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Establishing a link between anxiety sensitivity, exercise intolerance, and overeating

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ESTABLISHING A LINK BETWEEN ANXIETY SENSITIVITY, EXERCISE INTOLERANCE, AND OVEREATING

by

BRIDGET A. HEARON

B.A., Bryn Mawr College, 2005
M.A., Boston University, 2008

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Approved by

First Reader

Michael W. Otto, Ph.D.
Professor of Psychology

Second Reader

Heather W. Murray, Ph.D.
Research Assistant Professor of Psychology

Third Reader

Paula A. Quatromoni, D.Sc., R.D.
Associate Professor, Sargent College &
Associate Professor, Boston University School of Public Health

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BRIDGET A. HEARON

Boston University Graduate School of Arts and Sciences, 2013

Major Professor: Michael W. Otto, Professor of Psychology

ABSTRACT

Obesity has reached epidemic proportions, highlighting the need to better understand contributors to under-exercise and overeating. Anxiety Sensitivity (AS) is hypothesized to amplify negative affect and avoidance motives, and has been linked to maladaptive coping behaviors such as eating pathology as well as distress during and avoidance of exercise. The current series of studies was designed to extend research that relied on self-report assessments, and investigate the role of AS in objectively-assessed eating and exercise behavior across three community samples. The first two studies examined eating in the context of experimentally-induced negative affect in a sample representing all weight categories ($N = 57$); and distress, perceived exertion, and affect changes during exercise in normal and obese weight groups ($N = 38$). The third study extended this investigation to a naturalistic setting, using actigraphy, affect, and dietary monitoring across a three-day period in normal and obese weight groups ($N = 32$). The hypotheses were that AS would predict more eating in the context of negative affect; greater perceived exertion and distress during exercise, as well as avoidance of exercise, with findings most pronounced in obese participants. Results were as follows. In the first study, more calories consumed following a negative affect induction was predicted by the interaction between a dimension of AS (mental concern) and the expectancy of loss of control from eating in overweight/obese participants. In the second study, there was no significant association between AS and ratings of exertion or distress during exercise; however, a trend suggested the expected affective benefits of acute exercise were not evident in obese participants with greater AS and exertion. The final study found that AS was associated with more calories consumed across the monitoring period in women but not men (who were equally represented across AS and weight groups), and was also predictive of more calories consumed in the context of negative affect. Additionally, high AS predicted less engagement in moderate-intensity exercise in obese participants and more in normal weight participants. Overall, these studies provide support for the hypothesis that AS is a predictor of both exercise avoidance and overeating behavior.

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List of Abbreviations

AAQ	Acceptance and Action Questionnaire
AS	Anxiety Sensitivity
ASI	Anxiety Sensitivity Index
AS-MC	Anxiety Sensitivity Index – Mental Concern Subscale
AS-PC	Anxiety Sensitivity Index – Physical Concern Subscale
AS-SOC	Anxiety Sensitivity Index – Social Concern Subscale
BDI-II	Beck Depression Inventory-II
BMI	Body Mass Index
BRSPE	Borg Rating Scale of Perceived Exertion
CDC	Centers for Disease Control and Prevention
CE	Compensatory Eating
DTS	Distress Tolerance Scale
EDI	Eating Disorders Inventory
EEI	Eating Expectancy Inventory
EES	Emotional Eating Scale
FCQ-S	Food Craving Questionnaire-State Version
MTPT-C	Computerized Mirror-tracing Persistence Task
PANAS	Positive and Negative Affectivity Scales
PAR-Q	Physical Activity Readiness Questionnaire
SUDS	Subjective Units of Distress Scale

Chapter 1. General Introduction

Overweight and obese status has reached epidemic proportions in the United States with approximately two-thirds of the American population falling into an unhealthy weight category (CDC, 2012). Based on 2012 statistics, 34% of Americans are overweight as defined by a body mass index (BMI) greater than 25 with another 35.7% of individuals meeting criteria for obesity (BMI > 30, CDC, 2012). This increase in overweight/obese status is particularly concerning when compared to 1980 statistics which showed only 15% of Americans in the obese weight range (Flagel et al., 2002). In fact, 65% of the world population now resides in a country where being overweight or obese causes more deaths than being underweight (World Health Organization, 2009). Indeed, despite a survey of more than 180,000 Americans indicating that 46% of women and 33% of men reported actively trying to lose weight, only 19% and 22%, respectively, reported meeting minimum recommendations for caloric restriction and physical activity to achieve and maintain weight loss (Bish, Blanck, Serdula, Marcus, Kohl, & Khan, 2005). Such statistics highlight the need for research to better understand factors that contribute to overeating behavior and avoidance of physical activity.

In the current series of studies, we examined a single variable, distress intolerance, which unlike the vast majority of previously identified predictors of overeating and exercise avoidance, may contribute to our understanding of both of these factors. Broadly defined, distress intolerance is the perceived inability to tolerate distressing somatic and affective states (McHugh & Otto, 2012) with evidence suggesting those individuals with high distress intolerance experience negative affect and physical discomfort in an amplified way leading to a greater likelihood of avoidance based coping strategies (Zvolensky & Otto, 2007). Anxiety sensitivity (AS), a way of operationalizing distress tolerance (McHugh & Otto, 2011), has received increased attention as a factor that may contribute to both sides of the weight gain dilemma, maladaptive eating and lack of physical activity.

AS refers to the fear of anxiety-related symptoms caused by a belief that somatic arousal and anxiety itself have catastrophic consequences across three domains, physical (e.g. having a heart attack, dying), mental (e.g. losing control, going crazy), and social (e.g. interpersonal rejection, embarrassment; McNally, 2002). It is distinct from trait anxiety (Taylor, Koch, & Crockett, 1991) and elevations in this trait are common across a number of Axis I disorders including anxiety disorders and depression which also tend to have higher rates in obese as opposed to normal weight populations (Petry et al., 2008; Schmidt, Lerew, & Jackson, 1997; Schmidt, Zvolensky, & Maner, 2006).

AS predicts heightened sensitivity to negative affective states (Ehlers, 1995; Otto et al., 1995; Reiss, 1991; Schmidt et al., 1997; Taylor, Koch, Woody, & McLean, 1996) which means those individuals with elevated levels of AS may be more likely to engage in behavioral attempts to reduce these states than individuals with lower levels of AS. Indeed, findings in the substance abuse literature have demonstrated a link between AS and the use of alcohol, marijuana, and nicotine for coping motives (DeMartini & Carey, 2011; Johnson, Mullin, Marshall, Bonn-Miller & Zvolensky, 2010; Zvolensky, Feldner, Leen-Feldner, Bonn-Miller et al., 2004). That is, individuals with elevated AS were more likely to endorse using these substances as a means of alleviating distressing affect or somatic discomfort. To place these findings in the context of weight management difficulties, AS may lower the threshold for tolerating negative affect or somatic distress making an individual more likely to impulsively eat when confronted by negative affect, and fail to persist or engage in physical activity that causes somatic discomfort.

The purpose of the current, multiple-study investigation was to examine the role of AS in eating and exercise avoidance in both laboratory and naturalistic settings. This introduction will provide a brief review of the literature on AS and eating and exercise behavior to provide a framework for the series of studies to follow.

AS and Maladaptive Eating Behavior

An abundance of research has examined the relationship between negative affect and eating behavior. The affect regulation model of binge eating, one of the most prevalent theories of binge eating, proposes that individuals engage in over-eating behavior as a means to reduce negative mood states through the comfort and distraction provided by food (Hawkins & Clement, 1984). Support for this theory is plentiful but mixed, with many studies demonstrating a link between onset of a negative mood state and binge episodes in individuals with eating disorders (Agras & Telch, 1998; Chua, Touyz & Hill, 2004; Davis & Jameison, 2005; Lynch, Everingham, Dubitzky, Hartman, & Kasser, 2000), yet limited evidence supporting the theory's predicted relief of negative affect following the binge episode. Moreover, evidence suggests that the emotional aftermath of a binge episode may be complex with patients reporting decreases in anxiety but increases in depression (Hetherington, Altemus, Nelson, Bernat, & Gold, 1994; Kaye, Gwirtsman, George, Weiss, & Jimerson, 1986). A number of subsequent theories have attempted to address this post-binge affect discrepancy including *escape theory*, in which negative affect leads to a shift in cognitive attention from higher-level abstract thinking to the immediate environment such that individuals experience relief of the affective state during the binge, but not necessarily following it (Baumeister, 1990); *restraint theory*, which posits that those trying to restrict caloric intake may become so disinhibited by negative affect that cognitive control over eating behavior is simply lost for a period of time resulting in the binge episode with no conscious expectation that the negative affective state will be relieved (Herman & Polivy, 1980); and *expectancy theory*, which posits that it is not actual relief from negative affect that drives binge episodes but rather the learned expectation that eating will provide comfort (Holstein, Smith & Atlas, 1998).

More recently, Tice, Bratslavsky, and Baumeister (2001) examined the role of negative affect in derailing the self-regulatory system providing some clarification as to the process by which negative affect leads to overeating behavior. In a study that involved affect manipulation, those participants lead to believe their negative affect was unchangeable or "frozen" during the hour following induction consumed significantly less calories when food was presented than those participants who underwent the same induction but were not lead to believe their negative affect was unchangeable. Such a finding indicates that an in-the-moment belief that eating works as an affect regulation strategy is necessary for an individual to forgo long-term self-regulation goals in favor of prioritizing immediate impulses in an attempt to regulate negative affect in the short term. Other research suggests that self-control or regulation is a finite resource that can become fatigued when faced with daily stressors (Baumeister, Vohs, & Tice, 2007; Muraven &

Baumeister, 2000). Therefore, in the case of dietary restraint, those individuals who are purposely trying to exert self-control over eating behavior may be susceptible to lapses in self-control over consumption when this resource becomes depleted. In this instance, consumption of additional calories may not represent a volitional effort on the individual's part to manage his negative affect, but rather a lack of self-control resources or capacity to continue exerting regulation over hunger/food craving cues. Further research suggests that these two accounts are not mutually exclusive and could interact to influence eating behavior. Tice and Bratslavsky (2000) proposed that emotion regulation is similar to other forms of behavioral self-regulation (i.e. dieting); however, emotion regulation differs in that it can undermine other kinds of self-control as well. Indeed, the authors point out that self-control failure can happen through both under-regulation (i.e., not exerting sufficient self-control effort from the start) and mis-regulation (i.e. using a strategy to control an impulse that is ineffective or detrimental to self-regulation goals). The authors propose that prioritizing affect regulation over other self-control goals is a mis-regulation of self-control resources since engaging in a behavior, such as eating to manage affect when one has the goal of dieting, leads to greater negative affect in the long-term, thereby, creating a cycle where individuals continually deplete self-control resources to manage this affect. Therefore, one instance of purposeful eating to manage negative affect may lead to a depletion in self-control resources throughout the day, due to the secondary negative affect brought on by engaging in maladaptive coping.

Regardless of whether overeating behavior is driven by one or both of these theories, the amplification of negative affect by AS may place individuals elevated on this construct at even greater risk for maladaptive overeating. In the case of the model presented by Tice and colleagues (2001), amplification of negative affect by AS may serve to lower the threshold for prioritizing short-term affect regulation over long-term self-regulatory goals. With regard to self-control fatigue (Mauravan & Baumeister, 2000; Baumeister et al; 2007), AS amplification of negative affect may represent an additional stressor that requires an individual to exert self-control resources to manage, thereby, depleting self-control resources that could otherwise be used to regulate food intake. In both instances, the amplified aversiveness of negative affect by AS may contribute to overeating behavior.

Published studies examining the role of AS in eating pathology prior to this dissertation have been limited to self-report examinations. Anestis and colleagues (2007; 2008) examined the role of high AS in eating pathology in two studies. Results of their cross-sectional analysis indicated that AS was directly related to the Bulimia subscale of the Eating Disorders Inventory (EDI; Garner, Olmsead, & Polivy, 1983) as well as a secondary analysis which revealed that interoceptive awareness, the ability to correctly distinguish bodily states, may also mediate this relationship in both a clinical and non-clinical sample. A follow-up examination revealed that the relationship between the AS and the Bulimia subscale of the EDI was mediated by an alternate measure of distress intolerance - the Distress Tolerance Scale (DTS; Simons & Gaher, 2005). A recent study investigating the role of AS subscales in disordered eating found that a relationship between the AS mental concern subscale (AS-MC) and eating disorder pathology (as assessed by the EAT-26; Garner, Olmsted, Bohr, & Garfinkel, 1982) was mediated by experiential avoidance as assessed by the Acceptance and Action Questionnaire (AAQ; Hayes et al. 2004).

This line of research encourages additional investigation of the role of AS in eating behaviors. Indeed one of the major limitations in this line of research to date is that it focuses specifically on eating at a pathological level (i.e. greater reported bulimia symptoms in the case of Anestis et al. 2007; 2008, and greater reported overall eating disorder pathology in the case of Fulton et al., 2012). This represents a limitation when trying to examine overeating behavior more broadly as current prevalence of overweight/obesity far exceeds the prevalence rate of eating disorders in the American population (Hudson, Hiripi, Pope, & Kessler, 2007; CDC, 2012) indicating that the majority of overweight/obese individuals must be engaging in some form of maladaptive eating that does not fall into the specific definition of a binge episode or meet diagnostic criteria for an eating disorder. Research using only self-report questionnaires examining binge eating or disordered eating specifically may not fully capture the eating behavior leading to overweight/obese status. Moreover, relying on generalized self-reports of eating pathology or eating to manage negative affect may be problematic as research demonstrates that self-identifying as an emotional eater does not reliably translate to actual eating behavior in experimental settings (Evers, et al., 2009). Thus, study of the role of AS in objective eating behavior is warranted.

