Unhealthy Eating as a Mediator of the Relationship Between Stress and Anxiety: 
A Longitudinal Study of College Students Moderated by Depression

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ABSTRACT

Unhealthy Eating as a Mediator of the Relationship Between Stress and Anxiety: A Longitudinal Study of College Students Moderated by Depression

A thesis presented to the Department of Psychology

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Stress has been shown to be a risk factor for anxiety especially among college-aged individuals. Anxiety disorders are the most prevalent psychiatric problem among college students. This study looked at the relationship between stress, unhealthy eating and anxiety, moderated by depression. Further, we hoped to determine whether this relationship differed between the two types of anxiety: anxious arousal and anxious apprehension. We hypothesized that (1) both subtypes of anxiety would increase as stress increases; (2) unhealthy eating would mediate the relationship between stress and both subtypes of anxiety; and (3) depression would moderate the relationship between unhealthy eating and both subtypes of anxiety.

Methods: We used self-report questionnaires that asked participants (ages 18-23, N=103) to rate the frequency of stress, unhealthy eating, anxiety and depression longitudinally across the span of a semester. Total effect, mediation and moderated mediation models were tested in Mplus with separate models predicting anxious arousal and anxious apprehension.
Results: When controlling for baseline anxiety, unhealthy eating did not mediate the relationship between stress and end of semester anxiety. However, unhealthy eating did predict an increase in anxious arousal over time.

Discussion: These results highlight the possible role of unhealthy eating as a risk factor for anxious arousal based on the evidence that unhealthy eating predicted longitudinal increases in anxious arousal but not anxious apprehension.
Unhealthy Eating as a Mediator of the Relationship Between Stress and Anxiety: A Longitudinal Study of College Students Moderated by Depression

Anxiety has been defined as the subjective feeling of tension, fear, nervousness, and worry associated with stimulation of the nervous system (Aritza et al., 2017; Spielberger, 1983). Anxiety is prevalent and persistent among university students (Aritza et al., 2017; Gregor, 2005). Anxiety disorders are the most prevalent psychiatric problems among college students, with approximately 11.9% of college students suffering from an anxiety disorder (Blanco et al., 2008). Additionally, the vast majority of college students often experience moderate (77.6%) or serious (10.4%) anxiety due to stressors related to their studies (Abouserie, 1994). Stress has been shown to be a risk factor for anxiety, especially among college-aged individuals (American Psychiatric Association, 2013; Brandy et al, 2015). A majority (62%) of students felt overwhelmed (ACHA, 2017) and between 12.8 and 22% of students experienced functional impairment due to this altered mood state (Eisenberg et al, 2007). Despite the prevalence of stress and anxiety among university students, most do not receive specific treatment to reduce their anxiety levels (Aritza et al., 2017; Cranford et. al., 2009). Due to the pervasiveness of clinically significant stress and anxiety among college students, it is important to further our understanding of what behaviors may be intensifying this problem. This study aims to further our understanding of whether unhealthy coping behavior may exacerbate feelings of anxiety. More specifically, we look at whether unhealthy eating increases feelings of anxiety among undergraduate students who are experiencing academic stressors.

Links Between Stress and Unhealthy Eating

In the current literature it is now widely acknowledged that there are connections between eating behavior and stress wherein the relationship is bidirectional: unhealthy eating has been shown to reduce stress in the short term and stress has been shown to cause unhealthy
eating (Finch & Tomiyama, 2015; Jackson et al., 2010). This study aims to investigate whether stress can cause unhealthy eating.

When looking at the research on whether stress can cause unhealthy eating, stress has been found to both affect food choice and eating behavior. A random sample of college students found that students who experienced higher levels of stress reported being less healthy and more likely to engage in poor health habits compared to peers who reported lower levels of stress (Hudd et al., 2000). When looking at the effects of stress on food choice, over 41.7% of the female college students surveyed ate more or much more when experiencing stress, while 72.8% of respondents snacked slightly or much more than when not experiencing stress (Oliver & Wardle, 1999). Similarly, in a cross-sectional study, twenty five percent of Midwestern high school students reported using food and disrupted eating behavior, as defined by skipping meals and eating while distracted by TV, as a coping mechanism when dealing with their problems (Martyn-Nemeth et al., 2009). While these studies suggest that there exists a relationship between stress and unhealthy eating, longitudinal evidence is needed in order to determine whether stress can actually predict increases in unhealthy eating. A longitudinal study spanning three years was able to find support for that predictive relationship (Jackson et al., 2010). When chronically confronted with stressful conditions, adults over the age of twenty-five were found to engage in unhealthy eating behaviors as defined by overeating or increased consumption of ‘comfort foods’ that help to alleviate the physiological symptoms of stress (Jackson et al., 2010). While these studies do support the existence of a connection between eating and stress, it is important to note the varied operationalization of unhealthy eating behavior when determining whether there is a significant causal relationship between stress and unhealthy eating.
Eating behavior and unhealthy eating are very broad concepts that have not been consistently operationalized beyond whether the eating can be categorized as disordered or not (APA, 2013). Unhealthy eating has been defined by measures ranging from ‘watching TV while eating’ all the way to ‘when I am sad I eat more’ (Martyn-Nemeth et. al., 2009; Finch & Tomiyama, 2015). Even within the self-report cross-sectional measures, there have been inconsistencies in the definition of eating behavior and unhealthy eating. BMI, comfort food consumption in a lab setting, and self-report instruments that relied on recalling past behaviors were all used (Jackson et. al., 2010; Finch & Tomiyama, 2015; Martyn-Nemeth et. al., 2009). Because of these discrepancies in methodology, it is still unclear whether students’ stress at the beginning of a semester will significantly affect unhealthy eating as defined by emotional eating later on in the semester. In a cross-sectional study on female middle school students stress, tiredness, boredom, tension and anxiety have all been proven triggers for emotional eating patterns like those displayed when binge eating (Nguyen-Rodriguez, Unger & Spruijt-Metz, 2009). Due to this psychologically complicated nature of emotional eating compared to ‘unhealthy eating’ as defined by different meal times or eating while distracted, emotional eating may be more sensitive to heightened stress levels and thus amplified as a long-term response to stress (Nguyen-Rodriguez, Unger & Spruijt-Metz, 2009). This study builds upon our understanding of the link between stress and unhealthy eating among all college-aged individuals to further our understanding of what the costs of unhealthy eating may be. One such cost that needs to be carefully taken into consideration is anxiety.

