene, 2021; Dunton et al., 2020). Nonetheless, the approach bias toward high-calorie food images may have been impacted by participant exercise behaviors. Future research would benefit from measuring and having explicit instructions about pre-study sleep and exercise behaviors to control for potential confounding effects on reaction times in response to high-calorie foods.

Recent literature has also explained approach biases for high-calorie foods via AATs as being influenced by the degree to which participants rate food images as appealing (Piqueras-Fiszman et al., 2014) or desirable (Kahveci et al., 2020). While the shorter reaction times in response to high-calorie foods seen in the current sample is consistent with previous research using a different set of food images, this approach bias may be better explained by trait food craving levels, unmeasured health behaviors (e.g., sleep, exercise engagement), or food-related ratings (e.g., appeal or desirability). Though the images used in the current study were pilot tested and successfully used with other college samples, it is possible the participants in the present study found the images more appealing or desirable than other samples, which impacted findings. Future work should
collect participant ratings on the appeal and desirability of food images to assess the influence of these ratings on inhibitory control processes.

Unexpectedly, main effects of self-reported FAAQ food cravings and food craving*task interactions on reaction time were non-significant across experimental paradigms (i.e., Go/No-Go or AAT). Non-significant findings may be due to floor effects of self-reported FAAQ approach and avoidance food craving ratings in the current sample, which are substantially lower than those seen in previous investigations using the Food Approach and Avoidance Questionnaire (Ahlich et al., 2017; Ahlich et al., 2020). Low ratings of both approach and avoidance food craving may be representative of the indifference quadrant of the ambivalence model of craving (Breiner et al., 1999). When applied to alcohol use, weak activation of both approach and avoidance alcohol cravings are characterized by indifference to consuming alcohol, leading individuals to consume only low levels of alcohol (e.g., social drinking only). In the current study, low levels of self-reported FAAQ approach and avoidance food craving may be reflective of participants’ indifference to consuming certain foods, leading them to consume foods in moderation rather than engaging in restrictive or overeating behaviors. Future research should test associations between different combinations of approach and avoidance food craving (i.e., approach, avoidant, ambivalent, and indifferent quadrants of the AMC) to better understand the influence of varying levels of both approach and avoidance food cravings on disordered eating behaviors.

Lack of main effects and interactions could also be due to attenuated accuracy of reaction time data collected via online format. While recent literature suggests that online experiment platforms provide reasonable accuracy and precision for reaction time data
compared to in-lab studies (Anwyl-Irvine et al., 2020; Hilbig, 2015; Leeuw & Motz, 2015), several uncontrollable factors may have influenced participants ability to respond accurately and with full attention when outside of a controlled lab setting. Data indicate that fully online studies provide greater convenience and similarly higher response rates compared to in-person data collections, but online formats can also lead to increases in self-reported distractions and greater tendency to consult outside sources (Clifford & Jerit, 2014; Jun et al., 2017). To maintain participant convenience and reduce distractions, future studies would benefit from incorporating a supervision component to web-based experimental studies investigating food craving and disordered eating behaviors.

**Food Craving and Self-Reported Disordered Eating**

As anticipated, examinations of self-reported food cravings showed differential associations with self-reported disordered eating behaviors. First, higher self-reported FAAQ approach food craving was significantly and uniquely associated with increased uncontrolled eating and odds of engaging in higher levels of binge eating. These associations are consistent with previous studies of the ambivalence model of food craving (Ahlich et al., 2020; Rancourt et al., 2019) and other literature supporting links between food craving and overeating/binge eating behaviors (Jarosz et al., 2007; Neumark-Sztainer et al., 2007; Van den Eynde et al., 2012; Verzijl et al., 2018). Second, higher self-reported FAAQ avoidance food craving was uniquely associated with more restrained eating, which is also in line with previous FAAQ literature (Ahlich et al., 2020; Rancourt et al., 2019). Importantly, results provide additional evidence for the independent motivational process of avoidance food craving. These findings provide
further support for an additive (rather than an interactive) model, such that avoidance inclinations increase the ability to predict individuals’ engagement in restrictive eating behaviors. The inclusion of avoidance food craving inclinations allows for a more comprehensive understanding of motivations underlying the full spectrum of disordered eating.

In contrast to hypotheses and associations with self-reported food craving, behavioral measures of food craving did not support similar associations with disordered eating behaviors. Specifically, average reaction time on go stimuli of high-calorie foods was not significantly associated with binge eating or uncontrolled eating. After adjusting p-values controlling for false discovery rate, average reaction time when approaching high-calorie foods via the up arrow key was also not significantly associated with binge eating or uncontrolled eating. These inconsistent associations indicate that subjective reports of food craving may be more impactful on self-reported eating behaviors than objective experiences of food craving.

The tripartite model of attitudes (Eagly & Chaiken, 1993; Rosenberg & Hovland, 1960) proposes that an individual’s attitude elicits three types of manifestations: (1) cognitive (e.g., verbal responses on questionnaires), (2) affective (e.g., sympathetic nervous system responses), and (3) behavioral (e.g., overt actions). Viewing the current findings through a tripartite model lens, the cognitive or verbal reports of food craving via the FAAQ may have had a greater influence on an individual’s self-reported eating behavior than a behavioral measure of their food craving. Further, there is evidence that subjective experiences are more salient to behavioral outcomes than objective measures across the eating disorder literature. For example, subjective perceptions of body
weight/size account for a greater proportion of variance in disordered eating (Wilson et al., 2005) and eating disorder risk factors (e.g., thin-ideal internalization and body dissatisfaction; Lee & Lee, 2020) compared to objective measures of body weight/size. When possible, future studies may benefit from measuring both subjective and objective food craving and disordered eating behaviors to understand if objective measures of food craving influence objective measures of disordered eating behaviors. If objective measures of food craving are shown to predict objectively measured disordered eating, behavioral measures of food craving may provide an avenue of measurement that eliminates the concern of the cognitive and affective manifestations of individual’s attitudes around food craving.

**Self-Reported Food Craving and Eating Disorder Diagnoses**

Self-reported food cravings have historically differentiated individuals diagnosed with a restrictive eating disorder (i.e., anorexia nervosa) from those diagnosed with an eating disorder characterized by binge eating and subsequent compensatory behaviors (i.e., bulimia nervosa; Moreno et al., 2009). Consistent with hypotheses and previous FAAQ research (Rancourt et al., 2019), odds ratios indicated that increasing values of approach food craving and avoidance food craving corresponded with higher likelihood of meeting criteria for bulimia nervosa. The original development and validation study of the FAAQ also showed that self-reported approach food craving was associated with greater likelihood of meeting criteria for binge eating disorder and self-reported avoidance food craving was associated with greater likelihood of meeting criteria for anorexia nervosa (Rancourt et al., 2019). Across both binge eating disorder and anorexia nervosa, analyses could not be pursued in the current study due to small number of
participants meeting self-reported diagnostic criteria. Thus, one limitation of the current study was a lack of participant pre-study screening for eating disorder symptoms.

The rate of meeting self-reported criteria for an ED was substantially lower in the current sample than data suggest is typical for university student populations in the United States (e.g., ranging from 16.4% to 48%: Falvey et al., 2021; Kang et al., 2021) and those seen in university samples collected on the same campus as the present study (Ahlich et al., 2020; Rancourt et al., 2019). Lower rates seen in the current sample may be in part due to data collection occurring during the height of the COVID-19 pandemic; however, data are mixed on the impact of COVID-19 on disordered eating behavior engagement. Collectively, literature suggests that disordered eating behaviors either decreased or remained stable for those without a history of an ED (e.g., decreases in overeating and loss of control eating: Breiner et al., 2021; objective binge eating, compensatory physical exercise: Castellini et al., 2020), while individuals with food insecurity (Christensen et al., 2021) and those with a history of an ED (Castellini et al., 2020; Schlegl et al., 2020; Termorshuizen et al., 2020) showed increases in ED symptoms. Consistent with rates seen in the current study, the impact of COVID-19 may have been stronger for patients with bulimia nervosa compared to other ED diagnoses (Branley-Bell & Talbot, 2020; Schlegl et al., 2020). While rates of bulimia nervosa in the current sample may have been influenced by the pandemic, results also highlight the strength of the relationship between both facets of food craving and likelihood of meeting self-reported diagnostic criteria for bulimia nervosa. Future investigations using the FAAQ would benefit from pre-screening and over sampling individuals engaging in the
full range of disordered eating behaviors to see if results from Rancourt and colleagues (2019) are observed across samples.

The significant relationships between both facets of food craving and likelihood of bulimia nervosa are notable since the levels of FAAQ approach and avoidance food craving seen in the current sample were low compared to previous food craving work completed at this university. Specifically, the mean approach food craving score of 2.16 ($SD = 1.84$) and mean avoidance food craving score of 2.22 ($SD = 1.86$) are substantially lower than those seen in previous research assessing approach and avoidance food craving via the FAAQ using similar participant recruitment methods (e.g., approach mean = 3.29, avoidance mean = 3.23: Ahlich et al., 2017; approach mean = 4.21, avoidance mean = 3.85: Ahlich et al., 2020). Similar to the low eating disorder diagnosis rates, FAAQ approach and avoidance food craving levels reported by the current sample may have been impacted by data collection occurring in unsupervised environments during the height of COVID-19. The significant relationships between both facets of low-level food craving and bulimia nervosa warrant further investigation to provide evidence-based recommendations on minimum food craving levels that increase individuals’ likelihood of engaging in bulimia behaviors.

**Design Considerations**

The proposed study had several notable strengths, including the dual cue-reactivity experimental paradigm design, a combination of both self-report and objective measures of approach and avoidance food craving, and a strong theoretical basis. Importantly, there are multiple design considerations that warrant attention. First, the amount of cognitive activity required for participants to complete the dual cue-reactivity
design may have produced high levels of mental fatigue. Individuals performing any cognitive-motor task (e.g., visual attention: Boksem et al., 2005; task switching: De Jong, 2000) for a prolonged period can show gradual increase in mental fatigue, which can lead to a decrease in reaction time and increase in errors (Kato et al., 2009). To remove data that may have been influenced by mental fatigue, multiple criteria from previous literature were implemented. Specifically, (1) data with an error percentage of 35% or greater were classified as poor data (Brockmeyer et al., 2015), and (2) RT data under 300 ms and over 2000 ms were discarded (Piqueras-Fiszman et al., 2014). Therefore, although behavioral hypotheses were not supported, precautions were taken to reduce mental fatigue and remove poor quality data, increasing confidence that the data analyzed were of high quality and reliable.