AS and Physical Activity

Negative affect during exercise represents one contributor to exercise avoidance as evidence suggests that reports of negative affect during exercise inversely predict future exercise adherence. For example, Williams and colleagues (2008) found that negative affect during moderate-intensity exercise among sedentary participants predicted less physical activity at 6 and 12-month follow-ups when compared to those who did not experience equivalent levels of negative affect during exercise. This may be particularly detrimental to overweight/obese individuals as research shows they are more likely to report negative affect during exercise than those in the normal weight range (Ekkekakis & Lind 2006). In addition, AS may contribute to these findings as it heightens sensitivity to negative affect (Ehlers, 1995; Otto et al., 1995; Reiss, 1991; Schmidt et al., 1997; Taylor et al., 1996) and contributes to distress associated with unpleasant physical sensations such as pain (Asmundson, Norton, & Veloso, 1999; Ocañez, McHugh, & Otto, 2010; Zvolensky, Goodie, McNeil, Sperry, & Sorrell, 2000). Indeed, overweight/obese samples report greater perceived exertion and physical discomfort than normal weight controls exercising at equivalent intensity levels (Deforche, De Bourdeaudhuij, & Tanghe, 2006; Ekkekakis & Lind, 2006; Hulens et al., 2003). Therefore, AS may serve to amplify the aversiveness of somatic sensations associated with exercise such as increased heart rate, respiration, and muscle fatigue as well as negative affect associated with this behavior.

Several studies have already examined the role of AS in self-reported physical activity with the general consensus demonstrating a link between elevated AS and avoidance of exercise. In a sample of undergraduates, McWilliams and Asmundson (2001) found that the physical concern subscale of AS was associated with less exercise frequency in men but not women. In a sample composed entirely of undergraduate females, an effect of AS was found such that those with high AS reported significantly less exercise than those with low AS (Sabourin et al., 2011). Additionally, a recent investigation examining a sample of more than 200 adults found that higher AS was associated with less vigorous physical activity with no evidence that this effect was moderated by sex (Moshier et al., 2012).

Smits and colleagues (2010) conducted the first published laboratory-based examination of the relationship between AS, body mass, and distress during exercise. In this study, participants completed a 20-minute treadmill exercise at 70% of their age-adjusted maximum heart rate. Results revealed that those participants with both elevated AS and higher body mass reported the greatest ratings of distress during the exercise task. This finding indicates that, as expected, AS effects on exercise may be greatest among obese individuals.

Taken together, these studies provide support that elevated AS is associated with less physical activity; however, studies are needed to clarify the role of perceived exertion and negative affect during exercise in conjunction with AS.

Additional Contributors to Overeating Behavior

Compensatory eating (CE) and health halos may also contribute to maladaptive eating behavior. Compensatory eating refers to an increase in caloric intake to compensate for caloric deficits brought about by physical activity (Epstein & Wing, 1980), and represents one of the reasons using physical activity in the absence of dietary monitoring is often an unsuccessful intervention strategy for sustained weight loss (Ross & Janssen, 2001; King et al., 2008; Pomerleau et al., 2004). Although CE is sometimes a volitional behavior (i.e. purposely using food as a reward for exercising), it is often unintentional such that individuals who initiate an exercise program subtly increase their caloric consumption at meals without realizing it (King et al., 2007). Additionally, halo effects refer to factors such as food placement, advertising, and presentation which lead individuals to underestimate calorie content and engage in subsequent over-consumption of food (Wansink & Chandon, 2006; Chandon & Wansink, 2007). Although research to date has demonstrated the effects of CE and halos in negating the effects of diet and exercise, no studies have examined halo effects in the context of exercise nor have they examined AS as a potential contributor to CE and halo effects.

The Current Project

Given preliminary findings suggesting that AS may contribute to maladaptive eating and exercise avoidance, further studies are warranted to investigate this construct in objectively measured eating and exercise. The overall aim of this series of studies was to first examine the role of AS in laboratory-based eating and exercise and then to extend these findings beyond the constraints of the experimental environment to the naturalistic setting.

The study described in Chapter 2 examines the role of AS on eating behavior in the context of experimentally-induced negative affect with a sample ranging across weight groups. This builds upon previous studies examining the role of AS in eating pathology (Anestis et al., 2007; 2008; Fulton et al., 2012) as rather than relying on self-report, we examined actual eating behavior. Additionally, the measures used to examine eating in the aforementioned studies are both widely used in the field of eating pathology;

however, overeating behavior does not solely occur in the context of a diagnosable eating disorder. Therefore, this investigation may be better suited to capture the possibly more subtle increases in consumption when a negative affect is induced that would not necessarily meet diagnostic criteria for a binge episode.

Chapter 3 employs an identical physical activity challenge to that used by Smits and colleagues (2010), but in addition to distress during exercise, will also examine ratings of perceived exertion as well as changes in negative affect prior to and following exercise. Also, we examine AS effects on accuracy of estimates of calories burned during the exercise challenge. As detailed in Chapter 4, we examined accuracy of estimates of calories consumed during a sham taste test post exercise. This taste test was also used to examine whether AS contributes to CE shortly after exercise. The role of physical activity on halo effects was also examined in this study by having participants rate the calorie content of food images before and/or after the exercise challenge. Taken together, this study will contribute to our understanding of AS effects on an individual's experience during exercise as well as changes which may occur after exercise completion such as affect shifts, perceptions of the health benefits of the exercise behavior and subsequent eating.

Finally, the study described in Chapter 5 extends these findings beyond the confines of the experimental setting by examining eating and physical activity in the naturalistic setting through the use of actigraphy, affect and dietary monitoring. This study will compliment the previous chapters, as it is important to explore the influence of AS on eating and exercise behavior in the context of daily life. In this way, we can examine eating behavior in the context of naturally occurring negative affect rather than relying on experimental induction. Additionally, this study will objectively capture physical activity over a much longer period of time than what is possible in the laboratory setting and will be free from biases and inaccurate reporting that often plagues self-reported physical activity (Neuhouser, Di, Tinker, Thomas, Sternfeld, et al., 2013).

Together, this series of studies provides further clarification of the role of AS in maladaptive eating and exercise behavior, extending findings that have largely been limited to self-report measurements of pathological eating and physical activity. Accordingly, recommendations can be made as to the utility of addressing high AS in weight-management treatment programs for the subset of overweight/obese individuals elevated on this construct.

Chapter 2. The Role of Anxiety Sensitivity and Eating Expectancy in Maladaptive Eating Behavior[1]

According to the Centers for Disease Control, approximately 34% of Americans are overweight as defined by a body mass index (BMI) greater than 25, with another 34% meeting criteria for obesity (e.g., BMI >30; CDC, 2010) indicating that more than two-thirds of the American population is in an unhealthy weight range. This number represents a significant increase in obesity rates--less than 15% of Americans met criteria for obesity in 1980 (Flagel et al., 2002)--and highlights the need for research to better understand eating pathology and maladaptive eating behaviors.

A wealth of research has examined the relationship between negative affect and eating behavior. One of the most prevalent theories, the affect regulation model of binge eating, proposes that individuals engage in over-eating behavior as a means to reduce negative mood states through the comfort and distraction provided by food (Hawkins & Clement, 1984). Support for this theory is plentiful but mixed with many studies demonstrating a link between onset of a negative mood state and binge episodes in individuals with eating disorders (Agras & Telch, 1998; Chua, Touyz & Hill, 2004; Davis & Jameison, 2005; Lynch, Everingham, Dubitzky, Hartman, & Kasser, 2000), yet limited evidence supporting the theory's predicted relief of negative affect following the binge episode. Indeed, evidence suggests that the emotional aftermath of a binge episode may be complex with patients reporting decreases in anxiety but increases in depression

[1] Chapter 2 of this dissertation has been accepted for publication by *Cognitive Therapy and Research*. It includes both a preliminary study examining self-report measures as well as a second study that examined eating in the laboratory setting as per the dissertation prospectus.

(Hetherington, Altemus, Nelson, Bernat, & Gold, 1994; Kaye, Gwirtsman, George, Weiss, & Jimerson, 1986). Subsequent theories which address this post-binge affect discrepancy include *restraint theory*, which posits that those trying to restrict caloric intake may become so disinhibited by negative affect that cognitive control over eating behavior is simply lost for a period of time resulting in the binge episode with no conscious expectation that the negative affective state will be relieved (Herman & Polivy, 1980); *escape theory*, in which negative affect leads to a shift in cognitive attention from higher-level abstract thinking to the immediate environment such that individuals experience relief of the affective state during the binge but not necessarily following it (Baumeister, 1990); and *expectancy theory*, which posits that it is not actual relief from negative affect that drives binge episodes but rather the learned expectation that eating will provide comfort (Holstein, Smith & Atlas, 1998).

Despite the extensive research conducted to clarify the relationship between negative affect and over-eating behavior, one of the major limitations is that it is often focused on individuals meeting criteria for a specific eating disorder. This represents a limitation when trying to examine obesity more broadly as current prevalence of overweight/obesity far exceeds the prevalence rates of eating disorders in the American population (Hudson, Hiripi, Pope, & Kessler, 2007; CDC, 2010) indicating that the majority of overweight/obese individuals must be engaging in some form of maladaptive eating which does not fall into the specific definition of a binge episode or meet diagnostic criteria for an eating disorder. Indeed, negative affect induction results in greater eating among non-eating disordered overweight/obese women with higher levels of trait negative affect (Jansen et al., 2008), and the additional amount of food consumed by this subtype of women (i.e. approximately 150 kilocalories more than other experimental groups) is more modest than what would traditionally be considered a binge episode. This line of research supports the notion that (1) negative affect may influence overeating in overweight/obese individuals, but this eating may be a more subtle consumption of additional calories than a true binge episode, and (2) research using only self-report questionnaires examining binge eating or disordered eating specifically may not fully capture the eating behavior leading to overweight/obese status.

One option for understanding maladaptive overeating in the context of negative affect is to examine the underlying role of distress intolerance as operationalized by anxiety sensitivity (AS). AS assesses the fear of anxiety-related symptoms (Peterson & Reiss, 1992), often fueled by beliefs that somatic arousal and anxiety have catastrophic physical (e.g., having a heart attack, dying), mental (e.g., losing control, going crazy) or social (e.g., interpersonal rejection) consequences (McNally, 2002). AS is distinct from trait anxiety (Taylor, Koch, & Crockett, 1991), and has been implicated in the development of panic attacks and a number of Axis-I disorders (Schmidt, Lerew, & Jackson, 1997; Schmidt, Zvolensky, & Maner, 2006). Because of the heightened sensitivity to negative affective states (Ehlers, 1995; Otto et al., 1995; Reiss, 1991; Schmidt et al., 1997; Taylor, Koch, Woody, & McLean, 1996), individuals with elevated AS levels may be more likely to make behavioral attempts to reduce their negative affect relative to persons with normative or low AS levels. Indeed, AS, as measured by the Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky, & McNally, 1986) has been related to emotional and somatic intolerance, predicting maladaptive coping responses to these stimuli across a wide range of substance-using populations (McHugh & Otto, 2011). For example, research in substance abuse literature has demonstrated a link between AS and the use of alcohol, marijuana, and nicotine for coping motives (DeMartini & Carey, 2011; Johnson, Mullin, Marshall, Bonn-Miller & Zvolensky, 2010; Zvolensky, Feldner, Leen-Feldner, Bonn-Miller et al., 2004).

In an initial examination of this construct in eating behavior, Anestis and colleagues (2007; 2008) examined the role of high AS in eating pathology in two studies. Results of their cross-sectional analysis indicated that AS was directly related to the Bulimia subscale of the Eating Disorders Inventory (EDI; Garner, Olmsead, & Polivy, 1983) as well as a secondary analysis which revealed that interoceptive awareness may also mediate this relationship in both a clinical and non-clinical sample. A follow-up examination revealed that the relationship between the AS and the Bulimia subscale of the EDI was mediated by an alternate measure of distress intolerance - the Distress Tolerance Scale (DTS; Simons & Gaher, 2005).

In addition to overall AS, subdimensions of the construct (ie., physical concerns, mental concerns, and social concerns) have also been shown useful for understanding maladaptive coping behaviors. For example, a study of 90 smokers revealed that the AS subdimensions of mental concerns (AS-MC; e.g. “When I can’t keep my mind on a task, I worry that I might be going crazy”) and physical concerns (AS-PC, e.g. “It scares me when my heart beats rapidly”) were associated with greater expectancy that smoking could help reduce a negative affective state (Zvolensky et al., 2004). AS and its subdimensions may serve the eating literature in a similar fashion, helping identify individuals who are most likely to use food to cope with negative affect. A recent study also investigating the role of AS subdimensions in disordered eating found that a relationship between AS-MC and eating disorder pathology (as assessed by the EAT-26; Garner, Olmsted, Bohr, & Garfinkel, 1982) is mediated by experiential avoidance as assessed by the Acceptance and Action Questionnaire (AAQ; Hayes et al., 2004). This line of research encourages additional investigation of the role of AS in eating behaviors. In particular, because research has shown that self-reported emotional eating does not necessarily translate into observable eating behavior (Evers et al., 2009), studies examining the role of AS in emotional eating are warranted to expand upon the self-report methods using questionnaires that probe specifically for eating disorder symptoms rather than assessing emotional eating more directly. Also, to parallel findings in the substance abuse literature, investigations are needed to determine whether high AS is specifically linked to coping motives for eating, as captured by assessment of eating expectancies with the Eating Expectancy Inventory (EEI; Hohlstein, Smith & Atlas, 1998).