**Links Between Unhealthy Eating and Anxiety**

This study hopes to build upon our understanding of the effect of unhealthy eating on community populations’ level of anxiety. In order to have a comprehensive look at the
relationship between stress, unhealthy eating and anxiety in college-aged individuals it is important to understand how these two variables interact in both the short term and the long term. Eating has been shown to act as a coping mechanism in the short term that allows the individual to suppress undesirable feelings while in the long term the eating behavior itself may contribute to and even exacerbate anxiety as well as stress and depression (Polivy & Herman, 1999; Inzlicht, Tullett & Gutsell, 2012; Della Longa & De Young, 2018; Zeidner & Endler, 1996).

**Unhealthy Eating and Anxiety in the Short Term.** Past research has hypothesized that unhealthy eating can reduce anxiety in the short term by acting as an attentional buffer wherein an individual eats emotionally as a way to distract from the real issues at hand. Individuals high in emotional eating, or eating in response to emotional arousal states, can also be labeled as engaging in sub-clinical levels of binge eating or eating larger amounts of food than nutritionally required (Van Strien, Frijters, Bergers & Defares, 1986; Heatherton & Baumeister, 1991). Two of the main theories in the literature that attempt to explain what drives this behavior are the Escape from Self-Awareness Theory of Binge Eating and the Masking Hypothesis. According to the Escape from Self-Awareness Theory of Binge Eating, binge eating is thought to directly reduce anxiety through the act of consuming food (Heatherton & Baumeister, 1991). Similarly, the Masking Hypothesis states that overeating is used to mask distress in other, less controllable, aspects of life by allowing the individual to attribute any emotional upset to the eating behavior alone (Polivy & Herman, 1999). For individuals who tend to eat emotionally, engagement in binge eating provides an escape from the emotional distress of anxiety, as defined by worry about social rejection and negative evaluation, by narrowing their attention to the immediate environment thus shutting out broad thoughts contributing to the anxious state (Heatherton &
However, this operationalization of anxiety as worry does not account for the distinction between the two separable subtypes of anxiety: anxious arousal and anxious apprehension (Heatherton & Baumeister, 1991; Fajkowska, Domaradzka & Wytykowska, 2017; Nitschke et al., 2001). Anxious arousal is described by symptoms of physiological arousal and somatic tension, while anxious apprehension is characterized by worry, typically about future events (Fajkowska, Domaradzka, & Wytykowska, 2017). Despite the proven discrepancy between the two types of anxiety, current literature on eating as a coping mechanism has not made this distinction.

According to the theories outlined above, eating acts as a coping mechanism that allows the individual to avoid dealing with real issues (Inzlicht, Tullett & Gutsell, 2012). In a study where female college students were given ice cream after being told that they had failed the task provided to them by the researchers in the lab, post-experimental anxiety as measured according to a ‘current feelings scale’ was more often attributed to eating the ice cream rather than the failure felt by not being able to complete the task successfully (Polivy & Herman, 1999; Inzlicht, Tullett & Gutsell, 2012). According to these hypotheses, those women were using food to suppress undesirable feelings that they were not even aware they were experiencing in the first place. That said, these hypotheses focused on food and eating unhealthily as a short term immediate reaction and have been formulated based on studies conducted within the confines of a lab setting. These studies have also failed to look at anxious apprehension versus anxious arousal separately. Thus, it is unclear whether these theories will hold up when looking at students’ feelings of anxious arousal and anxious apprehension in response to real-life events longitudinally.
Both of these theories have prompted investigations of how unhealthy eating affects anxiety that examined the short-term immediate reaction to negative life events, but neither the Escape from Self-Awareness Theory nor the Masking Hypothesis has been assessed longitudinally. It is possible that the escape from the negative emotion in the moment will allow an individual to avoid dealing with future anxiety by providing a distraction. That said, current research has found that avoidant behavior, and more specifically eating unhealthily, is a maladaptive behavior that may actually exacerbate the negative emotions being avoided in the first place (Della Longa & De Young, 2018; Zeidner & Endler, 1996). In a cross-sectional study of undergraduate students using online surveys it was found that avoidance was positively related to binge eating (Della Longa & De Young, 2018). Thus eating may be an ineffective coping mechanism in that by ‘escaping’ from awareness and ‘masking’ the distress that first caused the increased consumption of food, emotional eaters are actually just adding to their list of worries. This research suggests that unhealthy eating may actually be a maladaptive behavior in the long term.

**Unhealthy Eating and Anxiety in the Long Term.** While unhealthy eating may have a physiological and behavioral buffering effect when dealing with stressors in the short term, it can actually contribute to and exacerbate stress, anxiety and depression in the long term. In the long term, the eating behavior itself can become a major contributor to the negative emotions that gave rise to the behavior in the first place (Inzlicht, Tullett & Gutsell, 2012). In a cross-sectional study on the effect of negative stereotyping and it’s spillover into other domains in college-aged women, it was found that overeating led to increased anxiety and depression, as measured by a Positive Affect Negative Affect self-report questionnaire that looked at anxiety as a single construct (Inzlicht, Tullett & Gutsell, 2012). The heightened risk for long-term anxiety and
depression was partially due to unhealthy eating leading to weight gain. Even small amounts of weight gain have been shown to increase perceptions of negative stigma and greater body dissatisfaction, which are both proven risk factors for increased anxiety and depression as measured by comprehensive self-report surveys that combined anxious arousal and anxious apprehension into a singular measure of anxiety (Hayward, Vartanian & Pinkus, 2018; Magallares et al., 2017). According to the Escape from Self-Awareness theory and the Masking Hypothesis, in the long term an individual who is inclined towards self-soothing with food would continually turn towards food to deal with the anxiety (again not distinguishing between anxious arousal and anxious apprehension,) and depression from the weight gain (Heatherton & Baumeister, 1991; Inzlicht, Tullett & Gutsell, 2012). This individual would see weight gain as uncontrollable and thus would keep turning to food for comfort (Polivy & Herman, 1999).