While the experimental design is consistent with previous literature examining approach and/or avoidance motivations toward food cues via behavioral measures (Carbine et al., 2017; Piqueras-Fiszman et al., 2014), hunger may exacerbate individuals’ approach and avoidance inclinations toward high- and low-calorie food images. For example, individuals with higher inclinations to approach high-calorie foods may show stronger inclinations when hungry as compared to when satiated (Piqueras-Fiszman et al., 2014). To control for the effects of hunger on approach and avoidance motivations, hunger was entered as a covariate in all analyses and the influence of hunger was considered in the interpretation of results. Notably, the internal consistency of hunger ratings for women in the current sample was less than acceptable ($\alpha = .66$). While previous literature using the same hunger VAS did not report internal consistency for their samples (Carbine et al., 2017; Stratton et al., 1998; Stubbs et al., 2000), VAS
reliably predicted meal initiation, amount of food eaten, and were sensitive to experimental manipulations. For the current sample, participant hunger ratings were only significantly correlated with and predictive of one measured variable: uncontrolled eating. Specifically, self-reported FAAQ approach food craving was associated with increased uncontrolled eating above and beyond the experience of hunger. Thus, despite relatively low internal consistency for hunger ratings among female participants, hunger did not appear to universally influence the present findings.

Relatedly, a third limitation was the inability to measure only approach or only avoidance inclinations independently. While approach and avoidance inclinations are posited to be independent based on the ambivalence model of craving (Breiner et al., 1999), these inclinations also occur simultaneously. Given this, it would be impossible to isolate and measure only one inclination; therefore, both aspects of craving will influence participants’ responses on both Go/No-Go and AATs. Similar to previous FAAQ literature (Ahlich et al., 2020), self-reported FAAQ approach and avoidance food craving inclinations were significantly correlated across both male and female participants. In an effort to understand the individual influence of each inclination, the alternative inclination was included as a covariate in all statistical models (Moerbeek et al., 2001). Approach and avoidance inclinations were simultaneously significant predictors of two outcome variables: 1) restrained eating and 2) likelihood of meeting self-reported diagnostic criteria for bulimia nervosa. Collectively, these data reinforce the utility of the ambivalence model of craving to account for the full spectrum of disordered eating behaviors.
A fourth notable limitation was that the current study only assessed self-reported eating behaviors rather than a measure actual food intake. Literature suggests that self-reported eating does not reflect actual food intake, especially in reference to emotional eating (see review by Bongers & Jansen, 2016). Additional data indicate that food intake measured in an artificial, laboratory setting also may not fully represent individuals’ food intake in their real-world environment (Boh et al., 2016). Despite the noted limitations, no study has tested the application of the ambivalence model of craving to food craving using multiple measures of cue reactivity that may be less influenced by verbal overshadowing or social desirability. Thus, the current study is an essential first step to assessing the ambivalence model of craving to food craving utilizing multiple measures of desires to both consume and not consume foods.

**Implications**

Results of the current study highlight the importance of subjective food craving reports and their impact on self-reported eating behaviors compared to objective experiences of food craving. Findings provide further support for the utility of the ambivalence model of craving to the full spectrum of disordered eating behaviors and the value of considering the avoidance dimension of food craving. Although behavioral hypotheses were not supported in the current online and unsupervised study, future research should examine whether the same Go/No-Go and AAT measures are associated with the different facets of food craving and the spectrum of disordered eating behaviors when collected in a more controlled environment.

The Go/No-Go and AAT methods of the current study may be useful to implement with individuals engaging in overeating and/or undereating to target food
cravings for specific problematic foods (Barlow & Durand, 2005; Ferrer García et al., 2017). Although cognitive behavioral therapy (CBT) is considered the gold-standard treatment for individuals with eating disorders (Fairburn et al., 2009), evidence suggests that among individuals who do not respond to CBT, exposure treatment is an effective adjunct (Martinez Mallén et al., 2007; Toro et al., 2003). Cue-exposure response prevention (CERP) shows reduced frequency of binge eating behaviors both in the short and long term (see systematic review by Magson et al., 2021). Similarly, Approach-Bias Modification (AppBM) studies provide evidence of successfully modifying approach-avoidance tendencies, leading to reductions in cravings for chocolate (Kemps et al., 2013) and bulimia symptoms (Brockmeyer et al., 2015). Thus, Go/No-Go and AATs methods provide avenues through which food cravings could be effectively targeted in difficult-to-treat individuals engaging in the full spectrum of disordered eating behaviors.

In addition to being integrated into treatment, modeling of RT data serves as another promising future direction. RT data from the current study may provide an avenue to better understand abnormal cognitive processing in individuals experiencing even low levels of approach and/or avoidance food craving. Borrowing techniques and models from cognitive psychology, White and colleagues’ (2010) called for the application of sequential sampling models to two-choice RT data (e.g., stop-signal Go/No-Go; Verbruggen & Logan, 2009). Specifically, sequential modeling improves analysis of Go/No-Go RT data by decomposing accuracy and RT distributions into distinct components of cognitive processing. Furthermore, this modeling approach can help identify the source of differences (i.e., response caution or response bias) between individuals reporting varying degrees of approach and avoidance food craving (White et
al., 2010). Consistent with a clinical science approach, these data may be more appropriate as the basis of a quantitative mechanism model that would allow for prediction of individual treatment outcomes and more precise treatment approaches than seen through current analytic strategies.

Conclusions

The current study is a preliminary step to test the applicability of the ambivalence model of craving to food craving using behavioral paradigms. Consistent with extant work, self-reported FAAQ approach food craving was associated with overeating behaviors while self-reported FAAQ avoidance food craving was associated with restrictive eating behaviors. Although behavioral hypotheses were not supported in a fully online and unsupervised experimental environment, results provide further evidence of the importance of independently evaluating both approach and avoidance food craving inclinations. Future research should continue to test behavioral measures of approach and avoidance food cravings with individuals at risk for or who are engaging in disordered eating behaviors under more controlled conditions. Advancement in our understanding of approach and avoidance food cravings as treatment targets and measures of treatment progress is crucial for individuals engaging in the full range of disordered eating behaviors.
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### Table 1.

*Baseline Descriptive Statistics for Primary Variables for Overall Sample and by Experiment Completers and Non-Completers*

<table>
<thead>
<tr>
<th></th>
<th>Overall (N = 302)</th>
<th>Completers (n = 249)</th>
<th>Non-Completers (n = 53)</th>
<th>Test Statistic</th>
<th>df</th>
<th>p</th>
<th>d</th>
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</thead>
<tbody>
<tr>
<td>Hunger</td>
<td>M 3.39, SD 2.44</td>
<td>M 3.37, SD 2.43</td>
<td>M 3.47, SD 2.50</td>
<td>t = 0.27</td>
<td>300</td>
<td>.787</td>
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<td>Approach Food Craving</td>
<td>2.14, 1.81</td>
<td>2.18, 1.83</td>
<td>1.96, 1.71</td>
<td>t = -0.79</td>
<td>300</td>
<td>.429</td>
<td>0.12</td>
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<td>Avoidance Food Craving</td>
<td>2.21, 1.90</td>
<td>2.28, 1.91</td>
<td>1.89, 1.86</td>
<td>t = -1.36</td>
<td>300</td>
<td>.175</td>
<td>0.21</td>
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<tr>
<td>Restrained Eating</td>
<td>23.08, 10.85</td>
<td>23.26, 10.84</td>
<td>22.25, 10.95</td>
<td>t = -0.62</td>
<td>300</td>
<td>.538</td>
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<td>Uncontrolled Eating</td>
<td>2.09, 0.68</td>
<td>2.08, 0.67</td>
<td>2.13, 0.76</td>
<td>t = 0.45</td>
<td>300</td>
<td>.655</td>
<td>0.07</td>
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<tr>
<td>ED Symptom Count&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.66, 17.82</td>
<td>20.60, 17.96</td>
<td>21.94, 17.30</td>
<td>U = 6450.50</td>
<td>.900</td>
<td>.08</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>24.11, 5.42</td>
<td>24.37, 5.41</td>
<td>22.91, 5.34</td>
<td>t = -1.79</td>
<td>300</td>
<td>.075</td>
<td>0.27</td>
</tr>
<tr>
<td>Age</td>
<td>19.85, 2.77</td>
<td>19.79, 2.89</td>
<td>20.13, 2.14</td>
<td>t = 0.82</td>
<td>300</td>
<td>.411</td>
<td>0.13</td>
</tr>
</tbody>
</table>

*Note.* All significance tests were two-tailed. ED Symptom Count<sup>a</sup> = Mann Whitney U Test used to compare males and females; M = mean score; SD = standard deviation; t = t-test; p = p-value; U = Mann-Whitney U; d = Cohen’s d.
Table 2. Baseline Descriptive Statistics for Primary Variables for Overall Sample and by Quality Data and Poor Data

<table>
<thead>
<tr>
<th></th>
<th>Overall (N = 302)</th>
<th>Quality Data (n = 240)</th>
<th>Poor Data (n = 62)</th>
<th>Test Statistic</th>
<th>df</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunger</td>
<td>3.39 2.44</td>
<td>3.42 2.45</td>
<td>3.37 2.48</td>
<td>$t = 0.16$</td>
<td>300</td>
<td>.877</td>
<td>0.02</td>
</tr>
<tr>
<td>Approach Food Craving</td>
<td>2.14 1.81</td>
<td>2.16 1.84</td>
<td>2.14 1.85</td>
<td>$t = -0.50$</td>
<td>300</td>
<td>.960</td>
<td>0.01</td>
</tr>
<tr>
<td>Avoidance Food Craving</td>
<td>2.21 1.90</td>
<td>2.23 1.86</td>
<td>2.17 2.04</td>
<td>$t = -0.20$</td>
<td>300</td>
<td>.843</td>
<td>0.03</td>
</tr>
<tr>
<td>Restrained Eating</td>
<td>23.08 10.85</td>
<td>23.08 10.77</td>
<td>23.47 11.14</td>
<td>$t = 0.25$</td>
<td>300</td>
<td>.805</td>
<td>0.04</td>
</tr>
<tr>
<td>Uncontrolled Eating</td>
<td>2.09 0.68</td>
<td>2.09 0.68</td>
<td>2.09 0.72</td>
<td>$t = -0.07$</td>
<td>300</td>
<td>.948</td>
<td>0.01</td>
</tr>
<tr>
<td>ED Symptom Count$^a$</td>
<td>20.66 17.82</td>
<td>20.18 17.72</td>
<td>22.38 18.54</td>
<td>$U = 6516.50$</td>
<td>.391</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>24.11 5.42</td>
<td>24.24 5.33</td>
<td>23.69 5.66</td>
<td>$t = -0.71$</td>
<td>300</td>
<td>.481</td>
<td>0.10</td>
</tr>
<tr>
<td>Age</td>
<td>19.85 2.77</td>
<td>19.79 2.93</td>
<td>19.90 2.03</td>
<td>$t = 0.27$</td>
<td>300</td>
<td>.787</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Note. All significance tests were two-tailed. ED Symptom Count$^a$ = Mann Whitney U Test used to compare males and females; $M$ = mean score; $SD$ = standard deviation; $t = t$-test; $p = p$-value; $d =$ Cohen’s $d$. 