To better understand the relationship between AS, eating expectancies, and food consumption, we utilized a two-study design. Study 1 examined the relationship between AS, eating expectancy, and self-reported emotional eating in an overweight/obese population. Study 2 was designed to extend upon the self-report findings from Study 1 by examining in vivo food consumption following negative mood induction. Also, in Study 2, we recruited participants representing a range of weight classifications (normal weight, overweight, and obese) to determine if the role of AS and eating expectancy was unique to overweight/obese individuals. Also, we excluded individuals with elevated levels of trait negative affect to determine the unique contribution of AS outside the context of this previously established risk for maladaptive eating behavior.

For Study 1, we hypothesized that AS would be significantly related to self-reported emotional eating in response to negative affect as well as higher levels of eating expectancies. For Study 2, we hypothesized that AS total as well as each AS subdimensions would predict food consumption following a negative mood induction, with this effect most prominent in overweight/obese individuals. We also further hypothesized that eating expectancy and AS subdimensions would interact with weight status such that overweight/obese individuals elevated in both of these constructs would consume the greatest number of calories, reflecting the parallel findings in the smoking literature described above (Zvolensky et al., 2004). Specifically, we predicted that AS-PC would significantly interact with Eating Expectancy Scale 1 (eating to manage negative affect) and that AS-MC would significantly interact with Eating Expectancy Scale 3 (eating leads to feeling out of control) to predict greater calories consumed in the overweight/obese subsample of participants. By examining the interaction of AS-PC with Eating Expectancy Scale 1, we examined the coping relationship most commonly associated with AS in the substance abuse literature, engaging in a maladaptive behavior due to a belief that this behavior will reduce the unpleasant mood states; whereas, linking AS-MC with Eating Expectancy Scale 3, proposes a sensitivity to cognitive symptoms linked to eating behaviors such that those who both fear a loss of mental control and those who expect to feel out of control when eating will consume the most calories.

Study 1

Methods

Participants

Participants were recruited using Internet postings and flyers placed in the local community. Individuals aged 18 and older who responded to these advertisements were screened to identify those who were overweight or obese (BMI>25), non-depressed as judged by a BDI score less than 14, and did not report current use of antidepressant medications. These eligibility criteria were employed to select the subset of individuals most likely to engage in maladaptive over-eating as well as to examine the role of AS and eating expectancy outside the context of trait negative affect. All eligible participants were invited to the laboratory for a single study visit which lasted approximately two hours. Forty-two participants (20 women) provided informed consent and were enrolled in the study. Those completing study procedures were provided $25 compensation. All study procedures received approval from Boston University's Institutional Review Board. Demographic information for Study 1 is presented in Table I.

Procedures

All participants were asked to refrain from eating one hour prior to their study appointment to control for variability in hunger due to time of last meal for ratings of craving. After obtaining informed consent, participants completed a battery of self-report questionnaires followed by a measurement of height and weight.

Measures

Anxiety Sensitivity. Anxiety sensitivity was measured using the Anxiety Sensitivity Index (ASI; Peterson & Reiss, 1992), a 16-item questionnaire designed to assess one's tendency to respond fearfully to anxiety-related symptoms. Data on the reliability and validity of the ASI scales have been favorable (Reiss, Peterson, Gursky, & McNally, 1986) with high levels of internal consistency also demonstrated (average alpha coefficient: 0.84; Peterson & Reiss, 1992). In addition, it has been determined that the ASI represents a hierarchical construct such that three subscales, AS-physical concerns (items 3, 4, 6, 8, 9, 10, 11, 14), AS-mental concerns (items 2, 12, 15, 16), and AS-social concerns (items 1, 5, 7, 13) contribute to the higher order general factor (Zinbarg, Barlow, & Brown, 1997). With regard to internal consistency of the subscales, alpha coefficients range from acceptable to high, AS-PC alpha coefficient: .89, AS-MC alpha coefficient: .85, AS-SOC alpha coefficient: .62 (Zinbarg & Barlow, 1996). Research indicates that the ASI is distinct from trait anxiety and can be distinguished from anxiety symptom frequency (McNally, 1996; Rapee & Medoro, 1994).

Eating Expectancies. The Eating Expectancy Inventory (EEI; Hohlstein, Smith & Atlas, 1998) was used as a measure of attitudes toward food. This 34-item measure is based on a five-factor model of eating expectancies and thus scores can be derived for each of the scales: 1) Eating helps manage negative affect, 2) Eating as a reward, 3) Eating leads to feeling out of control, 4) Eating enhances cognitive competence, and 5) Eating alleviates boredom. Higher scores on each of these scales indicate a stronger belief that eating will result in the outcome named in the subscale. Internal consistency for the subscales is high with alpha coefficients ranging from .78 - .94. Research conducted by Simmons, Smith and Hill (2001) indicates that the EEI is both a reliable and valid measure of eating expectancies and supports the five-factor model.

Emotional Eating. Urge to eat in response to emotional cues was measured using the Emotional Eating Scale (EES; Arnow, Kenardy, & Agras, 1995) which supports a three-factor structure of emotional eating: 1) anger/frustration, 2) anxiety, and 3) depression. Internal consistency for the measure was coefficient alpha of .81 with subscales ranging from .72 to .78. This measure has been shown to accurately identify emotion driven urges to eat while remaining uncorrelated with general measures of psychopathology (Arnow et al., 1995; for an example, see Courbasson, Rizea, & Weiskopf, 2008). This measure differs from the EEI in that individuals report their desire to eat when experiencing a given emotional state whereas the EEI measures the belief that eating will lead to a given outcome (e.g. a reduction in negative affect or feeling a loss of control).

Craving. Food craving during the assessment session was measured using the Food Craving Questionnaire – State version (FCQ-S; Cepeda-Benito et al., 2000), which is a 15-item scale that assesses multiple dimensions of food craving in response to specific situations (e.g., stressful events). This scale has demonstrated construct validity and has been shown to reliably discriminate between state and trait cravings with high overall internal consistency (alpha coefficient: .96).

Results

To examine the associations between AS, eating expectancy and self-reported urge to eat in response to negative emotional states, Pearson correlations among these variables were examined (Table II). As hypothesized, AS was related to eating expectancies as well as reported urge to eat in response to emotional cues. Scores on the ASI were significantly correlated with four out of five EEI scales (manage negative affect, reward, loss of control, alleviate boredom) with the exception of Scale 4, eating enhances cognitive competence. In addition, ASI was also significantly positively correlated with state craving for food as measured by the FCQ-S ($r = .32$, $p < .05$).

Also consistent with our hypotheses, the ASI was significantly correlated with all three scales of the EES, anger/frustration, anxiety and depression as well as the total EES score (see Table II) indicating that participants who scored higher on the ASI were also more likely to endorse urges to eat in response to each of the emotional states represented by the subscales of the EES. ASI was not only associated with a belief that eating could lead to a given outcome such as negative affect reduction as measured by the EEI but also was associated with stronger urges to eat when feeling emotional distress.

Study 1 Discussion

Consistent with our hypothesis, those who scored higher on measures of AS also tended to endorse a greater expectancy that eating could be useful as an affect regulation strategy as well as lead to feeling out of control. In addition, higher AS was associated with greater self-reported urge to eat across all three domains encompassed in the EES, anger/frustration, anxiety and depression, providing support for the broad applicability of this construct as highlighted in previous research (Carter et al., 1999; McHugh & Otto, 2011; Schmidt & Joiner, 2002; Zvolensky et al., 2001). These results underscore the need to further examine the role of AS and eating expectancy in relation to actual eating behavior as well as to clarify whether such relationships are unique to overweight individuals or also occur in those in the normal BMI range.

Study 2

Participants

Identical recruitment strategies to those used in Study 1 were employed for Study 2. Inclusion criteria remained the same with the exception that there was no restriction on BMI and participants from Study 1 were excluded from Study 2. All eligible participants were invited to the laboratory for one study visit that lasted approximately two hours. Sixty participants (27 women, 33 men) provided informed consent and were enrolled in the study. Data from three participants were excluded due to one participant needing to leave before study procedures were completed and two participants failing to follow directions provided by experimenters. An additional two participants declined weight and height measurement rendering their data unusable for any analyses that include BMI. All study procedures received approval from Boston University's Institutional Review Board, and those participants completing study procedures received $25 compensation. Demographic information for Study 2 is presented in Table III.

Mood Induction Task

Frustration, the targeted negative mood induction, was induced using the Computerized Mirror-tracing Persistence Task (MTPT-C; Strong et al., 2003). In this task, all visual feedback is reversed and the participant must move a red dot along the shape of a star using a computer mouse. As mistakes in tracing occur, computerized auditory feedback (a loud buzz-like sound) is provided. As further detailed in the methods section below, this negative mood state was prolonged through the addition of a 20-minute delay in which participants were not exposed to any outside stimuli. This addition was meant to evoke additional emotions such as boredom to represent the combination of negative mood states that can emerge in daily life.

Measures

The same questionnaires were used in both Study 1 and Study 2 with the addition of the Positive and Negative Affectivity Scale (PANAS; Watson, Clark & Tellegen, 1988), which was employed as a brief measure of affect and yields the factors of positive affectivity and negative affectivity. Internal consistency of these factors has been determined to be acceptably high (Positive Affect alpha coefficient: .86-.90, Negative Affect alpha coefficient: .84-.87). Total calories consumed were calculated by weighing each food item prior to and following food exposure and multiplying by the calorie estimates provided on the food packaging.

Procedures

All participants were asked to refrain from eating for two hours prior to their study appointment to control for baseline levels of hunger. Mild deception was employed to mask the true nature of the study in an effort to reduce changes in eating behavior due to the social influence of the experimental setting. Therefore, participants were led to believe that the study was examining physiological changes in response to mood states even though no physiological data were recorded.

After providing informed consent, participants completed an initial battery of self-report questionnaires that did not measure eating-related variables in order to conceal the true nature of the study. “Physiological testing” leads were then attached to the participant’s middle and index finger, and they were asked to keep that hand still due to the “physiological testing.” Participants then completed a frustration induction task (Computerized Mirror Tracing Persistence Task; Strong et al., 2003) following a standardized set of instructions provided by the experimenter.

Following the completion of the task, the experimenter entered the room and informed the participant that a colleague who must check the “physiological data” was running late, and instructed him to remain seated without outside stimulation such as cell phones, magazines etc. until the colleague arrived. Participants were made to wait for 20 minutes in an effort to increase and prolong feelings of frustration. After 20 minutes, the experimenter re-entered the room with a tray of pre-weighed snacks, which consisted of potato chips, cookies, salted peanuts, and chocolate candy. The experimenter informed participants that the late colleague was expected to arrive shortly, and offered a snack. Participants were informed that they could eat as little or as much food as they desired as the remainder would be thrown away. The experimenter then left the participant with the food for exactly 10 minutes. Physiological testing leads were placed on the non-dominant hand of each participant and food was placed in close proximity to the dominant hand minimizing the effect of the lead attachment on ability to consume the snack foods.

Following this period, the experimenter re-entered the room with his/her late colleague who detached the leads from the participant’s fingers while the experimenter removed the food from the room. Participants then completed a second questionnaire battery which consisted of the aforementioned eating measures.

Prior to leaving, height and weight were measured and participants were debriefed regarding the true nature of the study. No participant elected to have his/her data excluded after learning the true intent and no participant endorsed realizing the study was related to eating behavior until after the food was removed from the experimental room.

Results

Preliminary Analyses

Participants consumed a mean of 336.3 (*SD* = 298.9) calories during the food exposure with no significant difference in calories consumed between normal weight and overweight/obese participants. Participants did not differ on food consumption between sweet (chocolate and cookies; *M* = 165.69, *SD* = 21.9) and savory (potato chips and nuts; *M* = 199.12, *SD* = 26.4) calories consumed (t (56) = -1.43, p = .16). Mean ASI total score for the sample was 15.8 (*SD* = 8.1) with a mean of 13.1 (SD = 6.8) for normal weight participants and a mean of 18.3 (*SD* = 8.6) for overweight/obese participants. Although all ASI means are within normal limits for a non-clinical sample (Peterson & Reiss, 1993), the difference between means for the normal and overweight/obese samples was significant (t (53) = -2.47, p = .02; d = .7).

Mood Manipulation Check

An examination of change in PANAS scales prior to and following mood induction for those participants included in the analyses revealed both a significant reduction in positive affect (Pre: *M* = 29.1, *SD* = 8.5; Post: *M* = 24.4, *SD* = 8.5 t (56) = 7.76, p < .01; d = .6) as well as a significant increase in negative affect (Pre: *M* = 11.7, *SD* = 2.8; Post: M = 12.8, SD = 3.3; t (56) = -2.26, p < .01; d = .4).

Anxiety Sensitivity Independent of Eating Expectancies

Similar to Study 1, ASI total score was associated with state craving for food (measured prior to food exposure) at a trend level, (r = .26, p = .053). Multiple regressions were used to examine the main effect of ASI total score as well as each subscale score in predicting total calories consumed. In each analysis, sex was added as a covariate due to research suggesting a differential response to food cues between men and women (Havermans et al., 2011). Likewise, BMI and BMI by AS interaction were examined to evaluate whether AS effects were general or specific to overweight/obese individuals. Contrary to our hypothesis, ASI total score was not significant when considered as a main effect or in interaction with BMI as a predictor of calories consumed, nor were any of the three ASI subscales, AS-PC, AS-MC, and AS-SOC.