However, by not differentiating between anxious arousal and anxious apprehension, these studies fail to account for whether the emotional reaction to unhealthy eating behavior was due to physiological arousal or increased worry or both (Hayward, Vartanian & Pinkus, 2018; Magallares et al., 2017; Inzlicht, Tullett & Gutsell, 2012). Due to the longitudinal nature of the current study, and the conflicting evidence as to whether unhealthy eating is an effective coping mechanism, it is important to make this distinction because of the possible long-term effects of unhealthy eating psychologically and physiologically as well. Additionally, the majority of studies on this subject have focused on dieters and clinically diagnosed binge-eaters, thus we must be careful when leveraging these findings for the general population (Nguyen-Rodriguez, Unger & Spruijt-Metz, 2009). Past literature has failed to determine whether these theories hold true when looking at the longitudinal relationship between eating and anxiety for all college-aged individuals and across the different subtypes of anxiety. It is hypothesized that while unhealthy
eating may reduce both types of anxiety in the moment, it will increase both types of anxiety in the long term.

The majority of studies conducted on the long term relationship between unhealthy eating and anxiety have been unable to determine the direction of the relationship and have failed to distinguish between the types of anxiety (Hou et al., 2013; Lai et. al., 2013; Polivy & Herman, 1999). In past studies, anxiety has been operationalized with self-report questionnaires that combine panic, generalized anxiety, separation anxiety, social phobia and school phobia into one measure (Hou et al., 2013; Hayward, Vartanian & Pinkus, 2018; Magallares et al., 2017; Heatherton & Baumeister, 1991). This study hopes to expand upon the existing research by looking at whether a similar relationship exists when examining unhealthy eating and the separate subtypes of anxiety longitudinally. Mixed evidence on the relationship between unhealthy eating and anxiety suggests that whether unhealthy eating leads to anxious arousal and/or anxious apprehension may depend on moderating individual differences between participants. One potential moderator with a proven link to unhealthy eating is depression (Nguyen-Rodriguez, Unger & Spruijt-Metz, 2009).

**Possible Moderating Role of Depression.** As with anxiety, the most likely age group for major depression is 15 to 24 years old (Blazer et al, 1994; Kessler et al., 2012; Rohde et al., 2013). Fifty-three percent of college students label themselves as depressed (Furr et al, 2001) and 13.8% meet clinical levels of depression (Eisenberg et al, 2007). Greater levels of depression have also been shown to be associated with higher levels of college stress (Dyson & Renk, 2006). While most research has investigated whether unhealthy eating is directly associated with depression, there is also evidence that depression may moderate the link between unhealthy
eating and anxiety (Cartwright et al., 2003; Falkner et al., 2001; Murakami & Sasaki, 2010; Sjöberg et al., 2005; Wadsworth & Compas, 2002).

Women with a tendency towards feeling depressed who also exhibited increased comfort eating behaviors were found to experience increased anxiety in a longitudinal study of racially diverse women between the ages of 18 and 19 years old (Finch et. al., 2015). Conversely, individuals without elevated depressive symptoms experienced a protective effect of comfort eating in that eating the comfort foods described above actually decreased anxiety in the short term (Finch et. al., 2015). In other words, comfort eating buffered feelings of anxiety only in individuals without elevated levels of depression symptoms. A possible explanation for these findings is that women who emotionally eat have been shown to have changes in appetite where higher levels of depressive symptoms have been associated with greater comfort eating and a greater tendency to “self-medicate” by eating sugary foods in order to feel better (Konttinen, Mannisto, Sarlio-Lahteenkorva, Silventoinen & Haukkala, 2010; Schuman, Gitlin & Fairbanks, 1987). Yet simultaneously, higher levels of depressive symptoms are also associated with anhedonia, which can diminish the stress-buffering effects of comfort eating (Sloan, Strauss & Wisner, 2001). It has also been found that the presence of a depressive mood dampens the pleasantness related to food consumption. The combination of these two effects suggest that comfort eating may not be an effective coping response in individuals exhibiting higher levels of depressive symptoms thus causing these individuals to experience the negative consequences of eating unhealthily more acutely compared to non-depressed individuals (Finch et. al., 2015; Willner & Healy, 1994).

Based on this research, it seems depressed mood may play a moderating role in the relationship between unhealthy eating and anxiety. The present study aims to determine whether
the relationship between unhealthy eating behavior and each subtype of anxiety will be moderated by depression such that unhealthy eating will increase both subtypes of anxiety when individuals exhibit high levels of depression and will decrease both subtypes of anxiety when individuals exhibit low levels of depression.

**Current Study**

In sum, anxiety disorders are the most prevalent psychiatric problem among college students. One of the major risk factors for anxiety, especially among college-aged individuals, is stress. It has been proven that stress is also linked to increased engagement in unhealthy eating behaviors wherein that individuals who are experiencing heightened stress and more likely to engage in this unhealthy behavior. This unhealthy eating can reduce anxiety in the short term by acting as an attentional buffer and/or mood enhancer but may actually increase anxiety in the long term. In doing so, the unhealthy eating can actually contribute to and exacerbate stress, anxiety and depression. Yet, it is unclear as to whether depression moderates the relationship between unhealthy eating and anxiety. There is some evidence to support the claim that depressed individuals will experience increased long-term anxiety from eating unhealthily while non-depressed individuals will experience decreased long-term anxiety levels due to eating behavior. Thus, in this study we investigate whether the relationship between stress and anxiety is partially mediated by unhealthy eating, where the relationship between unhealthy eating and anxiety is moderated by depression. Further, we investigate whether this relationship differs between the two types of anxiety: anxious arousal and anxious apprehension.

We hypothesized that (1) both subtypes of anxiety increase as stress increases; (2) unhealthy eating mediates the relationship between stress and both subtypes of anxiety; (3) depression moderates the relationship between unhealthy eating and both subtypes of anxiety,
such that individuals with high levels of depression who engage in unhealthy eating will experience increased anxious apprehension and anxious arousal whereas individuals who exhibit low levels of depression will not exhibit changes in either type of anxiety.