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Table 3.
Correlations of Primary and Control Variables by Sex

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hunger</td>
<td>–</td>
<td>.07</td>
<td>.01</td>
<td>-.02</td>
<td>.26*</td>
<td>-.07</td>
<td>-.01</td>
<td>3.39 (2.34)</td>
</tr>
<tr>
<td>2. Approach Food Craving</td>
<td>.22**</td>
<td>–</td>
<td>.67**</td>
<td>.45**</td>
<td>.51**</td>
<td>.10</td>
<td>.28*</td>
<td>1.70 (1.43)</td>
</tr>
<tr>
<td>3. Avoidance Food Craving</td>
<td>.05</td>
<td>.71**</td>
<td>–</td>
<td>.68**</td>
<td>.34**</td>
<td>.19</td>
<td>.29*</td>
<td>1.94 (1.64)</td>
</tr>
<tr>
<td>4. Restrained Eating</td>
<td>.03</td>
<td>.46**</td>
<td>.71**</td>
<td>–</td>
<td>.29*</td>
<td>.24*</td>
<td>.24*</td>
<td>22.33 (9.59)</td>
</tr>
<tr>
<td>5. Uncontrolled Eating</td>
<td>.26**</td>
<td>.69**</td>
<td>.46**</td>
<td>.29**</td>
<td>–</td>
<td>.09</td>
<td>.19</td>
<td>2.02 (0.58)</td>
</tr>
<tr>
<td>6. BMI</td>
<td>-.003</td>
<td>.21**</td>
<td>.26**</td>
<td>.29**</td>
<td>.18*</td>
<td>–</td>
<td>.37**</td>
<td>24.66 (5.47)</td>
</tr>
<tr>
<td>7. Age</td>
<td>.00</td>
<td>.10</td>
<td>.06</td>
<td>.08</td>
<td>.11</td>
<td>.16</td>
<td>–</td>
<td>20.03 (3.42)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>3.44</td>
<td>2.38</td>
<td>2.36</td>
<td>23.50</td>
<td>2.11</td>
<td>24.04</td>
<td>19.68</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>(2.51)</td>
<td>(1.97)</td>
<td>(1.94)</td>
<td>(11.33)</td>
<td>(0.72)</td>
<td>(5.26)</td>
<td>(2.66)</td>
<td></td>
</tr>
</tbody>
</table>

Note. Correlations of primary variables among males presented above the diagonal, and correlations of primary variables among females are presented below the diagonal. All significance tests were two-tailed. (*p < .05; **p < .01).
Table 4.
**Baseline Descriptive Statistics for Primary Variables for Final Sample and by Sex**

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Males</th>
<th>Females</th>
<th>Test Statistic</th>
<th>df</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N = 240)</td>
<td>(n = 79)</td>
<td>(n = 161)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hunger</td>
<td>3.43</td>
<td>3.39</td>
<td>3.44</td>
<td>t = 0.19</td>
<td>238</td>
<td>.853</td>
<td>0.02</td>
</tr>
<tr>
<td>Approach Food Craving</td>
<td>2.16</td>
<td>1.70</td>
<td>2.38</td>
<td>t = 2.74</td>
<td>238</td>
<td>.007</td>
<td>0.40</td>
</tr>
<tr>
<td>Avoidance Food Craving</td>
<td>2.22</td>
<td>1.94</td>
<td>2.36</td>
<td>t = 1.66</td>
<td>238</td>
<td>.098</td>
<td>0.23</td>
</tr>
<tr>
<td>Restrained Eating</td>
<td>23.11</td>
<td>22.33</td>
<td>23.50</td>
<td>t = 0.79</td>
<td>238</td>
<td>.432</td>
<td>0.11</td>
</tr>
<tr>
<td>Uncontrolled Eating</td>
<td>2.08</td>
<td>2.02</td>
<td>2.11</td>
<td>t = 0.99</td>
<td>238</td>
<td>.322</td>
<td>0.14</td>
</tr>
<tr>
<td>ED Symptom Count&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.34</td>
<td>16.75</td>
<td>22.09</td>
<td>U = 5230</td>
<td></td>
<td>.081</td>
<td>0.32</td>
</tr>
<tr>
<td>BMI</td>
<td>24.24</td>
<td>24.66</td>
<td>24.04</td>
<td>t = -0.84</td>
<td>238</td>
<td>.401</td>
<td>0.12</td>
</tr>
<tr>
<td>Age</td>
<td>19.79</td>
<td>20.03</td>
<td>19.68</td>
<td>t = -0.87</td>
<td>238</td>
<td>.387</td>
<td>1.09</td>
</tr>
</tbody>
</table>

*Note.* All significance tests were two-tailed. ED Symptom Count<sup>a</sup> = Mann Whitney U Test used to compare males and females; *M* = mean score; *SD* = standard deviation; *t* = *t*-test; *p* = *p*-value; *d* = Cohen’s.
Table 5.
Baseline Descriptive Statistics for Go/No-Go and Approach Avoidance Task Reaction Times in Seconds for Final Sample and by Sex

<table>
<thead>
<tr>
<th></th>
<th>Overall (N = 240)</th>
<th>Males (n = 79)</th>
<th>Females (n = 161)</th>
<th>Test Statistic</th>
<th>df</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT on Up Arrow on HCF</td>
<td>.558 (.112)</td>
<td>.545 (.120)</td>
<td>.564 (.108)</td>
<td>t = 1.19</td>
<td>236</td>
<td>.235</td>
<td>0.17</td>
</tr>
<tr>
<td>RT on Down Arrow on HCF</td>
<td>.564 (.113)</td>
<td>.556 (.126)</td>
<td>.568 (.107)</td>
<td>t = 0.68</td>
<td>236</td>
<td>.497</td>
<td>0.10</td>
</tr>
<tr>
<td>Go RT on HCF</td>
<td>.500 (.035)</td>
<td>.503 (.033)</td>
<td>.499 (.036)</td>
<td>t = -0.87</td>
<td>237</td>
<td>.382</td>
<td>1.88</td>
</tr>
</tbody>
</table>

*Note.* All significance tests were two-tailed. RT = reaction time; HCF = high-calorie food; M = mean score; SD = standard deviation; t = t-test; p = p-value; d = Cohen’s.
Table 6.
*Model Parameters for Hypothesis 1a: Self-Reported Food Craving Associated with Shorter Reaction on Go Stimuli on HCF*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Est</td>
<td>SE</td>
<td>Est</td>
<td>SE</td>
<td>Est</td>
</tr>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept ($\gamma_{00}$)</td>
<td>-.720*</td>
<td>.065</td>
<td>-.707*</td>
<td>.065</td>
<td>-.707*</td>
</tr>
<tr>
<td>Time ($\gamma_{10}$)</td>
<td>.148*</td>
<td>.070</td>
<td>.149*</td>
<td>.070</td>
<td>.149*</td>
</tr>
<tr>
<td>Task ($\gamma_{20}$)</td>
<td>-.033**</td>
<td>.001</td>
<td>-.033*</td>
<td>.001</td>
<td>-.024*</td>
</tr>
<tr>
<td>Approach FC ($\gamma_{30}$)</td>
<td>.001</td>
<td>.002</td>
<td>.005</td>
<td>.004</td>
<td>.009*</td>
</tr>
<tr>
<td>Approach FC*Task ($\gamma_{40}$)</td>
<td></td>
<td></td>
<td>-.007</td>
<td>.004</td>
<td>-.007</td>
</tr>
<tr>
<td>Age ($\gamma_{01}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.003*</td>
</tr>
<tr>
<td>Sex ($\gamma_{02}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.012</td>
</tr>
<tr>
<td>BMI ($\gamma_{03}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.001*</td>
</tr>
<tr>
<td>Hunger ($\gamma_{04}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.001</td>
</tr>
<tr>
<td>Avoidance FC ($\gamma_{05}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.003</td>
</tr>
<tr>
<td><strong>Variance Components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random intercept variance ($U_{0i}$)</td>
<td>.004**</td>
<td>&lt;.001</td>
<td>.004*</td>
<td>.001</td>
<td>.004*</td>
</tr>
<tr>
<td>Residual variance ($\epsilon_{ij}$)</td>
<td>.021*</td>
<td>&lt;.001</td>
<td>.021*</td>
<td>&lt;.001</td>
<td>.021*</td>
</tr>
<tr>
<td><strong>Fit Statistics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIC; BIC</td>
<td>-39597;</td>
<td>-31753;</td>
<td>-40112;</td>
<td>-32259;</td>
<td>-40110;</td>
</tr>
</tbody>
</table>