Interactions Between Anxiety Sensitivity and Eating Expectancies

To examine if anxiety sensitivity has greater predictive power in those with greater eating expectancy, two interactions were examined in separate regressions: (1) the interactions between EEI Scale 1 (eating to manage negative affect), and AS-PC (the AS physical concern subscale) as well as (2) EEI Scale 3 (eating leads to feeling out of control) and AS-MC (the AS mental concern subscale). Again, sex was treated as a covariate, and BMI was examined in conjunction with the variables of interest. For the evaluation of the interaction between EEI Scale1 and AS-PC, no effects were significant (Table IV). However, for the evaluation of the EEI Scale 3 by AS-MC interaction, significant effects were detected. Results of this analysis revealed a three-way interaction between EEI Scale 3, AS-MC, and BMI in predicting calories consumed (β = .662; *df* = 1, 44; *t* = 2.47; *p* = .02; *d* = .7), as well as a significant negative effect for AS-MC alone (β = -.50; *df* = 1, 44; *t* = -2.13; *p* = .04; *d* = .6). To evaluate the nature of the interaction, we examined the interaction between AS-MC and EEI Scale 3, separately for the normal weight and the overweight/obese individuals. Results revealed that the interaction term as well as sex, EEI Scale 3 and AS-MC were not significant when selecting for those in the normal weight range, but the interaction of AS-MC and EEI Scale 3 was significant in those with a BMI of 25 or greater. In this model, the interaction term contributed significantly (β = .927; *df* = 1, 25; *t* = 2.16; *p* = .04; *d* = .9) indicating that higher scores on both of these measures were associated with a greater amount of calories consumed. To better illustrate this effect, a median split for AS-MC and EEI Scale 3 scores was performed and depicted graphically showing calories consumed by normal weight and overweight/obese samples (Figure 1).

Study 2 Discussion

Contrary to our hypotheses, we did not find a simple and direct association between AS and calories consumed following a mood induction. However, a more-complex relationship was evident. First, a significant 3-way interaction between BMI, AS-MC and EEI Scale 3 was found for the prediction of calories consumed. To better understand this interaction, we examined the model separately for normal weight individuals and those in the overweight/obese category. Results indicated that among individuals for whom overeating poses the greatest concern (those who are already overweight/obese), a greater tendency to fear mental incapacitation coupled with a belief that eating will lead to feeling out of control predicted increased risk for maladaptive eating. This provides further support that, within a subsample of overweight individuals, AS contributes to maladaptive eating responses.

Discussion

Consistent with our hypotheses for Study 1, AS was associated with a greater expectancy that eating could be useful as an affect regulation strategy, as well as a belief that eating can lead to feeling out of control among overweight/obese individuals. Higher levels of AS were also associated with a greater self-reported urge to eat in response to negative emotional states. Based on these findings, Study 2 was conducted to examine actual eating behavior in the context of a negative mood induction in a sample of individuals who represented all weight classifications. Given the established relationship between trait negative affect and eating behavior (Grilo et al., 2001; Jansen et al., 2008), exclusion criteria were employed to select participants who did not endorse trait negative affect in an effort to examine AS outside the context of this potentially confounding/moderating variable. Our results did not support hypotheses for an overall effect of AS on laboratory-observed eating behavior regardless of weight category or eating expectancies. However, we did find significant interaction effects consistent with hypotheses. Specifically, we found a significant three-way interaction, reflecting a medium to large effect size, between BMI, EEI Scale 3 and AS-MC with further analyses suggesting that AS-MC and EEI Scale 3 interact to form an apparent risk factor for maladaptive eating in the overweight/obese participants but not those in the normal weight classification.

Although our hypotheses regarding the direct effects of AS on eating behavior were not supported, other studies have shown that the relationship between mood state and eating in response to emotional cues is complex. For example, research has demonstrated that self-identifying as an emotional eater does not reliably translate into observable eating behavior in experimental settings (Evers et al., 2009). Also, research suggests that the impact of emotional cues on eating may be specific to pre-existing mood state. For example, Jansen et al. (2008) found that pre-existing mood state moderated the effects of mood induction on eating in a non-clinical sample. Whereas overweight/obese individuals with high baseline negative affect consumed more calories following a sad mood induction, those with low negative affect behaved more similarly to the normal weight participants and showed no increased eating behavior following the induction. For the purposes of this study, AS was examined outside the context of elevated baseline negative affect to determine its independent effects; however, it may be the case that AS interacts with negative affect to predict eating behavior. Future research is needed to examine this possibility.

Our hypothesis regarding a positive interaction between AS-PC and EEI Scale 1 (expectancy that eating will help manage a negative affect) in overweight/obese individuals was not supported. Although previous research has shown that the AS-PC subscale is associated with the use of maladaptive coping responses to reduce negative affect (Zvolenskey et al., 2004), AS-MC, the fear of the cognitive consequences of anxiety, proved to be the more relevant subscale with regard to eating behavior in this sample, within our mood induction paradigm. This finding is consistent with work by Fulton and colleagues (2012) showing that AS-MC predicted disordered eating as measured by the EAT-26, a self-report measure commonly associated with detection of anorexia nervosa. The fact that actual consumption of additional calories was predicted by the interaction of AS-MC and EEI Scale 3 in overweight/obese participants in our study both expands this self-report association to actual eating behavior and also indicates there is a cognitive risk factor for maladaptive eating behavior that is outside the range of disorder eating assessed by the EAT-26, and supports a broader pattern whereby individuals who fear mental dyscontrol and loss of control with eating will be most likely to succumb to greater eating when under emotional stress.

Overall, our results contribute useful knowledge to the investigation of the role of AS in maladaptive eating behavior. Consistent with findings by Anestis and colleagues (2008), in Study 1 we found a relationship between AS and self-reported urge to eat in response to negative affect. Study 1 also demonstrated a link between AS and eating expectancy. Study 2 represented the first attempt, to our knowledge, to clarify the role of AS in actual eating behavior when a negative mood was experimentally induced. Our findings suggest that it may not be the fear of bodily sensations which tends to be most associated with AS, but rather the fear of mental dyscontrol which contributes to eating behavior in the context of the frustration induction employed in this study. Indeed, there appears to be a subset of overweight/obese individuals for whom the combined cognitive risk factors of fearing mental incapacitation more generally as well as more specifically feeling out of control when eating who are at greater risk for consuming additional calories in the context of a negative mood.

Although our study contributes to the understanding of the role of AS and eating expectancies in maladaptive eating behavior, several limitations and future directions should be considered. Both studies 1 and 2 are limited by their relatively small sample sizes, and hence, effects beyond the medium to large effect sizes detected may have been significant in a larger sample. Our study was also limited by our choice of affect induction strategy as well as the use of a laboratory setting for the assessment of eating behaviors. Indeed, we identified fear of mental incapacitation as relevant to eating behaviors, but this finding may be specific to our induction. As anxiety sensitivity has proven to be a marker of distress intolerance across a range of disorders including substance use, physical conditions and mood and anxiety disorders, additional research is needed across a greater range of affect inductions, and in people with pre-existing negative affect. Likewise, further investigation is needed to explicate the limitations on eating behaviors that are present in laboratory conditions (Evers et al., 2009). Studies of the role of AS and eating expectancy in a naturalistic setting would strongly contribute to the understanding of the true role of these constructs in eating behavior. In addition, examination of the role of these variables on eating behavior in eating disordered individuals would help to clarify whether this relationship is specific only to moderate consumption of additional calories in overweight/obese individuals or is also a predictor for individuals prone to engaging in true binge episodes.

In summary, we have provided evidence that AS is elevated in an overweight/obsese sample, that AS has predictive significance in relation to both eating motives (expectancies) and food craving. Additionally, we have demonstrated that subscales of AS identify potentially maladaptive eating patterns specific to an overweight/obese, as compared to a normal-weight, sample. Together, these findings support the notion that anxiety sensitivity may be a relevant risk factor for understanding the emergence or maintenance of obesity in the adult population. Further investigation of the role of AS in pathological eating behavior is particularly important given evidence that AS is a modifiable risk factor (see Craske et al, 2006; Smits, Berry, Tart, & Powers, 2008). Indeed, in the last few years, the field has witnessed the transformation of basic research on AS in smoking behaviors into novel clinical interventions for smoking cessation (Zvolensky et al., 2003). Given our findings, it appears that AS research may hold the same potential for understanding and intervening with maladaptive eating behaviors.

Chapter 3. Anxiety Sensitivity, Perceived Exertion, and Distress During Exercise

Obesity, as defined by a body mass index (BMI) of 30 or greater, has reached epidemic proportions in the United States with rates increasing from 15% in 1980 to 34% in 2010 (CDC, 2010; Flagel et al., 2002). Physical activity, when used in conjunction with dietary interventions, has demonstrated profound health benefits including weight loss and maintenance as well as the reduction in both the incidence of, and mortality from, a number of chronic health conditions including cancer, cardiovascular disease, stroke, and diabetes (Blair & Morris, 2009; Garrow & Summerbell, 1995; Goldberg & King, 2007; Leitzmann et al., 2007; Nocon et al., 2008; Paffenbarger, Hyde, Wing, & Hsieh, 1986).

Despite the obvious benefits of physical activity, 78% of the U.S. adult population does not engage in regular or sustained physical activity (Centers for Disease Control and Prevention, 2004). Additionally, of those who do adopt a regular physical activity program, more than half discontinue within three to six months (Dishman & Buckworth, 1996; Martin & Dubbert, 1985). The statistics paint an even bleaker picture among obese individuals such that only 19% of obese men and 17% of obese women in the United States meet minimum recommendations for daily physical activity (CDC, 2000), and obese individuals are even less likely to maintain a physical activity program than non-obese individuals (King et al., 1997, 2006). These statistics motivate the search for factors that influence rates of exercise avoidance among vulnerable populations.

Negative affect during exercise represents one contributor to exercise avoidance. For example, Williams and colleagues (2008) found that negative affect during moderate-intensity exercise among sedentary participants predicted less physical activity at 6- and 12-month assessments. This may be particularly detrimental to overweight/obese individuals as research shows they are more likely to report negative affect during exercise than those in the normal weight range (Ekkekakis & Lind 2006).

Distress intolerance, or the perceived inability to tolerate distressing somatic and affective states, may further moderate the effects of negative affect during physical activity. Anxiety sensitivity (AS), a measure of distress intolerance, is a trait-like variable that represents fear of anxiety-related symptoms (Peterson & Reiss, 1992), fueled by beliefs that somatic arousal and anxiety have catastrophic physical (e.g., having a heart attack, dying), mental (e.g., losing control, going crazy) or social (e.g., interpersonal rejection) consequences (McNally, 2002). Despite its obvious focus on anxiety-related symptoms, AS has performed well against other measures of distress intolerance across multiple domains of distress (McHugh et al., 2011), and has more recently been applied to health processes including eating behavior and exercise (Anestis et al., 2007; 2008; Deboer et al., 2012; Fulton et al, 2012; Hearon et al., 2012; Moshier et al., 2012; Smits et al., 2010).

Indeed, AS may be a central factor in exercise avoidance as it has been shown to heighten sensitivity to negative affective states (Ehlers, 1995; Otto et al., 1995; Reiss, 1991; Schmidt et al., 1997; Taylor, Koch, Woody, & McLean, 1996) as well as contributes to distress associated with unpleasant physical sensations such as pain

(Asmundson, Norton, & Veloso, 1999; Zvolensky, Goodie, McNeil, Sperry, & Sorrell, 2000). Therefore, AS may serve to amplify the aversiveness of somatic sensations associated with exercise and prolonged exertion - e.g., increased heart rate, respiration, and muscle fatigue - as well as the negative affect that may accompany these symptoms.

These effects may be particularly salient for obese individuals as there is evidence to suggest that high AS may be more common among this population. Elevated AS is a common factor in a number of Axis I disorders including anxiety and mood disorders while at the same time higher rates of these disorders are reported among obese individuals (Petry et al., 2008; Schmidt, Lerew, & Jackson, 1997; Schmidt, Zvolensky, & Maner, 2006). Providing further preliminary support for differences in AS between weight groups, a recent study conducted by our research team also noted that overweight/obese participants reported significantly higher AS than normal-weight participants (Hearon et al., 2012). Moreover, overweight/obese samples report greater physical discomfort and perceived exertion than normal-weight controls exercising at the same intensity level (Deforche, De Bourdeaudhuij, & Tanghe, 2006; Ekkekakis & Lind, 2006; Hulens et al., 2003). Therefore, reports of greater negative affect, perceived exertion and physical discomfort during exercise among obese individuals may be due, in part, to the amplification of affective and somatic distress by AS.

The possible amplification of negative affect by AS during exercise may also influence ratings of affect following exercise, as studies have shown that 20-minutes of moderate-intensity exercise (i.e., 70% of age-adjusted maximum heart rate) can yield significant affect benefits following exercise (Berger & Motl, 2000; Kirkcaldy &

Shephard, 1990; Ojanen, 1994; Raglin & Morgan, 1985) with some evidence to suggest that even shorter bouts at less intensity can increase positive affect in the short term (Ekkekakis, Backhouse, Gray & Lind, 2008). However, this affect benefit may be dependent upon enjoyment of the exercise experience itself (Miller, Bartholomew & Springer, 2005). Therefore, the AS amplification of negative affect and uncomfortable somatic sensations during exercise would likely decrease enjoyment during exercise, and, therefore, possibly reduce the affect benefits generally expected from this level of exercise.

Several studies have examined the role of AS in self-reported physical activity with the general consensus demonstrating a link between elevated AS and avoidance of physical activity. In a sample of undergraduates, McWilliams and Asmundson (2001) found that the physical concern subscale of AS was associated with less exercise frequency in men but not women; likewise, in a sample composed entirely of undergraduate females, those with high AS reported significantly less exercise than those with low AS (Sabourin et al., 2011). Additionally, a recent investigation examining a sample of more than 200 adults found an inverse relationship between AS and vigorous physical activity with no evidence that this effect was moderated by sex (Moshier et al., 2012).