Methods

Participants

Participants in this study were 103 undergraduate students enrolled at Brandeis University, ages 18-23. The mean age was 19 years old ($SD = 1.090$). Participants identified as 68.5% female, 25.0% male and 6.5% other; 94.4% of participants identified as non-Hispanic or Latino, with 60.2% White, 32% Asian, 6.8% African American, and 1% other. This age range was selected to capture the key emerging adulthood developmental period for psychopathology risk. Participants were excluded if they were not fluent speakers of English, as the tasks and questionnaires require English proficiency to be valid measures. There were no other exclusion criteria.

Participants were recruited via flyers around campus. These flyers indicated that the study would take about 2.5 hours with the potential to receive up to $80 --- $25 for the baseline visit, $5 for each weekly questionnaire ($20 if they complete all 4), and $15 for completing the final interview and questionnaires. If participants completed all parts of the study, they received a bonus payment of $20.

Each participant was given an informed consent form. Students could withdraw from the study at any time without penalty. All students read and signed the form and participated to the extent they felt comfortable.

The following precautions were taken to maintain confidentiality: The questionnaires were administered in the CoPE Lab at Brandeis University. All tasks took place in private testing
rooms with white noise machines to prevent accidental overhearing of interview responses. Non-identifying participant numbers were used for all data and all data was stored securely. Only the PI and faculty supervisors had access to the database that links participants’ identifying information to participant identification numbers. All study processes were reviewed and approved by the Brandeis University Institutional Review Board.

**Procedure**

This study was part of a larger longitudinal study investigating cognitive risk of anxiety and depression across three time periods: the beginning of the semester (T1), the four weeks leading up to finals (T2) and the two weeks after finals (T3). The study described here employed a short-term longitudinal design to enable prediction of change over time.

Participants were first provided informed consent forms at T1. They then completed the baseline questionnaires through the secure Qualtrics system on a research lab computer in a private room. Qualtrics generated a unique access code for each participant. This was the only identifier for the questionnaires to maintain confidentiality. The questionnaires took about 30-45 minutes to complete. For the completion of the questionnaires at T2 and T3, participants were provided a link to the secure Qualtrics system. This allowed remote access to the questionnaires. Again, a unique access code was the only identifier on the survey.

**Measures**

**Health and Demographic Questionnaire**: Basic participant demographic and health information.

**The Adolescent/Adult Life Events Questionnaire Revised (ALEQ-R, Hankin & Abramson, 2002)**: The frequency of stress was quantified using the Adolescent/Adult Life Events Questionnaire (ALEQ). The ALEQ self-report instrument assessed a wide range of
negative life events, including school/achievement problems, friendship and romantic
difficulties, and family problems (e.g., “Got a bad grade on a test or assignment”). This
assessment asked about how frequently an event happened within the past 3 months from (1)
ever to (4) always, how stressful it was, and how controllable it felt. The original ALEQ was
revised for the current study to include a broader coverage of stressors, expanding from 37 to 65
items. This study included self-ratings for all 65 items at baseline stress levels meaning that we
only used data collected at T1. Good levels of reliability and validity of the ALEQ has been
demonstrated (Hankin & Abramson, 2002).

The Mood and Anxiety Symptoms Questionnaire (MASQ, Watson & Weber et. al.,
1995) included a 17 item scale evaluating symptoms of anxious arousal (e.g., “Startled easily”,
“Was trembling or shaking.”) Participants rated each item on how much they have felt or
experienced it during the past week, from 1 ("not at all") to 5 ("extremely"). Good levels of
reliability, internal consistency and validity of the MASQ has been demonstrated (Hankin,
2008). The MASQ had good internal consistency in the current study (α=.86; α=.89).

The Penn State Worry Questionnaire (PSWQ, Meyer, Miller, Metzger, & Borkovec,
1990) is a 14- item questionnaire that assessed the degree to which an individual worries. For
each item, participants were presented with a statement and asked to indicate how true that
statement was for them using a 1-4 scale, with 1= never true, 2= sometimes true, 3= most times
true, 4= always true. Scores at T3 versus T1 were compared to determine the magnitude of
change in anxiety over the course of the semester. The PSWQ has been shown to have high
internal consistency (e.g. α=0.93) and favorable validity. (Brown, Antony & Barlow, 1992;
Meyer, Miller, Metzger & Borkovec, 1990). The PSWQ had good internal consistency in the
current study (α.=.93; α.=.91).
Dutch Eating Behavior Questionnaire (DEBQ, Barrada, Strien, & Cebolla, 2016): Unhealthy Eating was quantified using the Dutch Eating Behavior Questionnaire. The DEBQ measured eating patterns by way of three subscales: restrained eating, emotional eating, and external eating. This study focused on the 13-item emotional eating subscale (i.e. "Do you have the desire to eat when you are irritated). UE was measured at T1 and T2. This subscale has been shown to have high internal consistency, high validity for food consumption and high convergent and discriminative validity (van Strein, Frijters, Van Staveren, Defares & Deurenberg, 1986). In this study, the DEBQ emotional eating subscale had good internal consistency with Cronbach’s Alpha equal .95 at T1 and .92 at T2.

PROMIS Emotional Distress-Depression-Short Form (APA DSM-V research measures): To measure depression, we used the PROMIS Emotional Distress-Depression-Short Form. This form is an 8 item measure of depression symptoms in the last week (e.g., “I felt sad.”), rated in a scale from (1) never to (5) always. This measure did not have an item measuring appetite and eating behaviors, thus ensuring that the depression measure was not contaminated with unhealthy eating related content. This PROMIS short form has been shown to be a reliable and precise measure of generic symptoms of depression with high internal consistency and construct validity (Cella et al., 2010). For this study, data from the PROMIS Emotional Distress-Depression-Short Form was collected at T2 and had good internal consistency (α=.94).

Data Analysis

Mediation models were tested in Mplus, with separate models predicting anxious arousal and anxious apprehension using the Full Information Maximum Likelihood (FIML) estimation procedure. All paths included age and gender. Gender was coded where “1” indicated male, “2”
indicated female and ‘other’ was treated as missing data since it could encompass a wide range of gender identities and the number of participants in this group was too small to test for effects.