*Note. HCF = high calorie food; SE= standard error; FC = Food Craving; AIC = Akaike information criterion; BIC = Schwarz’ Bayesian Criterion; *p < .05. **p < .001.*
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept ($\gamma_{00}$)</td>
<td>-.679**</td>
<td>.105</td>
<td>-.673*</td>
<td>.105</td>
<td>-.684*</td>
</tr>
<tr>
<td>Time ($\gamma_{10}$)</td>
<td>.735*</td>
<td>.111</td>
<td>.735*</td>
<td>.111</td>
<td>.735*</td>
</tr>
<tr>
<td>Task ($\gamma_{20}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach FC ($\gamma_{30}$)</td>
<td>.007</td>
<td>.007</td>
<td>.009</td>
<td>.010</td>
<td>.008</td>
</tr>
<tr>
<td>Approach FC*Task ($\gamma_{40}$)</td>
<td>-.003</td>
<td>.011</td>
<td>-.003</td>
<td>.011</td>
<td></td>
</tr>
<tr>
<td>Age ($\gamma_{01}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex ($\gamma_{02}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI ($\gamma_{03}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hunger ($\gamma_{04}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoidance FC ($\gamma_{05}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance Components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random intercept variance ($U_{0i}$)</td>
<td>.034**</td>
<td>.003</td>
<td>.034*</td>
<td>.003</td>
<td>.034*</td>
</tr>
<tr>
<td>Residual variance ($\epsilon_{ij}$)</td>
<td>.075*</td>
<td>&lt;.001</td>
<td>.075*</td>
<td>&lt;.001</td>
<td>.075*</td>
</tr>
<tr>
<td>Fit Statistics</td>
<td>AIC: BIC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14278; 22210</td>
<td>14268; 22209</td>
<td>14296; 22219</td>
<td>14080; 22038</td>
<td>14075; 22077</td>
</tr>
</tbody>
</table>

*Note. HCF = high calorie food; SE = standard error; FC = Food Craving; AIC = Akaike information criterion; BIC = Schwarz’ Bayesian Criterion; * $p < .05$. ** $p < .001$
Table 8. 
Associations between Approach Food Craving, Binge Eating Behaviors, and Uncontrolled Eating

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Binge Eating&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Uncontrolled Eating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>OR</td>
</tr>
<tr>
<td>Intercept</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Age</td>
<td>-.04</td>
<td>.96</td>
</tr>
<tr>
<td>Hunger</td>
<td>.05</td>
<td>1.05</td>
</tr>
<tr>
<td>BMI</td>
<td>.02</td>
<td>1.02</td>
</tr>
<tr>
<td>Sex</td>
<td><strong>-1.24</strong></td>
<td><strong>.29</strong></td>
</tr>
<tr>
<td>FAAQ-Avoidance</td>
<td><strong>.61</strong></td>
<td><strong>1.85</strong></td>
</tr>
<tr>
<td>Total R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

|                    | b     | OR    | 95% CI  | p    | b     | β    | p     |
| Intercept          | ----  | ----  | ----    | ----  | 1.38  | ----  | <.001 |
| Age                | -.11  | .89   | .78, 1.03 | .113 | .01   | .02   | .655  |
| Hunger             | -.02  | .98   | .83, 1.15 | .801 | **.04** | **.14** | **.006** |
| BMI                | .02   | 1.03  | .95, 1.11 | .552 | .002  | .02   | .697  |
| Sex                | -.83  | .44   | .16, 1.19 | .105 | .01   | .01   | .873  |
| FAAQ-Avoidance     | .17   | 1.18  | .90, 1.55 | .235 | -.02  | -.06  | .396  |
| FAAQ-Approach      | **.77** | **2.17** | **1.59, 2.96** | **<.001** | .21   | **.56** | **<.001** |
| Total R<sup>2</sup> | ----  | ----  | ----    | ----  | ----  | ----  | ----  |

*Note. b = unstandardized regression coefficient; β = standardized estimate; OR = Odds Ratio for ordered logistic regression; CI = 95% confidence interval; Bolded indicates p < .05; a ordered logistic regression – ordinal variable (generalized linear model).
Table 9.
Model Parameters for Hypothesis 2a: Self-Reported Food Craving Associated with Shorter Reaction Time on go of HCF

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept ($\gamma_{00}$)</td>
<td>-.720**</td>
<td>-.707*</td>
<td>-.703*</td>
<td>-.696*</td>
<td>-.765*</td>
</tr>
<tr>
<td>Time ($\gamma_{10}$)</td>
<td>.148*</td>
<td>.150*</td>
<td>.149*</td>
<td>.134</td>
<td>.134</td>
</tr>
<tr>
<td>Task ($\gamma_{20}$)</td>
<td>-.033*</td>
<td>-.033*</td>
<td>-.027*</td>
<td>-.027*</td>
<td>-.027*</td>
</tr>
<tr>
<td>Avoidance FC ($\gamma_{30}$)</td>
<td>-.002</td>
<td>.002</td>
<td>.003</td>
<td>.004</td>
<td>.001</td>
</tr>
<tr>
<td>Avoidance FC*Task ($\gamma_{40}$)</td>
<td>-.008</td>
<td>.004</td>
<td>-.008</td>
<td>.004</td>
<td></td>
</tr>
<tr>
<td>Age ($\gamma_{01}$)</td>
<td>.004*</td>
<td>.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex ($\gamma_{02}$)</td>
<td>.015*</td>
<td>.007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI ($\gamma_{03}$)</td>
<td>&lt;.001</td>
<td>.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hunger ($\gamma_{04}$)</td>
<td>&lt;.001</td>
<td>.001</td>
<td></td>
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<tr>
<td>Approach FC ($\gamma_{05}$)</td>
<td>.003</td>
<td>.003</td>
<td></td>
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<tr>
<td>Variance Components</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Random intercept variance ($U_{0i}$)</td>
<td>.004**</td>
<td>&lt;.001</td>
<td>.004*</td>
<td>&lt;.001</td>
<td>.001*</td>
</tr>
<tr>
<td>Residual variance ($e_{ij}$)</td>
<td>.021*</td>
<td>&lt;.001</td>
<td>.021*</td>
<td>&lt;.001</td>
<td>.021*</td>
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<tr>
<td>Fit Statistics</td>
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<td></td>
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</tr>
<tr>
<td>AIC; BIC</td>
<td>-39597; -31753; -40112; -32259; -40111; -32249; -40145; -32274; -40147; -32233</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. HCF = high calorie food; SE = standard error; FC = Food Craving; AIC = Akaike information criterion; BIC = Schwarz’ Bayesian Criterion; * $p < .05$. **$p < .001$. 
Table 10.  
*Model Parameters for Hypothesis 2b: Self-Reported Food Craving Associated with Longer Reaction Time when Avoiding HCF*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
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<tr>
<td>Fixed Effects</td>
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<td></td>
</tr>
<tr>
<td>Intercept ($\gamma_{00}$)</td>
<td>-.595**</td>
<td>-.585**</td>
<td>-.595**</td>
<td>-.624**</td>
<td>-1.02**</td>
</tr>
<tr>
<td>Time ($\gamma_{10}$)</td>
<td>.538**</td>
<td>.540**</td>
<td>.540**</td>
<td>.559**</td>
<td>.560**</td>
</tr>
<tr>
<td>Task ($\gamma_{20}$)</td>
<td>-.022*</td>
<td>-.022*</td>
<td>-.010</td>
<td>-.009</td>
<td></td>
</tr>
<tr>
<td>Avoidance FC ($\gamma_{30}$)</td>
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<td>.006</td>
<td>.013</td>
<td>.009</td>
<td></td>
</tr>
<tr>
<td>Avoidance FC*Task ($\gamma_{40}$)</td>
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<td>.11</td>
<td>-.005</td>
<td>.010</td>
<td></td>
</tr>
<tr>
<td>Age ($\gamma_{01}$)</td>
<td>.017*</td>
<td>.015</td>
<td>.003</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Sex ($\gamma_{02}$)</td>
<td>-.015</td>
<td>.019</td>
<td>.002</td>
<td>.004</td>
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<tr>
<td>BMI ($\gamma_{03}$)</td>
<td>&lt;.001</td>
<td>.009</td>
<td>.001</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td>Hunger ($\gamma_{04}$)</td>
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<td>.009</td>
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<td></td>
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<tr>
<td>Variance Components</td>
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<td></td>
</tr>
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<td>.003</td>
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<td>.032</td>
</tr>
<tr>
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<td>&lt;.001</td>
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<tr>
<td>Fit Statistics</td>
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<td></td>
</tr>
<tr>
<td>AIC; BIC</td>
<td>11093;</td>
<td>19034;</td>
<td>11016;</td>
<td>18966;</td>
<td>10770;</td>
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</table>

*Note. HCF = high calorie food; SE = standard error; FC = Food Craving; AIC = Akaike information criterion; BIC = Schwarz’ Bayesian Criterion; * $p < .05$. **p<.001*
Table 11. Associations between Avoidance Food Craving and Restrained Eating

<table>
<thead>
<tr>
<th>Predictors</th>
<th>b</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>9.57</td>
<td>----</td>
<td>.030</td>
</tr>
<tr>
<td>Age</td>
<td>.01</td>
<td>.003</td>
<td>.958</td>
</tr>
<tr>
<td>Hunger</td>
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<td>-.02</td>
<td>.647</td>
</tr>
<tr>
<td>BMI</td>
<td>.34</td>
<td>.17</td>
<td>.001</td>
</tr>
<tr>
<td>Sex</td>
<td>-.34</td>
<td>-.01</td>
<td>.780</td>
</tr>
<tr>
<td>FAAQ-Approach</td>
<td>2.59</td>
<td>.43</td>
<td>&lt;.001</td>
</tr>
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<td>Total R²</td>
<td></td>
<td>.25</td>
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</tbody>
</table>

<table>
<thead>
<tr>
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<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>8.06</td>
<td>----</td>
<td>.020</td>
</tr>
<tr>
<td>Age</td>
<td>.07</td>
<td>.02</td>
<td>.642</td>
</tr>
<tr>
<td>Hunger</td>
<td>.24</td>
<td>.05</td>
<td>.184</td>
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<tr>
<td>BMI</td>
<td>.19</td>
<td>.10</td>
<td>.023</td>
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<td>Sex</td>
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<td>Total R²</td>
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<td>.54</td>
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Note. b = unstandardized regression coefficient; β = standardized estimate; Bolded indicates p < .05.
Table 12.  
*Associations between Approach and Avoidance Food Craving and Bulimia Nervosa*