Smits and colleagues (2010) conducted the first laboratory-based examination of the relationship between AS, body mass, and distress during exercise. In this study, participants completed a 20-minute treadmill exercise at 70% of their age-adjusted maximum heart rate. Results revealed that those participants with both elevated AS and higher body mass reported the highest ratings of distress during the exercise task providing further support that AS effects on exercise may be greatest among obese individuals.

In summary, evidence supports an association between high AS and avoidance of physical activity. This relationship may be particularly problematic for obese individuals as this population reports greater negative affect and physical distress during exercise, both of which may be amplified by AS. Despite the promise of previous findings to aid our understanding of exercise avoidance, there are no studies to our knowledge directly examining the role of AS in ratings of perceived exertion during and affect changes following exercise.

This represents an important research question since the amplification of negative affect and bodily discomfort experienced by those with high AS may lead individuals to misinterpret the intensity of their daily physical activity as greater than it actually is (i.e., mistakenly classifying light-intensity activity for the moderate-intensity exercise recommended to realize most health benefits). In turn, this may lead to overestimates of the health benefits achieved through a given activity such as overestimating cardiovascular benefits or calories burned. Indeed, research to date demonstrates that although exercise has a beneficial effect on appetite control in the short term (e.g., Martins et al., 2007; Martins et al., 2008), weight gain is common in the context of physical activity programs (Ross & Janssen, 2001; King et al., 2008; Pomerleau et al., 2004). This failure of programmed physical activity alone to produce sustained weight loss has been attributed, in part, to misjudgments about calorie expenditure and intake

(King et al, 2007; Blundell & King, 1998). Simply put, AS may aid in the identification of individuals more susceptible to compensatory eating following physical activity due to a misperception of the amount of calories actually expended.

In the current study, we built upon the work of Smits and colleagues (2010) by repeating their physical activity procedures; however, in addition to ratings of distress, participants also provided ratings of perceived exertion at five-minute intervals throughout the treadmill exercise, mood ratings prior to and after exercise, and an estimate of calories utilized during the workout. We hypothesize that AS will be associated with ratings of perceived exertion and distress such that those with higher AS will report greater distress and exertion. With respect to affect changes, we hypothesize that AS will interact with perceived exertion such that those with elevated AS who perceived their workout as most strenuous will not experience the positive affect increase that normally emerges after moderate-intensity exercise (see Bartholomew, Morrison, & Ciccolo, 2005; Miller, et al., 2005). We also hypothesize that AS will predict overestimates of calories burned during the workout period, particularly in those with higher levels of perceived exertion. Finally, given evidence that AS effects during exercise may be greatest among obese individuals, we hypothesize that BMI will serve as a moderator of the aforementioned effects.

Methods

Participants

Thirty-nine participants were recruited from the community using Internet postings. Interested individuals aged 18 to 55 completed a phone screen to determine initial eligibility. In order to allow for comparison between the normal and high extremes of AS and weight, only those with a body mass index (BMI) within the ranges of 18.5-24.9 (normal weight) or 30.0 to 39.9 (obese), and an Anxiety Sensitivity Index Score (ASI) score of less than 12 (normal AS) or greater than 20 (elevated AS) at the time of phone screening, were included. In addition, exclusion criteria included self-reported status as a current or recently quit (i.e. within the past 6 months) smoker, difficulty reading forms such as those at the doctor's office, pregnancy, or any health condition such as diabetes, asthma, cardiovascular disease, or musculoskeletal problems deemed uncontrolled or which would make exercise contraindicated as determined by a health history screening performed by the study physician. Given increased risk of health difficulties associated with aging and morbid obesity (American College of Sports Medicine, 2006), 55 represented the maximum allowable age and 39.9 represented the maximum allowable BMI in the study. Participants who attended the 2-hour study appointment and completed all procedures received $40 in compensation. One participant completed informed consent, but was discontinued from study procedures due to inability to follow safety instructions provided by the experimenter; therefore, data from this participant was excluded. Boston University's Institutional Review Board approved all study procedures.

Procedures

After participants completed informed consent, study staff measured height and weight, and the participant then met with the study physician to complete a health history screening which included the Physical Activity Readiness Questionnaire (PAR-Q; Shephard, Cox, & Simper, 1981). Upon clearance from the study physician, participants completed a battery of self-report questionnaires including a measures of AS and state affect described below. Participants next engaged in physical activity procedures. To control for exertion level, exercise was set at 70% of age adjusted maximum heart rate (calculated as 220 – age * .70) plus or minus 3 bpm. Heart rate was monitored using a Polar FT4 heart rate monitoring device which included a chest strap worn by the participant, and a watch which recorded and displayed heart rate held by the experimenter to ensure the participants' ratings of exertion were not influenced by knowledge of their heart rate. Study staff steadily increased treadmill speed during a 3-minute warm-up period until the targeted heart rate was achieved and maintained for 30 seconds. During the 20-minuted treadmill exercise period, study staff made any necessary adjustments to treadmill speed to maintain participants in the targeted heart rate range. Participants made ratings of perceived exertion using the Borg Rating Scale of Perceived Exertion (BRSPE; Borg et al., 1998) and ratings of distress using a Subjective Units of Distress Scale (SUDS; Wolpe, 1958) at 5-minute intervals during the treadmill exercise. Following completion of the treadmill exercise, participants again completed a measure of state affect as well as provided an estimate of calories burned during the 20-minute exercise.

Estimates were then compared to the measurement of actual calories burned provided by the Polar fitness device which accounts for height, weight, and gender in its calculation.

Measures

Demographics Questionnaire – The demographics questionnaire examined basic participant information such as age, education level, and race/ethnicity.

Positive and Negative Affectivity Scale (PANAS) – The PANAS was developed as a brief measure of affect, and yields the factors of positive and negative affectivity (Watson, Clark and Tellegen, 1988). Twenty-two emotions are rated on a 5-point scale of the extent each emotion is felt at the moment of assessment. The scale ranges from (1) very slightly or not at all to (5) extremely.

Anxiety Sensitivity Index (ASI) – The ASI is a 16-item self-report questionnaire designed to assess tendency to respond fearfully to anxiety-related symptoms by rating each item on a 5-point Likert scale from (0) very little to (4) very much (Peterson & Reiss, 1992).

Subjective Units of Distress (SUDS) - The SUDS (Wolpe et al., 1958) is a widely used measure in anxiety research which asks participants to rate distress on a 0 (no distress) to 10 (maximum distress) scale and demonstrates adequate psychometric properties (Kaplan, Smith & Coons, 1995).

Borg Rating Scale of Perceived Exertion (BRSPE) – The BRSPE asks participants to rate their level of physical exertion on a scale ranging from 0 (no exertion) to 10 (extreme exertion) and can be used repeatedly during an episode of physical activity. This measure has been shown to reliably estimate exertion when compared to physical measures such as heart rate (Borg, 1998). To help distinguish between ratings of distress and exertion, participants were instructed that the BRPSE was a measure of how hard they were physically working where 0 would represent absolutely no exertion such as lying in bed and 10 would represent the highest degree of physical exertion they could imagine, while SUDS ratings represented any distress related to the exertion and could encompass both physical and emotional discomfort.

Data Analysis

Data was examined for outliers with none found for variables used in the following analyses. One participant failed to make ratings of calories burned during exercise and is excluded from analyses examining that variable. To examine the hypotheses that included the interaction of AS and BMI, interaction terms for AS and BMI were calculated. BMI and ASI totals scores were mean centered for all analyses. To examine the relationship between AS, BMI, and perceived exertion in predicting changes in affect, a 3-way interaction of AS, BMI, and BRSPE was calculated. Regression models were then examined for each hypothesis. Given our relatively small sample size, significance testing was complimented by examination of effect sizes as informed by Cohen (1994).

Results

Preliminary Analyses

Demographic information is presented in Table V. The sample was relatively young with a mean age of 25 years (SD = 9) and predominantly female (71%). Consistent with our selection method for high and low ASI scores, there was no significant difference between mean ASI scores for obese (M = 15.87, SD = 11.8) and normal weight participants (*M* = 15.45, *SD* = 7.1; *t* (36) = -0.14, *p* = .89; *d* = .05). There were also no differences in PANAS positive affect scores between normal weight (*M* = 25.68, *SD* = 7.2) and obese participants (*M*= 29.63, *SD* = 9.3; *t* (36) = -1.48, *p* = .15; *d* = .48) prior to exercise.

Anxiety Sensitivity, Distress and Perceived Exertion During Exercise

To examine the effects of AS and weight on maximum reported distress during exercise, we entered ASI, BMI, and their interaction into a regression model predicting maximum SUDS ratings provided during the exercise challenge. Contrary to our hypothesis, results revealed no significant effects for ASI (β = .12; *df* = 1, 34; *t* = 0.68; *p* = .50; *d* = .23), BMI (β = .16; *df* = 1, 34; *t* = 0.42; *p* = .67; *d* = .14), or their interaction (β = -.16; *df* = 1, 34; *t* = -0.42; *p* = .68; *d* = .14). The same model was then examined for the prediction of the maximum perceived exertion during exercise; once again, no significant effects for ASI (β = -.25; *df* = 1, 34; *t* = -1.46; *p* = .16; *d* = .50), BMI (β = -.57; *df* = 1, 34; *t* = -1.59; *p* = .12; *d* = .55), or their interaction (β = .38; *df* = 1, 34; *t* = 1.06; *p* = .30; *d* = .36) were found.

Anxiety Sensitivity, Perceived Exertion and Changes in Positive Affect After Exercise

Changes in the PANAS positive scale prior to and following exercise (post - pre; positive scores indicating an increase in positive affect) ranged from a 6-point decrease in positive affect to a 16-point increase with a mean change of 3.58 point increase in positive affect overall (*SD* = 6.0). To examine the effects of BMI, ASI total, perceived exertion, and their 3-way interaction, a regression model was examined predicting changes in positive affect. Results revealed no main effects for ASI (β = .07; *df* = 1, 33; *t*

= 0.42; p = .68; d = .15), or BMI (β = -.04; df = 1, 33; t = -0.26; p = .80; d = .09), but a significant main effect for perceived exertion (β = .38; df = 1, 33; t = 2.26; p = .03; d = .79) with a trend toward significance for the 3-way interaction (β = -.29; df = 1, 33; t = -1.74; p = .09; d = .61) reflecting a moderate effect size emerged. The sample was then split by weight category (normal vs. obese) and the effect of ASI total score, perceived exertion and their interaction on changes in positive affect were examined for each group. In the normal weight group, results showed a significant main effect in the very large range for perceived exertion (β = .52; df = 1, 18; t = 2.42; p = .03; d = 1.14) indicating that greater perceived exertion was associated with an increased positive affect following exercise, but no significant findings for ASI nor the interaction of ASI and perceived exertion (with effects in the small range). However, in the obese group, moderate to large effect sizes were noted for ASI (β = .96; df = 1, 12; t = 1.12; p = .28; d = .65) and the interaction of ASI and perceived exertion (β = -1.28; df = 1, 12; t = -1.51; p = .16; d = .87). A mean split was then performed for ASI total score, and correlations between perceived exertion and positive affect changes were examined. For those obese individuals with relatively low AS, greater perceived exertion was associated with a moderate to large increase in positive affect (r = .61, p = .11), whereas, in those with relatively high AS, greater perceived exertion was associated with a moderate to large decrease in positive affect (r = -.58, p = .13) as judged by effect sizes. Taken together, these analyses indicate that for those with both high AS and BMI, greater perceived exertion is associated with a decrease in positive affect: however, for those in the normal weight group as well as obese individuals without high AS, greater perceived exertion is associated with an increase in positive affect.

Anxiety Sensitivity, Perceived Exertion and Estimates of Calories Burned

Overall, the sample was fairly accurate in estimating calories burned during the exercise period with an overall mean difference between actual and predicted calories burned of only 7.6, but with high variability in accuracy (SD = 109.5). To examine the effects of AS, perceived exertion and BMI on estimate accuracy, we entered ASI total, BMI, perceived exertion, and their 3-way interaction into a regression model predicting the difference between actual and predicted calories burned. Results indicated no significant effects for perceive exertion (β = -.18; df = 1, 32; t = -0.99; p = .33; d = .35) or BMI (β = .09; df = 1, 32; t = 0.52; p = .61; d = .21) with effect sizes in the small range. However, effect sizes for ASI (β = -.24; df = 1, 32; t = -1.39; p = .18; d = .49) and the interaction (β = .27; df = 1, 32; t = 1.51; p = .14; d = .53) were non-significant but in the moderate range.

Discussion

As obesity rates in the Unites States continue to rise (CDC, 2012), identification of psychological factors that may influence physical activity initiation and adherence becomes increasingly important. Although recent research suggests that AS may represent an important construct for identifying those individuals most likely to avoid exercise due to amplification of distress experienced during the workout (Smits et al., 2010), our study did not replicate these findings. In this sample, we found no direct effects of AS on perceptions of exertion and distress during a moderate-intensity exercise task. Additionally, our findings did not support research suggesting AS effects on exercise may be most evident among obese individuals (Ekkekakis et al., 2006; Smits et al., 2010). However, our results did reveal that the relationship between AS and exercise avoidance may be more complex than initially anticipated. We found effect sizes indicating that, overall, greater perceived exertion predicted an increase in positive affect in the context of moderate-intensity exercise. However, examination of a trend-level interaction between perceived exertion, AS, and BMI revealed that for obese individuals with relatively high AS, greater perceived exertion was associated, at the level of a large effect size, with a decrease in positive affect.