Depicted in Figure 1 as c is the total effect model which measured the relationship between stress and anxiety not taking unhealthy eating into account: \( \text{Anxious Apprehension}_{T3} = b_{\text{Anxious Apprehension}_{T1}} + b_{\text{Stress}_{T1}} + e; \) \( \text{Anxious Arousal}_{T3} = b_{\text{Anxious Arousal}_{T1}} + b_{\text{Stress}_{T1}} + e. \)

The second model tested path A of the moderated mediation without the moderator:

\( \text{Unhealthy Eating}_{T2} = b_{1}\text{Unhealthy Eating}_{T1} + e. \)

I then built upon this model to test path A of the moderated mediation with the moderator included: \( \text{Unhealthy Eating}_{T2} = b_{1}\text{Unhealthy Eating}_{T1} + b_{\text{Stress}_{T1}} + e. \)

The complete models were:

\( \text{Anxious Apprehension}_{T3} = b_{\text{Anxious Apprehension}_{T1}} + b_{\text{Stress}_{T1}} + b_{\text{Unhealthy Eating}_{T2}}*\text{Depression}_{T2} + b_{\text{Unhealthy Eating}_{T2}}*\text{Depression}_{T2} + e; \)

\( \text{Anxious Arousal}_{T3} = b_{\text{Anxious Arousal}_{T1}} + b_{\text{Stress}_{T1}} + b_{\text{Unhealthy Eating}_{T2}}*\text{Depression}_{T2} + b_{\text{Unhealthy Eating}_{T2}}*\text{Depression}_{T2} + e. \)

It should be noted that both unhealthy eating and depression were mean centered prior to running the above models.

The statistical model for the above models is portrayed in Figure 1. This is the visual representation of each of our four hypotheses: (1) Stress at T1 was expected to have a relationship with each type of anxiety at T3 (path c) while controlling for T1 anxiety; (2) T1 stress was expected to predict T2 unhealthy eating (path a) while controlling for T1 unhealthy eating; (3) T2 unhealthy eating was expected to predict T3 anxiety (path b) while controlling for T1 anxiety; (4) The relationship between stress and each type of anxiety was expected to be
mediated by unhealthy eating such that stress at T1 would predict increased unhealthy eating at T2 (path a) and increased unhealthy eating at T2 would predict increased anxiety at T3 (path b); and (5) The relationship between unhealthy eating and each type of anxiety would be moderated by depression such that increased depression at T2 would significantly increase the positive relationship between unhealthy eating and anxiety.

Results

Tables 1 shows bivariate correlations and descriptive statistics. As predicted, T1 and T3 anxious arousal were significantly correlated ($r(103)=.49, p<.001$), as were T1 and T3 anxious apprehension ($r(103)=.71, p<.001$) and T1 and T3 unhealthy eating ($r(99)=.69, p<.001$). Mean levels of these variables did not significantly differ between T1 and T3 based on paired sample t-tests thus showing mean level stability (MASQ: $t(102)=-0.15, p=.879$; PSWQ: $t(102)=1.07, p=.287$; DEBQ: $t(98)=1.20, p=.234$).

As expected, T1 unhealthy eating was significantly correlated with all the other measures: T1 anxious arousal, T3 anxious arousal, T1 anxious apprehension, T3 anxious apprehension and T1 stress. T2 unhealthy eating was significantly correlated with all measures except T1 anxious arousal (Table 1). Similarly, stress was significantly correlated with all measures except T3 anxious arousal (Table 1). All other measures, with the exception of T1 anxious apprehension and T3 anxious arousal (Table 1) were significantly correlated.

Next we ran path model analyses using the Mplus software to analyze the standardized regression coefficients of each independent variable on its corresponding dependent variables controlling for age and gender. Tables 2 and 3 show the results of these analyses.

Total Effect of Stress on Anxiety
T1 anxious arousal predicted T3 anxious arousal ($\beta=0.49$, $z=5.98$, $p<.001$; Figure 1).

Controlling for T1 anxious arousal, T1 stress did not predict T3 anxious arousal ($\beta=-.05$, $z=-0.48$, $p=.633$; Figure 1). Similarly, T1 anxious apprehension predicted T3 anxious apprehension ($\beta=0.65$, $z=9.25$, $p<.001$; Figure 1). Controlling for T1 anxious apprehension, T1 stress did not predict T3 anxious apprehension ($\beta=0.08$, $z=0.90$, $p=.367$; Figure 1).

**Stress as a Predictor of Unhealthy Eating**

Controlling for T1 unhealthy eating, T1 stress was expected to predict T2 unhealthy eating (path a). There was a significant relationship between T1 unhealthy eating and T3 unhealthy eating ($\beta=0.68$, $z=11.43$, $p<.001$; Figure 2) as well as between T1 unhealthy eating and T1 stress ($\beta=0.30$, $z=3.34$, $p<.001$; Figure 2). Contrary to our prediction, T1 stress and T2 unhealthy eating were not significantly related when controlling for T1 unhealthy eating ($\beta=0.02$, $z=0.33$, $p=.758$; Figure 2). Therefore, the hypothesis that T1 stress would predict T2 unhealthy eating when controlling for T1 unhealthy eating is not supported.

**Unhealthy Eating as a Predictor of Anxiety**

T2 unhealthy eating was expected to predict T3 anxiety (path b) while controlling for T1 anxiety. We ran two separate path model analyses for anxious arousal and anxious apprehension.

As expected, T1 anxious arousal significantly predicted T3 anxious arousal ($\beta=0.47$, $z=5.84$, $p<.001$; Figure 3) and T1 anxious apprehension significantly predicted T3 anxious apprehension ($\beta=0.64$, $z=8.69$, $p<.001$; Figure 3). Also consistent with our hypothesis, T2 unhealthy eating was significantly related to T3 anxious arousal ($\beta=0.18$, $z=2.07$, $p=.038$; Figure 3) when controlling for T1 anxious arousal. Therefore, the hypothesis that T2 unhealthy eating predicts T3 anxious arousal was supported. However, T2 unhealthy eating was not significantly related to T3 anxious apprehension ($\beta=0.06$, $z=0.84$, $p=.403$; Figure 3) when controlling for T1
anxious apprehension meaning that this hypothesis is not supported for anxious apprehension. In sum, T2 unhealthy eating predicted T3 anxious arousal but not T3 anxious apprehension when controlling for baseline anxiety.