<table>
<thead>
<tr>
<th>Predictors</th>
<th>b</th>
<th>OR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-6.42</td>
<td>.002</td>
<td>----</td>
<td>.001</td>
</tr>
<tr>
<td>Age</td>
<td>.08</td>
<td>1.09</td>
<td>.93, 1.27</td>
<td>.932</td>
</tr>
<tr>
<td>Hunger</td>
<td>.11</td>
<td>1.12</td>
<td>.89, 1.40</td>
<td>.895</td>
</tr>
<tr>
<td>BMI</td>
<td>.06</td>
<td>1.06</td>
<td>.97, 1.16</td>
<td>.197</td>
</tr>
<tr>
<td>Sex</td>
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<td>.17</td>
<td>.02, 1.35</td>
<td>.092</td>
</tr>
<tr>
<td>Total R²</td>
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<td>----</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Predictors</th>
<th>b</th>
<th>OR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-8.32</td>
<td>.000</td>
<td>----</td>
<td>.004</td>
</tr>
<tr>
<td>Age</td>
<td>-.08</td>
<td>.92</td>
<td>.75, 1.13</td>
<td>.434</td>
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<td>Hunger</td>
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<td>.92</td>
<td>.65, 1.29</td>
<td>.616</td>
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<td>.82, 1.12</td>
<td>.56</td>
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<tr>
<td>Sex</td>
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<td>.94</td>
<td>.07, 12.15</td>
<td>.963</td>
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<td>1.20</td>
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<td>1.50, 5.96</td>
<td>.002</td>
</tr>
<tr>
<td>FAAQ-Avoidance</td>
<td>.79</td>
<td>2.19</td>
<td>1.23, 3.91</td>
<td>.004</td>
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<tr>
<td>Total R²</td>
<td></td>
<td>----</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* b = unstandardized regression coefficient; OR = EXP(B) or Odds Ratio for logistic regression. †Logistic regression. Bolded indicates *p* < .05 for food craving measures.
Table 13.
Associations between Reaction Time for go on High Calorie Foods, Binge Eating Behaviors, and Uncontrolled Eating

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Binge Eating[^a]</th>
<th>Uncontrolled Eating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>OR</td>
</tr>
<tr>
<td>Intercept</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Age</td>
<td>-.11</td>
<td>.89</td>
</tr>
<tr>
<td>Hunger</td>
<td>-.02</td>
<td>.98</td>
</tr>
<tr>
<td>BMI</td>
<td>.02</td>
<td>1.03</td>
</tr>
<tr>
<td>Sex</td>
<td>-.83</td>
<td>.44</td>
</tr>
<tr>
<td>FAAQ-Avoidance</td>
<td>.17</td>
<td>1.18</td>
</tr>
<tr>
<td>FAAQ-Approach</td>
<td>.77</td>
<td>2.17</td>
</tr>
<tr>
<td>Total R^2</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

|                 | b                | OR   | 95% CI   | p   | b    | β    | p   |
| Intercept       | ----             | ---- | ----     | ---- | 1.45 | ---- | .002 |
| Age             | -.13             | .88  | .76, 1.02| .084 | .01   | .03  | .562  |
| Hunger          | -.02             | .98  | .83, 1.15| .769 | .05   | .18  | .001  |
| BMI             | .02              | 1.02 | .94, 1.11| .601 | .01   | .05  | .440  |
| Sex             | -.88             | .41  | .15, 1.14| .088 | -.001 | -.001| .989  |
| FAAQ-Avoidance  | .19              | 1.21 | .92, 1.60| .179 | .004  | .01  | .896  |
| FAAQ-Approach   | .77              | 2.16 | 1.58, 2.94| <.001 | .20   | .54  | <.001 |
| Go on HCF       | 2.12             | 8.32 | .02, 3869| .499 | .33   | .04  | .512  |
| Total R^2       | ----             | ---- | ----     | ---- | .36   |

[^a] ordered logistic regression – ordinal variable (generalized linear model); Bolded indicates p < .05.

Note. b = unstandardized regression coefficient; β = standardized estimate; OR = Odds Ratio for logistic regression; 95% CI = 95% confidence interval; RT when Approaching HCF = natural log-transformed average reaction time on go for high calorie food images;[^a] ordered logistic regression – ordinal variable (generalized linear model); Bolded indicates p < .05.
Table 14.
Associations between Reaction Time when Approaching High Calorie Foods via Up Arrow Key, Binge Eating Behaviors, and Uncontrolled Eating

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Binge Eating&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Uncontrolled Eating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>OR</td>
</tr>
<tr>
<td>Intercept</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Age</td>
<td>-.11</td>
<td>.89</td>
</tr>
<tr>
<td>Hunger</td>
<td>-.02</td>
<td>.98</td>
</tr>
<tr>
<td>BMI</td>
<td>.02</td>
<td>1.03</td>
</tr>
<tr>
<td>Sex</td>
<td>-.83</td>
<td>.44</td>
</tr>
<tr>
<td>FAAQ-Avoidance</td>
<td>.17</td>
<td>1.18</td>
</tr>
<tr>
<td>FAAQ-Approach</td>
<td>.77</td>
<td>2.17</td>
</tr>
<tr>
<td>Total R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>---</td>
<td>---</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Binge Eating&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Uncontrolled Eating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>OR</td>
</tr>
<tr>
<td>Intercept</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Age</td>
<td>-.09</td>
<td>.91</td>
</tr>
<tr>
<td>Hunger</td>
<td>-.02</td>
<td>.98</td>
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<tr>
<td>BMI</td>
<td>.03</td>
<td>1.03</td>
</tr>
<tr>
<td>Sex</td>
<td>-.97</td>
<td>.38</td>
</tr>
<tr>
<td>FAAQ-Avoidance</td>
<td>.18</td>
<td>1.20</td>
</tr>
<tr>
<td>FAAQ-Approach</td>
<td>.80</td>
<td>2.22</td>
</tr>
<tr>
<td>RT when Approaching HCF</td>
<td>-2.43</td>
<td>.09</td>
</tr>
<tr>
<td>Total R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Note. b = unstandardized regression coefficient; β = standardized estimate; OR = Odds Ratio for logistic regression; 95% CI = 95% confidence interval; RT when Approaching HCF = natural log-transformed average reaction time when approaching high calorie food images via up arrow key; <sup>a</sup> ordered logistic regression – ordinal variable (generalized linear model); Bolded indicates p < .05.
Table 15. 
*Associations between Reaction Time when Avoiding High Calorie Foods via Down Arrow Key and Restrained Eating Behaviors*  

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Restrained Eating</th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictors</td>
<td>b</td>
<td>β</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
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<td>.079</td>
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<tr>
<td>Age</td>
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<td>.786</td>
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<td>Hunger</td>
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<td>.01</td>
<td>.836</td>
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<td><strong>.030</strong></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
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<td>.000</td>
<td>.999</td>
<td></td>
</tr>
<tr>
<td>FAAQ-Approach</td>
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<td>-.11</td>
<td>.118</td>
<td></td>
</tr>
<tr>
<td>FAAQ-Avoidance</td>
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<td><strong>.747</strong></td>
<td>&lt;.001</td>
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</tr>
<tr>
<td>Total $R^2$</td>
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<td></td>
<td>.50</td>
<td></td>
</tr>
</tbody>
</table>

| | Intercept | Age | Hunger | BMI | Sex | FAAQ-Approach | FAAQ-Avoidance | RT when Avoiding HCF |
| | 6.20 | .13 | .04 | **.21** | .02 | -.61 | **4.33** | 1.32 |
| Total $R^2$ |  |  |  |  |  |  |  | .50 |

*Note.* $b =$ unstandardized regression coefficient; $β =$ standardized estimate; RT when Avoiding HCF = average reaction time when avoiding high calorie food via down arrow key. Bolded indicates $p < .05$. 

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Appendix A

Demographic Questions

1. Age: ___ (years)

2. Sex:
   a. Male
   b. Female
   c. Prefer to self describe: _______

3. Race (Check ALL that apply)
   a. African-American or Black
   b. American Indian or Alaska Native
   c. Asian
   d. Native Hawaiian or Pacific Islander
   e. White
   f. Prefer to self describe: _______

4. Ethnicity
   a. Hispanic/Spanish/Latinx
   b. Not Hispanic/Spanish/Latinx

5. Height: _____ (in feet and inches)

6. Weight: _____ (in pounds)
Appendix B

Hunger Visual Analogue Scales

1. **Current level of hunger**

   Not at all  
   
   100mm  
   
   Extremely

2. **Fullness (reverse scored)**

   Not at all  
   
   100mm  
   
   Extremely

3. **Desire to eat**

   Not at all  
   
   100mm  
   
   Extremely

4. **How much could you eat right now?**

   Not at all  
   
   100mm  
   
   Extremely

5. **Urge to eat**

   Not at all  
   
   100mm  
   
   Extremely

6. **Preoccupation with thoughts of food.**

   Not at all  
   
   100mm  
   
   Extremely
### Appendix C

#### Food Approach and Avoidance Questionnaire

This questionnaire related to YOUR ATTITUDES toward food over the LAST WEEK. Please indicate how much you agree with the statements below by indicating the number corresponding most closely to your general attitude over the LAST WEEK.

<table>
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<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Very Strongly</th>
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<tbody>
<tr>
<td>Not at All</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Food cravings make me think of ways to get what I want to eat.
2. I do things to take my mind off my food cravings.
3. When I crave something, I know I won’t be able to stop eating it once I start.
4. I think about the benefits of not giving in to my food cravings.
5. If I eat what I am craving, I often lose control and eat too much.
6. I avoid places that are likely to tempt my food cravings.
7. I feel like I have food on my mind all the time.
8. I get upset when I have a food craving.
9. I daydream about food.
10. I have thoughts like “just don’t eat it.”
11. If I am craving something, I become preoccupied by thoughts of eating it.
12. The thought of giving into my food cravings repulses me.
Appendix D
Eating Disorder Diagnostic Scale DSM-5

Instructions: Please carefully complete all questions, choosing NO or 0 for questions that do not apply.