Given previous findings which showed that obese individuals experience greater negative affect, physical distress, and perceived exertion during exercise (Deforche, De Bourdeaudhuij, & Tanghe, 2006; Ekkekakis & Lind, 2006; Hulens et al., 2003) in addition to evidence of an interaction between AS and BMI in predicting this distress (Smits et al., 2010), we hypothesized that AS would interact with perceived exertion such that obese individuals with elevated AS who perceived their exertion as greater would be least likely to benefit from the increase in positive affect usually experienced following moderate-intensity exercise (Bartholomew et al., 2005). Consistent with this hypothesis, our findings did indicate a trend toward a decrease in positive affect following exercise among obese participants with elevated AS who perceived their exertion as greatest. Conversely, a significant main effect for perceived exertion in the normal weight group as well as a strong association between perceived exertion and increased positive affect in obese participants with low AS was found. This indicates that those obese individuals with elevated AS may represent a unique population that does not experience the affect benefits of exercise when they perceive their workout as more strenuous, possibly due to less enjoyment during exercise (Miller et al., 2005).

Additionally, we did not find evidence to suggest that AS significantly contributed to overestimates of calories consumed when examined as a main effect or in conjunction with perceived exertion and BMI. However, the effect size for AS was in the moderate range indicating that elevated AS was associated with greater overestimates of calories expended during exercise.

Several limitations should be considered when interpreting results of this study. Our relatively small sample size prevented detection of effects below the moderate level as well as examination of 3-way interactions. Adding to this limitation, we struggled to recruit our main sample of interest, obese individuals with high AS. Interestingly, this limitation may be consistent with our hypothesis that physical activity is particularly aversive to this population. Another of our studies, using identical recruitment procedures that did not require physical activity as part of the experimental protocol, had no difficulty reaching its targeted number of obese individuals with high AS. However, due to the limited number of individuals in this group, results including AS and BMI interactions must be interpreted with caution. Also, although there were changes in positive affect following only 20 minutes of moderate-intensity exercise, research indicates that to realize full benefits, a continuous exercise bout of approximately 40 minutes is recommended (Ekkekakis, 2003; Hale et al., 2002), and examination of AS in the context of longer exercise sessions is required. Additionally, future studies with larger sample sizes and more even distribution among AS and weight categories are needed to better understand the effects of AS and potential moderators on physical activity.

In summary, although this study did not replicate previous findings indicating that obese individuals with high AS report greater distress during exercise (Smits et al., 2010) or note a significant relationship between AS and BMI in predicting perceived exertion, we did provide clarification as to the role of AS in predicting those most likely to realize the affect benefits following moderate exercise. Therefore, to increase physical activity initiation and adherence, interventions such as interoceptive exposure, which has been shown to reliably reduce AS (see Craske et al, 2006; Smits, Berry, Tart, & Powers, 2008), may have a role.

Chapter 4. Compensatory Eating after Exercise and Health Halos

Obesity remains a significant public health concern as the World Health Organization (WHO; 2009) reports that 65% of the world population now resides in a country where being overweight or obese causes more deaths than being underweight. This health concern persists despite reported efforts to lose or maintain weight. For example, a survey of more than 180,000 Americans revealed that 46% of women and 33% of men reported that they were actively trying to lose weight. Only 19% and 22% of this sample of women and men, respectively, reported meeting minimum recommendations for weight loss intervention - caloric restriction and a minimum of 150 minutes of moderate-intensity physical activity per week (Bish, Blanck, Serdula, Marcus, Kohl, & Khan, 2005). Such evidence suggests that many individuals recognize the need for weight reduction but have difficulty persisting with recommended weight loss strategies. In the current study, we explore two factors that may contribute to persistence of weight-management difficulty: compensatory eating (CE) following exercise and halo effects.

CE refers to an increase in caloric intake to compensate for caloric deficits brought about by physical activity (Epstein & Wing, 1980), and represents one of the reasons why physical activity in the absence of dietary monitoring is often an unsuccessful intervention strategy for sustained weight loss (Ross & Janssen, 2001; King et al., 2008; Pomerleau et al., 2004). Although CE is sometimes a volitional behavior (i.e., purposely using food as a reward for exercising), it is often unintentional, such that individuals who initiate an exercise program subtly increase their caloric consumption at meals without realizing it (King et al., 2007).

One source of this unintentional increase in calories may be halo effects. Halo effects refer to factors such as food placement, advertising, and presentation which lead individuals to underestimate calorie content and engage in subsequent over-consumption of food (Wansink & Chandon, 2006; Chandon & Wansink, 2007). For example, the inclusion of a healthy side dish in a photo of food is associated with reduced calorie estimations of a meal as compared to calorie estimates of the same meal without the healthy side dish (Chernev, 2010). Likewise, linking a food with healthy-eating messages also appears to decrease estimated calories of a meal (Chandon & Wansink, 2007). Research suggests that individuals tend to categorize foods dichotomously as either "healthy" or "unhealthy," and use the overall perceived healthiness of a meal to estimate its calorie content (Chernev, 2010). Therefore, incorporating a "healthy" side dish into a meal increases the individual's overall perception of its healthiness and decreases estimated calories. Indeed, there is evidence that halo effects are paradoxically greatest among individuals who are purposely trying to manage their weight as these individuals are even more susceptible to dichotomous categorization of "healthy" versus "unhealthy" foods (Chernev & Gal, 2010; Rozin, Ashmore, & Markwith, 1996; Wertenbroch, 1998; Knight & Boland, 1989).

With regard to exercise, there is evidence of a halo effect following a health prime. A study by Albarracin and colleagues (2009) found that simply viewing messages that promote exercise either subliminally or directly lead to increased eating behavior among participants who viewed pro-activity messages as compared to controls who viewed neutral messages. Hence, both actual physical activity and public health messages promoting exercise may be driving individuals to increase their calorie consumption. However, to our knowledge, no published study has specifically examined halo effects within the context of actual physical activity. More specifically, it is not known whether actual physical activity (i.e., engagement in a "healthy" behavior) leads individuals to underestimate the calorie content of food similar to the effects seen when a "healthy" side item is added to a meal or an individual is primed with a pro-activity message. Additionally, identification of psychological factors that predict a person's susceptibility to engage in both CE as well as halo effects may provide a valuable screening and intervention point for weight management treatments.

In this chapter, we will examine 1) whether exercise leads to halo effects, and 2) whether anxiety sensitivity (AS) serves as a predictor of both halo effects and CE. AS refers to the fear of anxiety-related symptoms caused by a belief that somatic arousal and anxiety itself have catastrophic consequences across three domains, physical (e.g. having a heart attack, dying), mental (e.g. losing control, going crazy), and social (e.g. interpersonal rejection, embarrassment; McNally, 2002). As detailed in previous chapters of this dissertation, AS predicts heightened sensitivity to negative affective states (Ehlers, 1995; Otto et al., 1995; Reiss, 1991; Schmidt et al., 1997; Taylor, Koch, Woody, & McLean, 1996) and has already been implicated in maladaptive eating behavior as well as distress during, and avoidance of, physical activity, with some evidence to suggest these effects are greatest among overweight/obese populations

(Anestis et al., 2007; 2008; Fulton et al., 2012; Hearon et al., 2012; Moshier et al., 2012; Smits et al. 2010). With regard to CE, AS may amplify negative affect and unpleasant somatic sensations experienced during exercise that could increase CE in two ways 1) by causing individuals to eat as a means of coping with the negative affect and somatic sensations, and 2) by causing individuals to over-estimate the intensity of their workout and subsequently misjudge the number of calories needed to replace those expended during exercise. In the case of halo effects, the over-estimation of exercise intensity may also contribute to perceptions of “healthiness” of the behavior, thereby, also amplifying the halo associated with the workout.

In the present study, we examined CE and halo effects in a sample of 38 adults who engaged in 20 minutes of moderate-intensity physical activity in the laboratory setting. We first hypothesized that we would replicate the findings of Chrenev (2010), such that participants who viewed images of the same foods with and without a healthy side dish included would rate the images including the healthy side dish as less caloric. We also hypothesized that physical activity would lead to a halo effect such that those who viewed the same food images prior to exercise would rate them as more caloric than those who viewed the images following exercise. In addition, we hypothesized that high AS would predict stronger halo effects as well as greater CE when food was offered after exercise and greater discrepancy between perceived and actual calories consumed. We also examined the moderating effects of BMI and sex on CE.

Methods

Participants

As previously reported in Chapter 3 of this dissertation, thirty-nine participants were recruited from the community using Internet postings. Interested individuals aged 18 to 55 completed a phone screen to determine initial eligibility. In order to allow for comparison between the normal and high extremes of AS and weight, only those with a body mass index (BMI) within the ranges of 18.5 to 24.9 (normal weight) or 30.0 to 39.9 (obese), and an Anxiety Sensitivity Index Score (ASI) score of less than 12 (normal AS) or greater than 20 (elevated AS) at the time of phone screening were included. In addition, exclusion criteria included self-reported status as a current or recently quit (i.e., within the past 6 months) smoker, difficulty reading forms such as those at the doctor's office, pregnancy, or any health condition such as diabetes, asthma, cardiovascular disease, or musculoskeletal problems deemed uncontrolled or which would make exercise contraindicated as determined by a health history screening performed by the study physician. Given the increased risk of health difficulties associated with aging and morbid obesity, 55 years represented the maximum allowable age and 39.9 represented the maximum allowable BMI in the study. Participants who attended the 2-hour study appointment and completed all procedures received $40 in compensation. One participant completed informed consent, but was discontinued from study procedures due to an inability to follow exercise safety instructions provided by the experimenter; therefore, data from this participant was excluded. Another participant reported a food allergy and did not participate in the compensatory eating task. Boston University's

Institutional Review Board approved all study procedures. Demographic information is provided in Table V.

Procedures

After participants completed informed consent, study staff measured height and weight, and each participant met with the study physician to complete a health history screening which included the Physical Activity Readiness Questionnaire (PAR-Q; Shephard, Cox, & Simper, 1981). Upon clearance from the study physician, participants completed a battery of self-report questionnaires including measures of AS and time since last meal or snack prior to the experimental appointment. They were then block randomized based on high vs. low AS and normal vs. obese BMI to provide calorie estimates of food images either before and after exercise or after exercise alone. Randomization did not allow any participant to rate the exact same image both before and after exercise. Those participants randomized to make calorie estimates prior to the exercise task did so approximately 10 minutes before the task commenced. Participants were also explicitly asked if they were taking any medications or diet pills/supplements that could affect their appetite as well as number of caffeinated beverages consumed that day. No participants endorsed use of medications or supplements known to affect appetite, and no participant endorsed greater than 2 caffeinated beverages on the day of the experimental appointment nor greater than 1 caffeinated beverage within the hour prior to the experimental appointment. Participants next engaged in physical activity procedures described in detail in Chapter 3 of this dissertation.

Following a 10-minute cool-down period after the moderate-intensity exercise, participants made post-exercise ratings of images. The experimenter showed participants the assigned images (described below) and asked the standardized question, “How many calories do you think are in this meal?” Following another 20 minutes of rest, participants were then informed they would be completing a taste test to determine snack preferences following exercise. Experimenters presented participants with a tray of pre-weighed snack foods including salted peanuts, chocolate chip cookies, potato chips, and chocolate and informed participants they could consume as little or as much food as they desired to complete the “taste test” and any remaining food would simply be thrown away. Participants were then left for exactly 10 minutes to complete the taste test. After this time, the experimenter removed the food from the room and asked participants to estimate how many calories they consumed during the taste test. This was later compared to actual calories consumed.

Measures

Demographics Questionnaire – The demographics questionnaire examined basic participant information such as age, education level, and race/ethnicity.

Anxiety Sensitivity Index (ASI) – The ASI is a 16-item self-report questionnaire designed to assess tendency to respond fearfully to anxiety-related symptoms by rating each item on a 5-point Likert scale from (0) very little to (4) very much (Peterson & Reiss, 1992).

Food Images

Identical images to those used by Chernev (2010) were used in this study. They included an image of a bacon cheeseburger (image code A1), the same bacon cheeseburger paired with an apple (image code B2), a bowl of chili (image code B1), and the same bowl of chili paired with three celery sticks (image code A2). To allow for comparison both within subjects before and after exercise as well as between subjects, participants were block randomized by weight and AS groups to view images as 1) Pre-exercise A, Post –exercise B, 2) Pre-exercise B, Post-exercise A, 3) Post-exercise A only, or 4) Post-exercise B only.

Data Analysis

Simple effects between weight groups (i.e., obese vs. normal weight) were examined using independent samples t-tests. We then used a 2x2 ANOVA to determine the possible between-subjects halo effects of viewing images pre or post exercise as well as with and without a healthy side dish. We then examined the same hypothesis within those subjects assigned to make ratings both before and after exercise using a repeated measures ANOVA. To examine the hypotheses that included the interaction of AS and BMI or AS and sex, interaction terms representing ASI total score and BMI as well as ASI and sex were calculated. BMI and ASI were mean centered for all analyses. Regression models were then examined for each hypothesis. Given our relatively small sample size, significance testing was complimented by examination of effect sizes as informed by Cohen (1994).

Results

Preliminary Analyses

All data was examined for outliers. In the case of calories consumed during the sham taste test, one participant consumed significantly more calories than the rest of the sample (i.e., greater than 4 standard deviations above the sample mean). A discrepancy of the same magnitude was noted for the difference between actual and estimated calories consumed for this participant; therefore, data from this participant was excluded for analyses including these variables. Consistent with our selection method for high and low ASI scores, there was no significant difference between mean ASI scores for obese (M = 15.87, SD = 11.8) and normal weight participants (M = 15.45, SD = 7.1; t (36) = -0.14, p = .89; d = .05).