**Relationship between Stress and Anxiety Mediated by Unhealthy Eating**

It was hypothesized that the relationship between stress and each type of anxiety would be mediated by unhealthy eating such that stress at T1 would predict increased unhealthy eating at T2 (Figure 4 path a) and increased unhealthy eating at T2 would predict increased anxiety at T3 (Figure 4 path b). Path model analyses were used to test this mediation model. As predicted, there existed a significant relationship between T2 unhealthy eating and T3 anxious arousal ($\beta=0.18$, $z=2.07$, $p=.038$; Figure 4). Contrary to our prediction, when controlling for T1 unhealthy eating and T1 anxious arousal, there were no other significant relationships in the mediation model. Also contrary to prediction there were no significant relationships in the mediation model for anxious apprehension, again controlling for T1 unhealthy eating and T1 anxious apprehension. The indirect effect of the anxious arousal path analysis ($\beta=0.00$, $z=0.31$, $p=.759$) and the anxious apprehension indirect effect ($\beta=0.00$, $z=0.29$, $p=.772$) were not significant. This lack of significance suggests that the hypothesized mediation model was not supported by our data.

**Moderated Mediation of the Relationship Between Stress and Anxiety**

To determine whether the relationship between unhealthy eating and each type of anxiety would be moderated by depression, we looked at each type of anxiety individually by testing separate mediation models: MASQ Anxious Arousal and PSWQ Anxious Apprehension. Standardized path coefficients and significance levels for key pathways are shown in Figure 5 and full model figures and tables are reported in Tables 2 and 3.
The moderated mediation models tested the effects of anxious arousal and anxious apprehension. Fig 5 shows the effects of anxious arousal with T2 unhealthy eating as a mediator and T2 depression as a moderator, while controlling for age, gender, T1 ALEQ stress, T1 MASQ anxious arousal, and T1 DEBQ unhealthy eating (Fig 5, Table 2). Fig 5 also shows the effects of T3 anxious apprehension with T2 unhealthy eating as a mediator and T2 depression as a moderator, while controlling for age, gender, T1 ALEQ stress, T1 PSWQ anxious apprehension, and T1 DEBQ unhealthy eating. In both models, as predicted, all variables were significantly related at baseline (Fig 5, Table 3), T1 and T3 unhealthy eating were related ($\beta=0.67, z=11.02; p<.001$), T1 and T3 anxious arousal were related ($\beta=0.41, z=4.33, p<.001$) and T1 and T3 anxious apprehension were related ($\beta=0.49, z=8.22, p<.001$). There was also a significant relationship between T2 depression and T3 anxious arousal ($\beta=0.26, z=2.52, p=.012$) and between T2 depression and T3 anxious apprehension ($\beta=0.29, z=2.40, p=.016$). Contrary to our prediction, there was no significant relationship between T1 stress and T2 unhealthy eating, T2 unhealthy eating and T3 anxious arousal, T2 unhealthy eating and T3 anxious apprehension, T1 stress and T3 anxiety nor between either type of anxiety and the interaction between unhealthy eating and depression (MASQ: $\beta=0.01, z=1.05, p=.295$; PSWQ: $\beta=-0.00, z=-0.48, p=.633$) when the model was moderated by depression. The indirect effect of the anxious arousal path analysis ($\beta=.00, z=0.30, p=.764$) and the anxious apprehension indirect effect ($\beta=.00, z=0.22, p=.823$) were not significant. Therefore, we were unable to support the claim that the relationship between unhealthy eating and each type of anxiety would be moderated by depression.

**Exploratory Analyses**

Due to the stability of unhealthy eating and anxiety across time-points, exploratory analyses were conducted to determine whether the predicted mediation model where T2
unhealthy eating would mediate the relationship between T1 stress and T3 anxiety when not controlling for baseline. Two separated models were run: one for MASQ anxious arousal and one for PSWQ anxious apprehension. A significant relationship was found between T1 stress and T2 unhealthy eating ($\beta=0.14$, $z=2.55$, $p=.011$) in both models. T2 unhealthy eating and T3 anxious arousal ($\beta=0.18$, $z=1.97$, $p=.048$) as well as T2 unhealthy eating and T3 anxious apprehension ($\beta=0.20$, $z=2.04$, $p=.042$) were also significantly related. The bootstrapped 95% confidence intervals of the anxious arousal indirect effect (-0.03, 0.17) and the anxious apprehension indirect effect (-0.01, 0.08) approached but did not reach significance. Thus, although all paths were significant, unhealthy eating did not significantly mediate the relationship between stress and anxiety when not controlling for baseline.

**Discussion**

Current clinical research suggests that there is a link between stress and unhealthy eating as well as between unhealthy eating and anxiety. (Martyn-Nemeth et. al., 2009; Nguyen-Rodriguez, Unger & Spruijt-Metz, 2009). Also, due to the relationship between stress, unhealthy eating, anxiety and depression we looked at whether depression moderates the relationship between stress, unhealthy eating and anxiety (Dyson & Renk, 2006; Finch et. al., 2015). We hypothesized that the relationship between stress and anxiety would be partially mediated by unhealthy eating where the relationship between unhealthy eating and anxiety would be moderated by depression such that individuals with high levels of depression who engage in unhealthy eating will experience increased anxious apprehension and anxious arousal whereas individuals who exhibit low levels of depression will exhibit decreases in both types of anxiety. This study evaluated these hypotheses assessing participants’ self-report responses to our questionnaires at various time points throughout the semester.
Our results were unable to confirm these hypotheses in longitudinal models controlling for baseline levels of anxiety and unhealthy eating. The stability of both anxiety measures across the span of the semester makes it hard to show any evidence of effective mechanisms for change, such as unhealthy eating. However, when we did not control for baseline levels of unhealthy eating and each type of anxiety, there was a significant relationship between stress and higher levels of unhealthy eating as well as between unhealthy eating and higher levels of anxiety. This suggests that the stability of anxiety and unhealthy eating across the semester overpowered the hypothesized mechanisms for change. Even so, unhealthy eating did not significantly mediate the relationship between stress and anxious arousal or the relationship between stress and anxious apprehension. However, unhealthy eating did prospectively predicted increases in anxious arousal (but not anxious apprehension) both directly and in the mediation model.