Over the past 3 months…

1. Have you felt fat? ……………………………………………………………… 0 1 2 3 4 5 6
2. Have you had a definite fear that you might gain weight or become fat? 0 1 2 3 4 5 6
3. Has your weight or shape influenced how you judge yourself as a person? 0 1 2 3 4 5 6

4. During the past 3 months have there been times when you have eaten what other people would regard as an unusually large amount of food (e.g., a quart of ice cream) given the circumstances? ………. YES NO

5. During the times when you ate an unusually large amount of food, did you experience a loss of control (e.g., felt you couldn’t stop eating or control what or how much you were eating?) ………………………………………... YES NO

6. How many times per month on average over the past 3 months have you eaten an unusually large amount of food and experienced a loss of control? 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16+

During episodes of overeating with a loss of control, did you…

7. Eat much more rapidly than normal?
………………………………………………………………………………………... YES NO

8. Eat until you felt uncomfortably full?
………………………………………………………………………………………... YES NO

9. Eat large amounts of food when you didn’t feel physically hungry?
…………………………… YES NO

10. Eat alone because you were embarrassed by how much you were eating? ……………….. YES NO

11. Feel disgusted with yourself, depressed, or very guilty after overeating? ……………….. YES NO
12. If you have episodes of uncontrollable overeating, does it make you very upset? .......... YES  NO

**In order to prevent weight gain or counteract the effects of eating, how many times per month on average over the past 3 months have you?**

13. Made yourself vomit? ....................... 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16+

14. Used laxatives or diuretics? ............... 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16+

15. Fasted (skipped at least 2 meals in a row)? 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16+

16. Engaged in more intense exercise specifically counteract the effects of overeating .......... 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16+

17. How many times per month on average over the past 3 months have you eaten after awakening from sleep or eaten an unusually large amount of food after your evening meal and felt distressed by the night eating? .........................

18. How much do eating or body image problems impact your relationships  Not at all Slightly Moderately Extremely with friends and family, work performance, and school performance? ................. 0 1 2 3 4 5 6

19. How much do you weigh? If uncertain, please give your best estimate. ______________ lbs. –or- ______________ kg.

20. How tall are you? _________ ft. ___________ in. –or- ___________ cm.

21. What is your highest weight at your current height? ______________ lbs. –or- ______________ kg.

22. What is your sex? MALE   FEMALE

23. What is your age? ______________
Appendix E

Dutch Eating Behavior Questionnaire – Restrained Eating Subscale

Circle the best response to describe your behavior over the last week:

<table>
<thead>
<tr>
<th>Question</th>
<th>Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If you put on weight, did you eat less than you normally would?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Did you try to eat less at mealtimes than you would like to eat?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. How often did you refuse food or drink because you were concerned about your weight?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Did you watch exactly what you ate?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Did you deliberately eat foods that were slimming?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. When you ate too much, did you eat less than usual the next day?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. Did you deliberately eat less in order not to become heavier?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. How often did you try not to eat between meals because you were watching your weight?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. How often in the evenings did you try not to eat because you were watching your weight?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. Did you take into account your weight in deciding what to eat?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix F

Three Factor Eating Questionnaire – Uncontrolled Eating Subscale

Please read each statement and select from the multiple choice options the answer that indicates the frequency with which you find yourself feeling or experiencing what is being described in the statements below.

<table>
<thead>
<tr>
<th></th>
<th>Definitely True</th>
<th>Mostly True</th>
<th>Mostly False</th>
<th>Definitely False</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sometimes when I start eating, I just can’t seem to stop.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. Being with someone who is eating, often makes me want to also eat.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. I often get so hungry that my stomach feels like a bottomless pit.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. I’m always so hungry that it’s hard for me to stop eating before finishing all of the food on my plate.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating – even if I’ve just finished a meal.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. I’m always hungry enough to eat at any time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. When I see something that looks very delicious, I often get so hungry that I have to eat right away.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. Do you go on eating binges even though you’re not hungry?</td>
<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
<td>At least once a week</td>
</tr>
<tr>
<td>10. How often do you feel hungry?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix G

Practice Trials: Go/No-Go

Time

500ms

750ms

500ms

500ms

750ms
Appendix H

Practice Trials: Approach-Avoidance Task
Appendix I

Experimental Trials: Go/No-Go
Appendix J

Experimental Trials: Approach-Avoidance Task

Time

200ms

100ms

100ms

***
Appendix K

Original Study

Current Study

As outlined, literature has provided a strong foundation for understanding the approach-avoidance compatibility effect via food-based stop-signal and joystick paradigms, whereby positive perceptions facilitate approach behavior and negative perceptions facilitate avoidance behavior. Still, substantial gaps in the literature remain. In particular, investigations of the multi-dimensional motivational process of food craving and its relation to the full spectrum of disordered eating behaviors are limited, both in the evaluation of approach and avoidance inclinations, as well as the use of behavioral measures of approach and avoidance food craving. A test of the AMC theoretical framework using go/no-go and joystick paradigms may provide less biased and automatic measures of approach and avoidance food craving as they relate to the full spectrum of disordered eating behaviors.

In the current study, food craving is defined a multi-dimensional motivational process that involves an individual’s competing desires to both consume and not consume certain food or certain types of food. Furthermore, the proposed study aims to test whether behavioral measures of approach and avoidance food craving differentially and more strongly predict the spectrum of disordered eating behaviors, compared to traditional self-report measures, using Go/No-Go and Joystick methodologies. The Go/No-Go and Joystick tasks will capture participants’ motivationally-driven behavior to approach and avoid high- and low-calorie foods without interrupting the automatic experience of food craving that may occur with verbal reporting or labeling of the food craving experience. Reaction time (RT) and force applied to the joystick will represent a straightforward assessment of the underlying motivational processes of approach and
avoidance food craving. How RT and force will reflect the AMC-described approach and avoidance food craving dimensions will vary based on experimental task (see below).

It is hypothesized that: (1) high self-reported approach food craving will be associated with (a) shorter RT on *go* stimuli of high-calorie foods (high-calorie foods); (b) shorter RT and greater force when approaching (pulling towards participant) high-calorie foods via the joystick; (c) high levels of self-reported binge eating behaviors and uncontrolled eating; and (d) higher likelihood of self-reported binge eating disorder; and (2) high self-reported avoidance food craving will be associated with (a) longer RT on *go* stimuli of high-calorie foods; (b) shorter RT and greater force when avoiding (pushing toward computer) from high-calorie foods via the joystick; (c) high levels of restrained eating; and (d) greater likelihood of self-reported anorexia nervosa; (3) high self-reported approach or avoidance food craving will be associated with equal likelihood of self-reported bulimia nervosa; (4) behavioral measures of approach food craving (i.e., RT on *go* stimuli of high-calorie foods, RT and force when approaching high-calorie foods via joystick) will more strongly predict self-reported binge eating behaviors, uncontrolled eating, and likelihood of binge eating disorder; and (5) behavioral measures of avoidance food craving (i.e., RT and force when avoiding high-calorie foods via joystick) will more strongly predict restrained eating and likelihood of anorexia nervosa.

**Method**

**Participants**

Participants aged 18-65 will be recruited through two methods, including the Psychology Department research participant pool and across campus more broadly via flyers and email blasts. To identify the appropriate sample size for the planned analyses requiring the most power (e.g., 2x2 ANOVA with continuous moderator), a power analysis was conducted in G*Power
(v3.1) based on Carbine and colleagues (2017) observed effect of condition across high- and low-calorie go/no-go tasks ($\eta^2 = .02$, which was converted into an $F$ effect size of .14). Correlations among repeated measures was set to a conservative .4, number of groups was set to 4, and number of measurements was set to 4. To detect the small sized effect of condition as seen in previous literature, with power .80, the total sample size required is 120. To account for 20% data loss, an additional 30 participants will be recruited, leading to an anticipated recruited sample of 150. Pre-screening will include measures of disordered eating to allow for over-sampling of individuals reporting moderate to high levels of disordered eating behaviors to ensure sufficient variability on disordered eating outcomes (EDEQ; Fairburn & Beglin, 1994).

Due to established sex differences in the eating disorder and food craving literatures (Burton et al., 2007; Konttinen et al., 2010; Opwis et al., 2017), efforts will be made to recruit 50% males. Following completion of the in-lab experiment, participants will be compensated with either partial course credit or $10 Amazon gift cards.

**Experimental Procedure**

To control for caloric intake, participants will be asked to stop eating and drinking (except water) by 10 pm the night before reporting to the lab during morning hours (i.e., 8-11 am; Carbine et al., 2017). In the lab, participants who provide verbal confirmation of fasting requirements will complete an online battery of questionnaires via Qualtrics assessing hunger, food craving, eating disorder symptomatology, restrained eating, and uncontrolled eating. After completing online questionnaires, participants will be offered multiple magazines to browse for three minutes to washout priming effects (Gellatly & Meyer, 1992). Magazines will be verified to not include body image, dieting, or food related content (e.g., home decor magazines).
Next, participants will complete a series of go/no-go and joystick tasks that were adapted from previous research (e.g., Go/No-Go: Carbine et al., 2017; Joystick: Krieglmeyer & Deutsch, 2010). There will be two control blocks (office supply stimuli) and eight mini experimental blocks (either low- or high-calorie food stimuli; see Figure 2). All participants will complete all 10 blocks. With four potential starting conditions (i.e., joystick low calorie, go/no-go low calorie, joystick high calorie, go/no-go high calorie), initial order of conditions will be balanced using a diagram-balanced Latin Square. This design guarantees that every condition occurs in each position exactly once and each condition precedes and follows every other exactly once. The three dependent variables of interest will be: (1) reaction time (RT) for both high- and low-calorie food tasks across go/no-go and joystick tasks; (2) the number of commission errors made to ‘no-go’ trials on each task; and (3) force of joystick on both approach and avoidance tasks. After completing the experiment, participants’ height and weight will be recorded by a female research assistant and participants will be debriefed (see Appendix K).