Anxiety Sensitivity and Compensatory Eating

The sample consumed an average of 379 calories (SD = 297) during the sham taste test. Participants did not differ between sweet (chocolate and cookies; M = 212.10, SD = 265.4) and savory (potato chips and nuts; M = 211.10; SD = 205.5) calories consumed (t (37) = .02, p = .98). To determine associations between AS and BMI, and calories consumed after exercise during the sham taste test, ASI total score, BMI, and their interaction were entered into a regression model also co-varying time since last food consumed prior to the study appointment. Results revealed no significant effects for ASI (β = -.04; df = 1, 32; t = -0.23; p = .82; d = .08), BMI (β = .12; df = 1, 32; t = 0.70; p = .49; d = .17) or their interaction (β = -.02; df = 1, 32; t = 0.09; p = .93; d = .03). Time since last meal was also not significant (β = .16; df = 1, 32; t = 0.92; p = .36; d = .33).

Sex was also examined as a possible moderator of AS effects on compensatory eating in a second regression model including ASI total score, sex, and their interaction in predicting calories consumed following exercise, again co-varying time since last meal. Results again revealed no significant effects for ASI (β = -.12; *df* = 1, 32; *t* = -0.77; *p* = .45; *d* = .27), their interaction (β = -.19; *df* = 1, 32; *t* = -1.19; *p* = .24; *d* = .42) or time since last meal (β = .05; *df* = 1, 32; *t* = 0.30; *p* = .77; *d* = .12). However, a significant main effect for sex in the large range did emerge (β = .44; *df* = 1, 32; *t* = 2.70; *p* = .01; *d* = .95) indicating that men consumed more calories than women.

Anxiety Sensitivity and Accuracy of Estimated Calories Consumed

To examine AS effects on accuracy of estimated calories consumed, a difference score was calculated between actual and estimated calories consumed. ASI total score, BMI, and their interaction were entered into a regression model predicting this difference score. Results revealed no significant predictors in this model, ASI total score (β = -.08; *df* = 1, 32; *t* = -0.44; *p* = .67; *d* = .16), BMI (β = .13; *df* = 1, 32; *t* = 0.75; *p* = .46; *d* = .27), interaction term (β = .04; *df* = 1, 32; *t* = 0.21; *p* = .83; *d* = .07). Sex was then examined as a possible moderator in an identical model that replaced BMI with sex. Results revealed no effect of ASI (β = -.17; *df* = 1, 32; *t* = -1.15; *p* = .26; *d* = .41) or the interaction of sex and ASI (β = -.19; *df* = 1, 32; *t* = -1.26; *p* = .22; *d* = .45) in predicting estimate accuracy. However, there was a significant main effect for sex (β = .53; *df* = 1, 32; *t* = 3.46; *p* < .01; *d* = 1.22) in the very large range. An independent samples t-test examining mean differences in estimate accuracy revealed that male participants (*M* = 456, *SD* = 381) reported significantly greater underestimates of calories consumed than female participants (*M* = 156, *SD* = 194; t (34) = -3.15, $p < .01$; d = 1.08).

Halo Effects for Food Images

We investigated the effects of the exercise condition and type of picture rated (i.e., with vs. without healthy side item) using both a between-subject comparison of changes in calorie ratings across exercise and a within-subject comparison of pre- and post-exercise calorie ratings for the subset of participants who completed ratings at both time points. For the between-subject analysis, we compared pre-exercise ratings of those randomized to the pre/post conditions and post ratings from the post-only conditions, using a 2x2 ANOVA to examine the effects of time (i.e., viewing images pre vs. post exercise) and picture type (i.e., viewing the cheeseburger alone or with the apple) as well as the interaction of these two factors predicting overall calorie estimates of the images that included the cheeseburger. Results were not significant for exercise ratings before and after exercise (F (1, 34) = 1.08, p = .31; d = .36), picture type (i.e., with or without apple; F (1, 34) = 0.33, p = .57; d = -.20), or their interaction (F (1, 34) = 0.06, p = .80; d = .19). The same 2x2 ANOVA was then used to examine total calorie estimates of the two images that included the bowl of chili with results again revealing no significant effects for pre/post exercise (F (1, 34) = 1.54, p = .22; d = -.42), picture type (i.e., with our without celery; F (1, 34) = .11, p = .74; d = .11) or their interaction (F (1, 34) = .04, p = .85; d = .11). Although non-significant, effect sizes for pre/post exercise rating for those pictures containing the cheeseburger and those containing the chili were in the small-to-medium range indicating a trend such that calorie estimates were greater for post–versus pre-exercise ratings.

To investigate the effects of making calorie ratings pre- versus post-exercise within those subjects who completed ratings at both time periods, a repeated measures ANOVA was used examining the sum of calorie estimates made for pictures prior to and following exercise, co-varying whether the chili and cheeseburger combination common to ratings made at each time point included either an apple paired with the cheeseburger or celery paired with the chili. Results revealed no significant effect for pre- versus post-exercise ratings (F (1, 17) = .32, p = .58; d = .27) or the covariate (F (1, 17) = .17, p = .43; d = .20).

Anxiety Sensitivity and Halo Effects

To determine whether anxiety sensitivity enhanced halo effects for ratings before and after exercise, ASI total, pre/post exercise timing, and their interaction were added into a regression model predicting the difference between the A images (i.e., those containing the apple paired with the cheeseburger as well as a single bowl of chili) and B images. (i.e., those containing the bowl of chili paired with celery as well as a single cheeseburger). Results indicated that ASI (β = -.05; df = 1, 15; t = -0.16; p = .87; d = .08), pre/post exercise (β = .14; df = 1, 15; t = 0.55; p = .59; d = .28) and their interaction (β = -.11; df = 1, 15; t = -0.40; p = .70; d = .21) did not significantly contribute to calorie estimates of the images presented.

Discussion

Despite a desire to lose weight, relatively few people are able to reach this goal and maintain a healthy weight over time (Bish et al, 2005; Flagel et al., 2002; CDC, 2012). In the current study we examined two factors, CE and halo effects, to determine their impact on perceptions of the calorie content of food as well as actual food consumption in the context of moderate-intensity physical activity.

With regard to CE, we did not find any associations between AS and calories consumed 30-minutes following the completion of moderate-intensity exercise. We also found no associations between AS and accuracy in estimating calories consumed during the sham taste test indicating that any possible amplification of negative affect or somatic distress during the workout did not influence participants' ability to monitor their subsequent caloric intake. However, a main effect for sex indicated that male participants were significantly more likely to underestimate the amount of calories they consumed than female participants. The difference in estimate accuracy between sexes may be due, in part, to differences in weight management behavior between men and women. As Bish and colleagues (2005) demonstrated, a higher overall percentage of women surveyed reported trying to lose weight than their male counterparts (46% vs. 33%). In addition, the same study revealed that women initiate weight management behavior at a lower BMI. For instance 60% of women in the overweight range (BMI range 25.0 – 29.9) endorsed trying to lose weight while men did not reach this level until they were in the obese weight category (BMI of 30.0 or greater; Bish et al., 2005). Such evidence suggests that women may be more calorie-conscious than men leading to greater estimate accuracy, particularly when all foods presented in the sham taste test (i.e., potato chips, cookies, chocolate and nuts) were "unhealthy." Although Chernev (2010) noted increased susceptibility to dichotomously categorizing foods as "healthy" or "un-healthy" and subsequent halo effects in individuals trying to control their weight, dieters completing the sham taste test would not have experienced this effect as all foods were "unhealthy."

This study also failed to repeat the previous halo findings of Chernev (2010) as viewing the same food images with or without a healthy accompaniment did not significantly influence calorie ratings. This inability to detect significant effects is likely due to our small sample size. In the study conducted by Chernev (2010), more than 900 participants made calorie ratings of the food images while effect size overall for differences between an unhealthy food alone versus the same food paired with a healthy one was significant but small (i.e., $d = .24$). Similarly, our effect sizes were also in the very-small-to-small range ($d = -.20$ to .11) with participants demonstrating opposite effects for the cheeseburger pictures such that estimates were greater for the image also containing an apple. This calls into question the reliability of halo findings in this context. Although the perception of caloric reduction when a healthy side dish is added may be subtle, if further study finds this type of halo effect reliable, this small difference can still contribute to weight management difficulties over time as even the 43-calorie average discrepancy observed by Chrenev (2010) could contribute to weight gain if such ratings do indeed translate to chronic differences in actual eating behavior. Also, Chernev (2010) noted that although all individuals are potentially susceptible to the halo effects of this image-rating paradigm, effects were greatest among those individuals self-identified as current dieters. This indicates that effects may be larger among specific populations, such as those elevated on dietary restriction, warranting further examination.

There were also no observable halo effects with regard to rating images before or after exercise. In fact, although results did not reach significance, effect sizes in the small-to-moderate range were found for both between and within subjects examination of exercise effects, indicating that participants assigned greater calorie ratings after exercise. Rather than replicating the effects of a health prime as reported by Albarracin and colleagues (2009) and as hypothesized, actual exercise in our study increased ratings of calories. This indicates that actual exercise and the effort needed to complete it may provide a different prime than a health message. Both the present study and the study by Albarracin and colleagues (2009) represent novel investigations and a replication of each is needed to determine if these are reliable estimates of priming effects, and whether indeed a conceptual prime provides different results from an effortful activity prime.

A number of limitations in the current study deserve further discussion. First, our small sample size limited our ability to detect effects below the moderate range, a limitation that may have been most detrimental in detecting halo effects in ratings of food images as previous research indicates that these effects tend to be small (Chernev, 2010). Additionally, the failure to observe an AS effect on CE may have occurred due to the short-term suppression of appetite in the context of moderate-intensity exercise (Martins et al., 2007; Martins et al., 2008). Indeed, Martins and colleagues (2007) found that appetite suppression following exercise was relatively short in duration; however, eating behavior in their study was not assessed until one hour following exercise completion. In our sample, it is possible that CE occurred in the hours following the study appointment that could not be monitored within the scope of this investigation. As Albarracin and colleagues (2009) demonstrated, simply viewing messages that promote physical activity can influence subsequent eating behavior. Therefore, AS effects on CE may be better recognized under these conditions rather than following actual exercise that can suppress appetite in the short term.

In summary, this study represents, to our knowledge, the first examination of the role of actual exercise behavior in halo effects as well as the role of AS in both halo effects and CE. Further studies are warranted that address our aforementioned limitations to determine whether halo effects are observed in the context of exercise when an adequate sample size is employed as well as when pro-activity messages as opposed to actual exercise are used as the halo prime. The possible AS amplification of CE in the context of a longer waiting period following exercise is also warranted.

Chapter 5. The Role of Anxiety Sensitivity in Daily Exercise and Eating Behavior

Overweight and obese status has reached epidemic proportions in the United States with approximately two-thirds of the American population falling into an unhealthy weight category (CDC, 2012). Based on 2012 statistics, 34% of Americans are overweight as defined by a body mass index (BMI) greater than 25 with another 35.7% of individuals meeting criteria for obesity (BMI > 30, CDC, 2012). This increase in overweight/obese status is particularly concerning when compared to 1980 statistics which showed only 15% of Americans in the obese weight range (Flagel et al., 2002). Such a staggering increase in obesity rates highlights the need for research to better understand factors contributing to this epidemic.

Weight gain and maintenance of overweight/obese status can be understood in terms of both the over-consumption of calories and insufficient physical activity to balance caloric intake. However, the variables influencing eating and exercise behaviors are complex, with any one set of predictors typically explaining only an aspect of such behaviors. For example, studies examining eating behavior have identified a number of predictors including both state and trait negative affect, expectancy that eating can relieve negative affect, dietary restraint, and disinhibition of eating behavior (Blundell, Stubbs, Golding, Croden, Alam & Whybrow et al., 2005; Delinsky & Wilson, 2008; Holstein, Smith & Atlas, 1998; Jansen et al., 2008), whereas predictors of physical activity include age, education level, social support, prior exercise history, and self efficacy (Boutelle, Jeffrey, & Friench, 2004; Dobkin, Abrahamowicz, Fitzcharles, Drista, & de Costa, 2005; Kinne, Patrick, & Maher, 1999; Marcus, Selby, Niaura, & Rossi, 1992). As a potential boon to the development of targeted interventions, there is preliminary evidence to suggest that a single variable, distress intolerance, may contribute to our understanding of both maladaptive eating and avoidance of physical activity.

Broadly defined, distress intolerance is the perceived inability to tolerate distressing somatic and affective states (McHugh & Otto, 2011) with evidence suggesting those individuals with greater distress intolerance experience negative affect and physical discomfort in an amplified way, leading to a greater likelihood of avoidance-based coping strategies (Zvolensky & Otto, 2007). Anxiety sensitivity (AS), a way of operationalizing distress intolerance (McHugh & Otto, 2011), has received increased attention as a factor that may contribute to both sides of the weight-gain dilemma, maladaptive eating and lower levels of physical activity. AS refers to the fear of anxiety-related symptoms caused by a belief that somatic arousal and anxiety itself have catastrophic consequences across three domains, physical (e.g. having a heart attack, dying), mental (e.g. losing control, going crazy), and social (e.g. interpersonal rejection, embarrassment; McNally, 2002). It is distinct from trait anxiety (Taylor, Koch, & Crockett, 1991), and elevations in this variable are common across a number of mood and anxiety disorders, which also tend to have higher rates in obese as opposed to normal-weight populations (Schmidt, Lerew, & Jackson, 1997; Petry et al., 2008; Schmidt, Zvolensky, & Maner, 2006).