This study’s finding that unhealthy eating prospectively predicted increases in anxious arousal but not increases in anxious apprehension is important given that previous literature has not made the distinction between the two types of anxiety. Anxious arousal, described by symptoms of physiological arousal and somatic tension, and anxious apprehension, characterized by worry, have been treated as a singular response to the behavior categorized under the umbrella of anxiety (Fajkowska, Domaradzka, & Wytykowska, 2017). Past literature has found that the types of foods consumed when engaging in emotional eating can be significantly correlated with and contribute to overall anxiety symptoms (Hou et al., 2013; Lai et. al., 2013). Individuals who engage in emotional or unhealthy eating behaviors have been shown to report heightened anxiety, as measured with a multiple affect scale, compared to those who maintained normal eating patterns (Polivy & Herman, 1999). The current study suggests these associations may have been driven specifically by anxious arousal.
While the reasons that unhealthy eating specifically predicts increases in anxious arousal and not anxious apprehension are speculative, one possibility is that consuming unhealthy foods has physiological effects that specifically lead to anxious arousal. Evidence suggests that some specific nutrients such as omega-3 fatty acids, folic acid, vitamin D3, selenium and calcium actually decrease anxiety and depression levels (Mischoulon & Freedman, 2013; Milaneschi et al., 2015; Mlyniec et al., 2014; Rucklidge & Kaplan, 2013). Unfortunately, none of these nutrients are found in the fried, processed and refined foods characteristic of an unhealthy eating profile (Roca et al. 2016). It is possible that the predicted increase in anxious arousal but not anxious apprehension is due to the nutritional makeup of the unhealthy food consumed when an individual eats emotionally. Future research should continue to differentiate between the types of anxiety to begin to look at how the nutritional makeup of healthy versus unhealthy food affects the relationship between unhealthy eating behavior and the different subtypes of anxiety.

While this study found evidence that unhealthy eating predicted longitudinal increases only in anxious arousal, and not anxious apprehension, unhealthy eating was positively associated with both forms of anxiety cross-sectionally. Based on our findings, it seems plausible that rather than being a mechanism for change as hypothesized, unhealthy eating could be one of the sources maintaining an individual’s levels of anxious apprehension. Unhealthy eating may perpetuate the cycle of anxious apprehension for people who are more susceptible to worry. Eating behavior itself has been found to be a possible contributor to the negative emotions that gave rise to it in the first place (Inzlicht, Tullett & Gutsell, 2012). This suggests that for someone who eats in order to deal with anxiety, the food that is intended as a way to diminish feeling of anxiety will instead perpetuate those anxious thoughts thus maintaining a cycle of worry. A study of undergraduate students looked at the factors that maintain high levels of social
appearance anxiety, or the fear of having one’s appearance negatively evaluated by others, and found that repetitive negative thinking about one’s appearance maintained, rather than changed, levels of internalizing symptoms such as anxiety (Reilly et al., 2018). This finding suggests that someone who is stuck in a cycle of negative self-talk related to eating behavior and body image may actually be maintaining the internalizing symptoms of anxiety when engaging in unhealthy eating behavior rather than changing them. The steadiness of anxious apprehension in an individual, especially as it relates to eating behavior, suggests that unhealthy eating may be a mechanism for stability rather than a mechanism for change.

Contrary to some theories, for neither anxious arousal nor anxious apprehension was unhealthy eating associated with lower levels of anxiety either longitudinally or cross-sectionally (symptoms in the past week). Past theories on why unhealthy eating may help reduce anxiety in the short term, such as the Escape from Self-Awareness Theory of Binge Eating and the Masking Hypothesis, were not supported over a longer period of time (Heatherton & Baumeister, 1991; Polivy & Herman, 1999). One possible reason for why we were unable to find support for these hypotheses is that past research has only proven them as effective coping mechanisms in the moment of distress rather than over a few weeks timeline, such as we assessed in this study. This study was able to look at mid-semester eating behaviors and whether these behaviors had any effect on the level of anxiety experienced by an individual later on in the semester. According to our findings, it seems as though while emotional eating may possibly be an effective coping mechanism for difficult emotions at the time of the eating behavior, this buffering effect did not prevent later anxiety, and in fact was associated with increased anxious arousal over time.

An additional potential reason for may be mixed findings of positive and negative associations between unhealthy eating and anxiety in the literature is the very inconsistent in the
operationalization of unhealthy eating (Jackson et. al., 2010; Finch & Tomiyama, 2015; Martyn-Nemeth et. al., 2009). BMI, comfort food consumption in a lab setting, and self-report instruments that relied on recalling past behaviors, have all been used under the umbrella of ‘unhealthy eating’ (Jackson et. al., 2010; Finch & Tomiyama, 2015; Martyn-Nemeth et. al., 2009). While this study used a self-report instrument with proven reliability, we chose to operationalize unhealthy eating as emotional eating since we were looking at eating in relation to internalized experiences of stress, anxiety and depression (DEBQ, Barrada, Strien, & Cebolla, 2016). This meant that we had to be cautious when leveraging findings from studies that looked at unhealthy eating as eating while distracted, skipped meals, et cetera (Martyn-Nemeth et. al., 2009). These differences in operationalization suggest that past theories supporting the claim that eating is an effective coping mechanism may not be relevant to the emotional aspect of unhealthy eating described here as it relates to anxiety and stress. Therefore, future research should build upon our understanding of the relationship between stress and unhealthy eating defined as emotional eating with a streamlined and consistent operationalization.