**Practice Trials**

The experiment will begin with two practice trials (2 blocks of 25 trials) that have neutral pictures (e.g., office supplies; Brodeur et al., 2010) not used elsewhere in the task to ensure that participants understand the task instructions. For the go/no-go practice trial, participants will be instructed to press the space bar when they see office supplies (e.g., scissors; go stimulus) and inhibit a response when they see a non-office related images (e.g., soap dispenser; no-go stimulus). Each go/no-go practice cue will be presented for 750 ms, followed by a blank screen for 500 ms, followed by a fixation point for 500 ms (see Appendix F).
For the joystick practice trial, participants will be instructed to pull the joystick away from the computer screen when they see office supplies (e.g., scissors; approach) and push the joystick toward the screen when they see non-office related images (e.g., soap dispenser; avoid). The direction in which participants are asked to move (push or pull) the joystick will be indicated by an isosceles triangle that will appear above (pointing upward; push) or below (pointing downward; pull) the image, respectively. Based on previous literature (Piqueras-Fiszman et al., 2014), the visual indicators of triangles provide un-biased instructions. The practice trial instructions will include the wording, “Please move the joystick in the direction in which the triangle is pointing.” This phrasing has been shown to eliminate positive or negative connotations assigned to particular motor response in the instructions of a task (i.e., negative valence associated with “push” and “away” when used in reference to oneself, and positive
valence associated with “pull” and “towards”; see Eder & Rothermund, 2008; Kraus & Hofman, 2013). For the joystick task practice trials, three asterisks will be presented for 200 ms to direct participants’ attention to the center of the screen, followed by a blank screen for 100 ms. Then, the image will appear in the center of the screen. After participants respond to all stimuli, the screen will be blank. The inter-trial interval will be 1000 ms (see Appendix G).

Following practice trials, all participants will complete the go/no-go and joystick high- and low-calorie tasks. Similar to the initial ordering of practice trials, initial order of experimental conditions will be balanced using a diagram-balanced Latin Square.

**Food Go/No-Go Tasks**

The go/no-go task will capture participants’ motivationally driven behavior to approach and avoid high- and low-calorie foods. Based on prior literature (Carbine et al., 2017; Price et al., 2016; see Figure 2) participants will complete four blocks of food go/no-go tasks to assess inhibitory control toward high- and low-calorie foods. On the food go/no-go high-calorie task, participants will be instructed to quickly, but accurately, press the spacebar when they see high-calorie food pictures (e.g., donut; go stimulus; approach; see Appendix H) and inhibit responses when they see low-calorie food pictures (e.g., celery; no-go stimulus; avoidance). In the low-calorie task, participants will be instructed to do the opposite and press the space bar when they see low-calorie food (go stimulus) and inhibit when they see high-calorie food (no-go stimulus).

For each task, there will be four blocks of 50 trials, 25 of which will be go trials and 25 of which will be no-go trials. Pictures will be presented for 750 ms, followed by a black screen for 500 ms, which will be followed by a fixation point for 500 ms (see Appendix H). Thirty eight high-calorie and 38 low-calorie food pictures were provided from Carbine and colleagues (2017), who have used the pictures in a go/no-go task after they were accurately categorized as
high- or low-calorie foods 95% of the time or better by 26 separate undergraduate participants. The pictures were provided to Carbine and colleagues (2017) by Killgore and colleagues (2013), who have used the images in multiple experiments (e.g., Killgore et al., 2013; 2010; Killgore & Yurgelun Todd, 2005). The high-calorie food images include 15 dinner meals (e.g., cheese burger), 16 images of desserts (e.g., ice cream), and 7 breakfast meals (e.g., waffles). The low-calorie food images include 25 fruits (e.g., cantelope) and 13 vegetables (e.g., celery). A noted limitation of the go/no-go paradigm is that the design is limited to measuring only approach behaviors (via button pressing) since avoidance behaviors would be represented through inhibiting of approach behaviors. Therefore, RT and force data measured through the joystick paradigm is essential to fully capture both approach and avoidance inclinations toward high- and low-calorie food stimuli.

**Joystick Task**

The joystick task will provide information on the intensity of approach and avoidance food craving motivation, yielding incremental validity beyond the traditional go/no-go task. Measuring intensity will show the degree to which participants hesitate when motivated to approach or avoid different types of food. On the joystick high-calorie task, participants will be instructed to move towards high-calorie food by pulling the joystick away from the computer (i.e., approach), and to move away from low-calorie food by means of pushing the joystick toward the computer (i.e., avoid; Seibt et al., 2008). In the low-calorie task, participants will be instructed to do the opposite and move towards low-calorie food by pulling the joystick away from the image (e.g., approach), and to move towards high-calorie food by pushing the joystick toward the image (e.g., avoid).
At the beginning of each trial, three asterisks will be presented for 200 ms to direct participants’ attention to the center of the screen, followed by a blank screen for 100 ms. Then, a food image will appear in the center of the screen and isosceles triangles (height: 1 cm; base: 20 cm; Piqueras-Fiszman et al., 2014) will appear above (pointing upward) or below the stimulus (pointing downward). After participants respond to all stimuli, the screen will be blank (see Appendix I). The inter-trial interval will be 1000 ms. The dependent variables will be measured as: (1) the time between the onset of the food stimulus and when the participants move the joystick 50% of the range in the respective direction (e.g., reaction time); and (2) the force with which the participant approaches and avoids high-calorie food stimuli when instructed.

The same high- and low-calorie images included in the go/no-go tasks will be used for joystick tasks. All stimuli will be presented on a blank background. The screen will have a resolution of 1024x768 pixels. The joystick will be a Logitech Attack 3 (see Appendix J).

**Measures**

**Demographics.** Demographic data including age, sex, race, ethnicity, height, and weight will be collected via self-report during the initial online questionnaire.

**Body Mass Index.** At the end of the experiment, participants’ height and weight will be measured by a female research assistant to calculate Body Mass Index (BMI). After removal of shoes, height will be measured to the nearest millimeter using a stadiometer and weight will be assessed to the nearest 0.1 kg using digital scales. BMI will be used as an index of body weight adjusted for participant height, and calculated from by using the equation BMI = Weight (kg)/Height (m)^2.

**Hunger.** Hunger levels will be assessed by averaging across six visual analog scales (VAS): (1) current levels of hunger; (2) fullness (reverse scored); (3) desire to eat; (4) how much
could you eat; (5) urge to eat; and (6) preoccupation with thoughts of food. Each VAS will consist of a 100-mm (10 cm) line, anchored from 0 (not at all) to 10 (extremely; Blundell et al., 2010; Carbine et al., 2017). Literature suggests that VAS measurements of hunger consistently and reliably predict meal initiation, amount of food consumed, and are sensitive to experimental manipulation (Stubbs et al., 2000).

**Intermittent Fasting.** Due to an increase in popularity (Barnosky et al., 2014) and the potential influence on approach and avoidance inclinations, two questions will be used to assess whether participants are engaging in intermittent fasting, or restricting energy 1-3 days/week allowing for ad libitum food consumption on nonrestriction days (Varady, 2011). The first question will ask, “Have you completed an intermittent fast?” with responses including yes and no. The second question will ask, “When was the last time you started a fast?” with a fill in the blank for responses. While participants’ responses to intermittent fasting questions will not change the proposed analyses, exploratory analyses will be conducted to investigate baseline differences across individuals engaging in intermittent fasting compared to those who do not.

**Approach and Avoidance Food Craving.** Food craving will be assessed using the approach and avoidance subscales of the Food Approach and Avoidance Questionnaire (FAAQ; Rancourt et al., 2019). The 6-item approach subscale reflects an individual’s motivation to consume a particular food or type of food. A sample item is “If I eat when I am craving, I often lose control and eat too much” with responses ranging from 0 (not at all) to 8 (very strongly). The 6-item avoidance subscale measures the competing desire to avoid or not consume a particular food or food type. A sample item is “I do things to take my mind off my food cravings” with responses ranging from 0 (not at all) to 8 (very strongly). For both subscales, higher values indicate more food craving motivations. Both the approach (.90) and avoidance
(.84) subscales demonstrated adequate marginal reliability in the development and validation study with mixed-sex adult samples.

**Disordered Eating.** Disordered eating will be assessed for screening purposes using the Eating Disorder Examination Questionnaire (EDEQ; Fairburn & Beglin, 1994). The EDEQ is a 28-item self-report questionnaire assessing a range of disordered eating attitudes and behaviors. A sample item is “Have you had a definite desire to have an empty stomach with the aim of influencing your shape or weight” with responses ranging from 0 (not one day) to 6 (every day). Items are summed and averaged to provide three subscale scores (Eating Concerns, Dietary Restraint, Weight Concerns, and Shape Concerns) and a global score. Higher scores reflect greater eating-related pathology. The EDEQ demonstrated acceptable psychometric properties in mixed-sex undergraduate samples (see review by Berg et al., 2012).

**Eating Disorder Symptoms.** Eating disorder symptomatology will be assessed using the Eating Disorder Diagnostic Scale - DSM-5 Version (EDDS-5; Stice, n.d.). The EDDS-5 is a 23-item questionnaire generates an ED symptom count, and preliminary diagnoses for anorexia nervosa (AN), bulimia nervosa (BN), and binge eating disorder (BED), low frequency AN, low frequency BN, low frequency BED, purging disorder, and night eating syndrome to fit the diagnostic changes in the DSM-5. An example item is “Over the past 3 months, have you felt fat.” Symptom count scores are computed via the sum of all raw scores or average of z-scores of all items when items are positively skewed; higher scores indicate greater ED symptomatology. When compared with clinical interviews, the EDDS-5 demonstrates accuracy of diagnosis, such that the proportion of individuals for whom the diagnosis generated by the EDDS-5 matched the proportion generated by the clinical interview (Sysko et al., 2015). The EDDS-5 has also
demonstrated excellent internal consistency with a mixed-sex adult community sample (α = .91; Becker et al., 2017).

**Restrained eating.** The restrained eating subscale of the Dutch Eating Behavior Questionnaire (DEBQ; Van Strien et al., 1986) will be used to assess restrained eating. The subscale consists of 10-items rated on a five-point scale from 1 (never) to 5 (very often). Items are will be summed for a total score, with higher scores indicating a greater degree of food restriction. An example item is “Do you deliberately eat less in order not to become heavier?” The restraint scale demonstrated excellent internal consistency in past research (women: α = .94; men: α = .94; Rancourt et al., 2019).

**Uncontrolled eating.** Uncontrolled eating behaviors will be captured using the uncontrolled eating subscale of the Three Factor Eating Questionnaire (TFEQ-R18V2; Cappelleri et al., 2009). The 9-item scale reflects difficulty in regulation or loss of control while eating. A sample item is “I’m always so hungry that it’s hard for me to stop eating before finishing all of the food on my plate” with responses ranging from 1 (definitely true) to 4 (definitely false). Higher values indicate more uncontrolled behavior. This scale has demonstrated acceptable internal consistency in previous research (women: α = .89; men: α = .89; Verzijl et al., 2018).

**Data Analytic Plan**

Preliminary analyses will include basic descriptives and will be conducted in SPSS (version 25; IBM, 2016). Due to noted sex differences in both disordered eating behaviors and food craving (Burton et al., 2007; Konttinen et al., 2010; Opwis et al., 2017), independent samples t-tests and chi-square tests will be conducted to test whether males and females significantly differ on any baseline characteristics (EDDS symptom count, ED diagnoses,
approach and avoidance food craving) or other demographic variables. Based on previous literature, it is expected that females will report higher levels of restrained eating (Burton et al., 2007), higher levels of food craving (Opwis et al., 2017), and more uncontrolled eating (Konttinen et al., 2010) compared to males. A correlation matrix will be produced including all demographic, baseline, and outcome data.

To examine hypotheses that individuals high in approach and individuals high in avoidance food craving will show differential RT on high- and low-calorie food tasks (Hypotheses 1a, 1b, 2a, and 2b), RT data for both go/no-go and joystick tasks will be examined via multilevel modeling (MLM; Hoffman & Rovine, 2007). Of note, MLM represents the most appropriate analytic strategy for go/no-go and joystick data, compared to traditional ANOVA, since data are hierarchically structured (i.e., trial nested within individual; Field & Wright, 2011). Additionally, MLM provides: (1) increased flexibility in addressing dependencies among observations with random effects, or effects of variables that are specified as varying across participants (i.e., approach food craving, age, sex, etc.); (2) main effects and interactions of categorical (i.e., high-calorie or low-calorie) and continuous (i.e., approach and avoidance food craving) independent variables may be examined simultaneously; and (3) data from participants with only partial response can be included because listwise deletion is not required (Hoffman & Rovine, 2007). Lastly, MLM has fewer and less strict data assumptions than traditional ANOVAs (Wright & London, 2009).

To test go/no-go hypotheses (Hypothesis 1a and 2a), RT data will be analyzed via analogous multilevel models in SPSS (IBM, 2016). Multilevel models will be estimated using maximum likelihood and the Satterthwaite method (see Fitzmaurice et al., 2004) will be implemented in the presence of incomplete data. If necessary, RT data will be natural log-
transformed to reduce skewness and to prevent illegitimate interactions with approach and avoidance food craving due to differences across participants at baseline (Faust et al., 1999). Across hypotheses, models will be specified in an iterative fashion, such that fixed and random factors will be individually added to the baseline (or null) model to ensure that the final model shows improved goodness of fit compared to the baseline model (Hoffman & Rovine, 2007; Wright & London, 2009).

For hypothesis 1a, model 1 will represent the baseline, intercept-only model. Model 2 will be a main effects model with homogeneous variances where (level 1) task (high-calorie or low-calorie) will be modeled as a fixed and repeated effect. The intercept will be modeled as a random and fixed effect. Model 3 will be a main effects model with (level 2) task and (level 2) approach food craving; approach food craving will be modeled as a random effect. Model 4 will include the (level 2) task by (level 2) approach food craving interaction, which will be modeled as a random effect (Field & Wright, 2011). Model 5 will represent the full model, including task, approach food craving, task by approach food craving, and all covariates (i.e., avoidance food craving, age, sex, BMI, intermittent fasting, and hunger). If Hypothesis 1a is supported, individuals high in approach food craving will show faster RT when going on high-calorie foods, compared to individuals low in approach food craving.

For hypothesis 2a, models will be specified and compared in the same order: (1) baseline, intercept-only model; (2) level 1 main effect model (task: high-calorie or low-calorie); (3) level 2 main effects model (task and avoidance food craving); (4) task, avoidance food craving, and (level 2) task by (level 2) avoidance food craving interaction (Field & Wright, 2011); and (5) full model with covariates added (i.e., task, avoidance food craving, task by avoidance food craving, and all covariates). Covariates will include approach food craving, age, sex, BMI, intermittent
fasting, and hunger. If Hypothesis 2a is supported, individuals high in avoidance food craving will show slower RT when going on high-calorie foods, compared to individuals low in avoidance food craving.

To test joystick hypotheses (Hypothesis 1b and 2b), RT and force data will be analyzed via four analogous multivariate multilevel models in SPSS (Hoffman & Rovine, 2007). Multivariate MLM represents the most appropriate analysis for joystick data since data from both push and pull behavior can be modeled as simultaneous dependent variables (Aguinis et al., 2013; Hoffman & Rovine, 2007), rather than in separate univariate analyses. Similar to go/no-go data, trials will be treated as nested within participants. Multivariate models also allow for comparisons of the magnitude of predictor effects (i.e., approach or avoidance food craving) across outcomes (i.e., RT on push, RT on pull, force on push, force on pull) when outcomes are on the same metric (Hoffman & Rovine, 2007).

Across joystick analyses, the first dependent variable (DV1) and second dependent variable (DV2) will be dummy coded. For RT joystick data, DV1 will be coded as push RT (1 = push RT, 0 = pull RT) and DV2 will be coded as pull RT (1 = pull RT, 0 = push RT). For force joystick data, DV1 will be coded as push force (1 = push force, 0 = pull force) and DV2 will be coded as pull force (1 = pull force, 0 = push force). Dummy coding will provide separate parameter estimates for the effects of independent variables (i.e., approach and avoidance food craving) for each outcome (i.e., pull RT, push RT, pull force, push force).

To test hypothesis 1b, models (RT and force) will be specified and compared in the same order as Go/No-Go models. Model 1 will represent the baseline, intercept-only model. Model 2 will represent a main effects model where (level 1) task (high-calorie or low-calorie) will be modeled as a fixed and repeated effect while the intercept will be modeled as a random and fixed
effect. Model 3 will be a main effects model with (level 2) task and (level 2) approach food craving; again, approach food craving will be modeled as a random effect. Model 4 will add the (level 2) task by (level 2) approach food craving interaction, which will be modeled as a random effect. Lastly, model 5 will represent the full model, including task, approach food craving, task by approach food craving, and all covariates (i.e., avoidance food craving, age, sex, BMI, intermittent fasting, and hunger). If Hypothesis 1b is supported, individuals high in approach food craving will show faster RT and greater force when pulling high-calorie foods via the joystick, compared to individuals low in approach food craving.

To test hypothesis 2b, models (RT and force) will be specified and compared in the same order: (1) intercept-only model; (2) level 1 main effect model (task: high-calorie or low-calorie); (3) level 2 main effects model (task and avoidance food craving); (4) task, avoidance food craving, and level 2 task by level 2 avoidance food craving interaction model; and (5) full model with the addition of all covariates (i.e., approach food craving, age, sex, BMI, intermittent fasting, and hunger). Again, task (high-calorie or low-calorie) will be modeled as a fixed and repeated effect while the intercept will be modeled as a random and fixed effect. Avoidance food craving will be modeled as a random effect. The task by avoidance food craving interaction will be modeled as a random effect. If Hypothesis 2b is supported, individuals high in avoidance food craving will show shorter RT and greater force when pushing toward high-calorie foods via the joystick, compared to individuals low in approach food craving.

To test associations between behavioral measures of approach and avoidance food craving and disordered eating behaviors (Hypotheses 1c, 2c, 3, 4, and 5), associations between restrained eating, uncontrolled eating, and self-reported ED symptoms and approach and
avoidance food craving will be examined via semi-partial correlations, controlling for age, sex, BMI, intermittent fasting, and hunger.
Logitech Attack 3
Debriefing Script

The experiment is over now, but before you go, I’d like to talk to you a little bit. At the beginning of the session, I told you what the study was about, but I didn’t tell you anything about what our hypotheses were, or what we were expecting to find. I was wondering if you had any ideas about what we were expecting to find?

Pause, and let people give their ideas. If participant says anything at this point, be encouraging and enthusiastic about hearing his/her thoughts. Ask questions such as “what made you think that?” If participant has no thoughts to contribute here, say: That’s fine, and continue onto the next part.

Sometimes when people participate in psychology experiments, they feel a little suspicious because they think that there might be a hidden purpose to the experiment. Did you have any feelings of suspicion about anything that happened during this session? Was there ever a time when you suspected that I was lying to you about anything?

Pause after each question to give participant a chance to respond. If participant says anything other than a firm “no” to any of these questions, ask open-ended questions in an effort to determine precisely which aspects of the experiment he/she was suspicious about. Try to get them to elaborate. Try not to reveal what was actually going on during the experiment until you’ve fully assessed the participant’s level of suspicion. If participant does voice a suspicion:

Could you tell me a little bit about that? Like, what specifically made you feel that way?
Were you certain [about whatever suspicion they just revealed], or were you just suspicious?
Do you think that having that suspicion might have influenced any of your responses during the session? It’s okay if it did, but it’s important for me to know about it.
When you’re finished discussing any suspicions that the participant had:

Okay, then, I can explain what the study is about. Your consent form states that the purpose of this study was to collect data to examine your attention during dual computer tasks, but this does not describe the entire study. In fact, we really are interested in how food craving impacts responses on different food-based computer tasks, as well as how your responses on those tasks may influence your participation in certain eating behaviors.

Discuss participants’ reactions to the test with him/her

At this point, I should stop and let you ask any questions you have. Is everything clear so far?

Answer any questions

Please understand that although we try to avoid using deception if possible, we needed to use deception in this experiment to really study the processes we’re
interested in. If people know beforehand what we’re really studying, it might influence their behavior.

Also, I want to ask you to please not discuss this study with anyone else you know who might participate. It is very important that people who participate in this study do not know beforehand what it is about. Okay?

Finally, sometimes participating in a study can trigger an emotional response. We’re going to give you a copy of the informed consent and some resources you can access should you feel upset or be concerned about feelings this study may have triggered.

If you would like any of your data withdrawn for any reason, please let me know now. Data includes our measurements of food craving, your responses on each computer activity, and your responses to questionnaires. Once you leave, your data will only be known by a number, it will be included in a large pool of data, and there will be no way to identify yours from other participants.

Pause for response and answer any questions. Give participant a copy of informed consent and mental health resources sheet.

We hope that you enjoyed participating in this study and if you have any more questions feel free to ask me! We sincerely appreciate the time you took to participate.