According to our findings, stress did not predict a change in unhealthy eating for college-aged individuals longitudinally when not considering a history of weight problems or eating disorders, but stress and unhealthy eating were associated cross-sectionally. A possible reason for this is that most previous research on how individuals respond to stress with food has focused on disordered eating and obese populations, rather than the general population (Martyn-Nemeth et. al., 2009). While other studies have found longitudinal increases in unhealthy eating predicted by stress in obese populations (Mouchacca, Abbott & Ball, 2013; Tsenkova, Boylan & Ryff, 2013; Richardsom, Arsenault, Cates & Muth, 2015), no studies have tested this finding among the college-aged general population. This suggests that the assumed model from previous cross-
sectional research stating that stress causes unhealthy eating may not hold up when looking at these two variables longitudinally in the general population (Hudd et al., 2000; Oliver & Wardle, 1999; Martyn-Nemeth et al., 2009; Jackson et al., 2010). Instead unhealthy eating and stress may either be mutually reinforcing one another or they may both be caused by a third variable not studied here. To gain further knowledge about the relationship between unhealthy eating and stress for non-clinical populations, future studies on this subject should continue to look at the non-clinical population with a more detailed operationalization of unhealthy eating. Questionnaires like the Dutch Eating Behavior Questionnaire in conjunction with food diaries tracking nutrient intake and other dietary assessment tools should be used to get a more comprehensive look at unhealthy eating and all of the different ways it could be affecting and affected by stress, anxiety, depression and other altered mood states (Cade et al., 2017). In doing so researchers can build upon our grasp of unhealthy eating, it’s relationship to stress, and how these two variables relate to the stability and/or change in an individual’s anxiety levels.

Future research should continue to look at non-clinical populations when studying eating behavior as a way to understand the risks and rewards of unhealthy eating. Eventually, this would hopefully provide preventative information for individuals at risk of developing an eating disorder. Future studies should also utilize a more detailed and consistent operationalization of unhealthy eating behavior in order to streamline to research process and eliminate some of the discrepancies in past research findings. By following diet research best practices and utilizing measures like weight gain and BMI we can start to unpack whether unhealthy eating acts as a mechanism for change or for stability. Beyond streamlining the operationalization of unhealthy eating and expanding the populations of interest for this line of research, future studies should also continue to make the distinction between anxious arousal and anxious apprehension.
In sum, the current study shows that when controlling for baseline anxiety, unhealthy eating did not mediate the relationship between stress and anxiety, yet unhealthy eating did predict an increase in anxious arousal over time. This study is a step towards uncovering how eating behavior affects two of the most common mood states among college-aged individuals in the United States: stress and anxiety. It is one of few studies looking at eating and eating behavior in non-clinical populations. Going forward, it will be critical to continue to explore the directionality of this relationship along with mechanisms of change and mechanisms of stability among these variables as a way to create and optimize clinical interventions on college campuses.
References


Table 1. Descriptive Statistics and Correlations of main measures

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* = p<0.05, ** = p<0.001. Mean and standard deviation provided in the shaded diagonal
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* = p<0.05, ** = p<0.001
### Table 3. Path Models for Anxious Apprehension

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<td>3.04</td>
<td>&lt;.001**</td>
</tr>
</tbody>
</table>

* = p<0.05, ** = p<0.001
Figure 1. Hypothesis 1 Total Effect Model

- Stress
  - β = 0.488 (<.001)
  - β = -0.045 (.633)
  - β = 0.376 (<.001)

- Anxious Arousal
  - β = 0.634 (<.001)
  - β = 0.072 (.368)
  - β = 0.513 (<.001)

T1 → T2 → T3

Beta coefficients indicate the strength and significance level of the relationships between the variables.
Figure 2. Hypothesis 2 Total Effect Model

Unhealthy Eating → Unhealthy Eating

β = 0.679 (<0.001)

Stress

β = 0.026 (0.742)

β = 3.00 (0.001)

T1 → T2
Figure 3. Hypothesis 3 Total Effect Model

Unhealthy Eating

β = .157 (.101)

β = .167 (.047)

β = .157 (.101)

Anxious Arousal

T1

β = .444 (<.001)

β = .063 (.374)

β = .305 (.001)

Anxious Apprehension

T1

T2

T3

Anxious Arousal

Anxious Apprehension
Figure 4. Hypothesis 4 Mediation Model

![Diagram showing mediation model with variables UE, Stress, Anxious Arousal, and Anxious Apprehension across time points T1, T2, and T3. The diagram includes paths and coefficients for the mediation process.]
Figure 5. Hypothesis 5 Moderated Mediation Model

\[
\begin{align*}
\text{Stress} & \rightarrow \text{Anxious Arousal} : \beta = .337 (<.001) \\
\text{Anxious Arousal} & \rightarrow \text{Depression} : \beta = .109 (.263) \\
\text{Depression} & \rightarrow \text{Anxious Arousal} : \beta = .407 (<.001)
\end{align*}
\]

\[
\begin{align*}
\text{Stress} & \rightarrow \text{Anxious Apprehension} : \beta = .343 (<.001) \\
\text{Anxious Apprehension} & \rightarrow \text{Depression} : \beta = .187 (.020) \\
\text{Depression} & \rightarrow \text{Anxious Apprehension} : \beta = .630 (<.001)
\end{align*}
\]

\[
\begin{align*}
\text{Stress} & \rightarrow \text{Anxious Arousal} : \beta = .384 (<.001) \\
\text{Anxious Arousal} & \rightarrow \text{Depression} : \beta = .256 (.012) \\
\text{Depression} & \rightarrow \text{Anxious Arousal} : \beta = .407 (<.001)
\end{align*}
\]

\[
\begin{align*}
\text{Stress} & \rightarrow \text{Anxious Apprehension} : \beta = .534 (<.001) \\
\text{Anxious Apprehension} & \rightarrow \text{Depression} : \beta = .035 (.683) \\
\text{Depression} & \rightarrow \text{Anxious Apprehension} : \beta = .630 (<.001)
\end{align*}
\]
Figure 6. Exploratory Analysis Mediation Model

- Stress
  - T1: $\beta = 0.39 \text{ (0.009)}$
  - T2: $\beta = 0.24 \text{ (<.001)}$
  - T3: $\beta = 0.18 \text{ (0.049)}$

- Unhealthy Eating
  - T1: $\beta = 0.04\text{ (0.394)}$
  - T2: $\beta = 0.18\text{ (0.049)}$
  - T3: $\beta = 0.20\text{ (0.042)}$

- Anxious Arousal
  - T1: $\beta = 0.13\text{ (0.011)}$
  - T2: $\beta = 0.14\text{ (0.011)}$
  - T3: $\beta = 0.18\text{ (0.049)}$

- Anxious Apprehension
  - T1: $\beta = 0.13\text{ (0.011)}$
  - T2: $\beta = 0.14\text{ (0.011)}$
  - T3: $\beta = 0.20\text{ (0.042)}$