When individuals experience emotional distress, they are more likely to prioritize short-term affect regulation (i.e. indulge immediate impulses) rather than attending to longer-term self-regulatory goals (e.g., Tice et al., 2001), and AS predicts heightened sensitivity to negative affective states (Ehlers, 1995; Otto et al., 1995; Reiss, 1991; Schmidt et al., 1997; Taylor, Koch, Woody, & McLean, 1996). Therefore, individuals with elevated levels of AS may be more likely to engage in behavioral attempts to reduce these affective states than individuals with lower levels of AS. For example, McHugh and colleagues (2013) found that distress intolerance moderated the relationship between negative affect and impulsive behavior in the form of delay discounting (e.g. the willingness to wait a longer period of time for greater reward as opposed to accepting a smaller, immediate reward), such that those with higher distress intolerance were more likely to accept the immediate reward in the context of an experimentally induced negative affect. Studies have also demonstrated a link between AS and the use of alcohol, marijuana, and nicotine for coping motives (DeMartini & Carey, 2011; Johnson, Mullin, Marshall, Bonn-Miller & Zvolensky, 2010; Zvolensky, Feldner, Leen-Feldner, Bonn-Miller et al., 2004). That is, individuals with elevated AS were more likely to report using these substances as a means of alleviating distressing affect or somatic discomfort. To place these findings in the context of weight management difficulties, AS may lower an individual's threshold for tolerating negative affect or somatic distress such that she is (1) more likely to impulsively eat when confronted by negative affect, and (2) fail to persist or engage in physical activity that causes somatic or affective discomfort.

Following initial findings of associations between AS and the self-report of maladaptive eating patterns (Anestis et al., 2007; Anestis et al., 2008; Fulton et al., 2012), our research group provided the first published evidence that AS is associated with objectively-assessed rather than self-reported eating behavior in the context of negative affect states. We found a significant interaction between the AS mental concern subscale and scale 3 of the Eating Expectancy Inventory (EEIscale 3; Eating Leads to Feeling Out of Control; Hohlstein, Smith & Atlas, 1998) in overweight/obese, but not normal-weight participants. This interaction indicated that obese individuals elevated on both of these constructs consumed significantly more calories in the context of an experimentally induced negative affect (Hearon et al., 2012). These findings encourage further examination of the link between AS scales and eating behaviors under conditions of negative affect.

Regarding exercise, AS has been linked to both distress during and avoidance of, physical activity, presumably because exercise exposes individuals to feared somatic sensations of arousal. For example, Moshier and colleagues (2012) examined self-reported physical activity in more than 200 participants and found an inverse relationship between AS and vigorous physical activity, replicating similar findings from separate studies in men (Asmundson et al., 2001) and women (Sabourin et al., 2011). Moreover, in a laboratory-based examination of the relationship between AS, body mass, and distress during exercise, Smits and colleagues (2010) found reports of distress in the context of a 20-minute treadmill exercise were greatest among those individuals with both elevated AS and higher body mass.

Taken together, studies of emotional eating patterns and exercise behavior provide support for AS as a double-edged risk factor that predicts both increased food intake and avoidance of physical activity. In the current study, we extend this research by examining the role of AS in predicting eating and exercise behaviors in a naturalistic setting, across a three-day monitoring period. Naturalistic study is important, given research showing that self-reported tendency to eat in response to negative affect does not reliably translate into observable eating behavior in experimental settings (Evers et al., 2009), and likewise, self-report of physical activity may be influenced by BMI and other demographic characteristics and may not correspond well to objective assessments (Neuhouser, Di, Tinker, Thomas, Sternfeld, et al., 2013). In the current study, participants wore actigraphs, recorded all food consumed, and completed assessments of affect throughout the day. Aside from these study procedures, participants were instructed to engage in activities and eating behavior as they would normally. In this way, we were able to examine the role of AS on eating and physical activity in everyday life.

We hypothesized that AS and BMI would interact to predict greater calories consumed across the monitoring period as well as greater calories consumed in the context of negative affective shifts in obese but not normal weight participants. We also hypothesized that AS and BMI would interact to predict less physical activity in the moderate and vigorous range for obese but not normal weight participants. We also examined sex differences in the context of eating behaviors.

Methods

Participants

Participants were recruited from the community using Internet postings. Interested individuals aged 18 or older completed a phone screen to determine eligibility. In order to allow for comparison between the normal and high extremes of AS and weight, only those with a body mass index (BMI) within the ranges of 18.5-24.9 (normal weight) or 30.0 or greater (obese), and an Anxiety Sensitivity Index Score (ASI; Peterson & Reiss, 1992) score of less than 12 (normal AS) or greater than 20 (elevated AS) at the time of phone screening were included. This allowed for the recruitment of 32 participants split by ASI score and BMI into four groups (low ASI and low BMI, n = 8; high ASI and low BMI, n = 8; low ASI and high BMI, n = 7; high ASI and high BMI, n = 9). Exclusion criteria included current pregnancy, any self-reported restrictions on physical activity, and difficulty reading forms such as those provided in a doctor's office. Participants who completed the study and returned all study materials received $150 in compensation. Boston University's Institutional Review Board approved all study procedures.

Procedures

Participants attended two hour-long appointments, the first on Monday and the second on the following Friday. After completing informed consent at the first appointment, participants were given a battery of self-report questionnaires to complete. They were then given the activity and heart monitor and instructed to wear it during waking hours over the following three days. Additionally, participants were asked to complete the Positive and Negative Affectivity Scales (PANAS; Watson, Clark and Tellegen, 1988) at five times each day (upon awakening, noon, 4:00 PM, 7:00 PM and 10:00 PM) over the 3-day period in addition to two additional PANAS measures for each day which they were instructed to complete in the event of a noticeable affective shift outside of the other completion times. They were also asked to record food intake and physical activity as described below, and were told to continue with daily activities as they normally would. Study staff measured height and weight at the first study appointment. On the Friday immediately following the three-day monitoring period, participants returned the monitoring devices and self-report measures. Participants were debriefed and, if all measures had been completed, fully compensated.

Measures

Demographics Questionnaire – The demographics questionnaire examined basic participant information such as age, education level, and race/ethnicity.

Activity Monitoring Device – The Actigraph ActiTrainer is an 8.6 x 3.8 x 1.5 cm activity monitor weighing 0.05 kg that is held in a holster at the waist. It uses a two-axis accelerometer to record body movement, from which it calculates, total distance traveled, number of steps, activity intensity level, current speed, and current pace. Additionally, a Polar T31 Wearlink Heart Monitor is strapped across the sternum to record heartbeats per minute (BPM), average BPM, and peak BPM, which it relays to the ActiTrainer. Raw data was analyzed using the ActiLife 5 software package.

Food Diaries and Nutrition Data Analysis – The food diary consisted of three monitoring forms (one for each day of the study) in which participants recorded the times at which they ate, where they ate, and what they ate. The number of servings of each food item was also recorded, as well as the affect felt by the participant at the time of eating. Lastly, the table included columns where participants recorded estimated amounts of food consumption through comparisons with two-dimensional visuals of various foods and serving sizes to help increase accuracy of participant estimates (2D Food PortionVisual; Nutrition Consulting Enterprises, Framingham, MA). At the second visit, study staff reviewed the food diaries with the participant. If there was a perceived lack of detail or specificity, participants were asked to complete the diaries with the aid of the 2D Food Portion Visuals and three-dimensional food models (Combo Food Model Kits; NCES, Inc., Olathe, KS).

Dietary intake data were collected and analyzed using Nutrition Data System for Research software version 2011, developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN.

Anxiety Sensitivity Index (ASI) – The ASI is a 16-item self-report questionnaire designed to assess tendency to respond fearfully to anxiety-related symptoms by rating each item on a 5-point Likert scale from (0) very little to (4) very much (Peterson & Reiss, 1992). Data on the reliability and validity of the ASI scales have been favorable (Reiss, Peterson, Gursky, & McNally, 1986) with high levels of internal consistency demonstrated as well (average alpha coefficient: 0.84; Peterson & Reiss, 1992). In addition, it has been determined that the ASI represents a hierarchical construct such that three subscales, AS-physical concerns (items 3, 4, 6, 8, 9, 10, 11, 14), AS-mental concerns (items 2, 12, 15, 16), and AS-social concerns (items 1, 5, 7, 13) contribute to the higher order general factor (Zinbarg, Barlow, & Brown, 1997). With regard to internal consistency of the subscales, alpha coefficients range from acceptable to high, AS-PC alpha coefficient: .89, AS-MC alpha coefficient: .85, AS-SOC alpha coefficient: .62 (Zinbarg & Barlow, 1996).

Positive and Negative Affectivity Scale (PANAS) – The PANAS was developed as a brief measure of affect and yields the factors of positive and negative affectivity (Watson, Clark and Tellegen, 1988). Twenty-two emotions are rated on a 5-point scale of the extent each emotion is felt at the moment of assessment. The scale ranges from (1) very slightly or not at all to (5) extremely. Internal consistency of these factors has been determined to be acceptably high (Positive Affect alpha coefficient: .86-.90, Negative Affect alpha coefficient: .84-.87).

Beck Depression Inventory - II (BDI-II) - The BDI-II is a 21-item measure of depressive symptoms. It has been shown to reliably assess aspects of depressive (Beck et al., 1996) symptoms, and was used as a measure of negative mood in the two weeks prior to study participation.

Eating Expectancies. The Eating Expectancy Inventory (EEI; Hohlstein, Smith & Atlas, 1998) was used as a measure of attitudes toward food. This 34-item measure is based on a five-factor model of eating expectancies from which we used scale 1, eating helps manage negative affect, to assess the extent to which participants believed eating could be used as an affect regulation strategy. Internal consistency for the subscales is high with alpha coefficients ranging from .78 - .94. The EEI was used to characterize the weight and AS groups selected for the study.

Consolidation of Food and Affect Data

We operationalized affect worsening as a PANAS negative affect scale change of 3 or greater as compared to the participant's average negative affect score (i.e. mean of all PANAS negative scales completed over the course of the study). This corresponds to a 0.5 change in standard deviation units according to norms provided by Crawford and Henry (2004). Using these methods, we were able to control for each participant's potentially differing levels of baseline negative affect and compute state affect changes on an individual basis.

For data analysis, epochs of time were defined as the 2 hours following an identified negative affective shift, and total calories consumed during this time period were examined. To compare differences in eating between instance of negative affect shift and no such shift, the epoch of time where an affect change occurred was compared to the same epoch of time on a different day when no negative affect change occurred. Total calories for epochs of time when more than one negative affect worsening occurred were averaged together. Likewise, relevant eating in epochs of time without affect change were averaged together. Hence, eating in the 2 hours following an affect-worsening epoch identified at 4:00 on Tuesday, for example, was compared to other 4-6 timeframes during the remaining 2 days of monitoring. No participant experienced affect worsening across the same epochs on all 3 days.

Consolidation of Activity Data

The use of the ActiTrainer device allowed for examination of activity data in the form of, 1) vector counts (i.e. readings of acceleration across 1-minute epochs), 2) average heart rate across 1-minute epochs. In terms of vector counts, standard device settings were used such that 0 – 100 counts represented sedentary activity level, 101 – 759 counts represented "life-style" activity (e.g. minimal movements that might occur in one's home or office such as getting up to answer the door or walking to a copy machine), 760 – 1952 counts representing light activity (e.g. walking at a fairly brisk pace outdoors), 1953 -5724 counts representing moderate activity (e.g., jogging, biking or doubles tennis), 5725 – 9498 counts representing vigorous activity (e.g., running, rowing), and 9499 counts or greater representing very vigorous activity (e.g., sprinting to the point of maximum physical exertion). Percentage of time across the monitoring period spent at each activity level was used as the main outcome variables for the vector count data.

For heart rate data, moderate physical activity was set at 65% or greater of a participant's age adjusted maximum heart rate (e.g., 220-age) and vigorous physical activity was set at anything greater than 77% of age adjusted maximum heart rate (American College of Sports Medicine, 2006). Consecutive epochs of 5 minutes or greater spent at 65% of age adjusted maximum heart rate were summed to create a total for time spent in the moderate activity (or greater) range and consecutive epochs of 3 minutes or greater at more than 77% of age adjusted maximum heart rate were summed to achieve total time spent in the vigorous range. To also examine participants' tendency to persist in activity at these heart rate ranges, maximum consecutive epochs of time spent in the moderate or above range and maximum consecutive epochs of time spent in the vigorous activity range were also recorded.

To ensure integrity of the physical activity data, eight hours was set as the criterion for the minimum amount of daily wear time of the device for data to be included in analyses. All 32 participants met this criterion. In addition, hand-written activity logs completed by participants were reviewed to insure that devices were only removed for the purposes of sleeping, bathing, napping or medical appointments (i.e., one participant described having to remove the device while undergoing a scheduled MRI) as instructed by study staff. In some cases, transmission of heart rate data did not remain consistent throughout the entire time the ActiTrainer device was worn. Therefore, heart rate data had to be available for a minimum of 80% of total device wear time in order for hear rate variables to be included in analyses. Eight of 32 participants did not have sufficient heart rate data to meet this criterion excluding them from analyses examining data based on heart rate.

Data Analysis

Given evidence in support of AS as a taxonomic as well as continuous variable (Bernstein et al., 2006; Broman-Fulks et al., 2008; Schmidt, Kotov, Lerew, Joiner, & Ialongo, 2005; Zvolensky, Forsyth, Bernstein, & Leen-Feldner, 2007), we complemented our categorical analyses of AS (using previously established norms to determine a score of 20 representing the cutoff for “high” versus “low” AS; Reiss, Peterson, Taylor, Schmidt, & Weems, 2008) with an examination of similar effects when AS scores were examined continuously.

To examine the hypothesized interactions between AS and BMI, interaction terms representing AS and BMI as continuous variables as well as AS as a categorical variable were calculated. To examine the role of sex in eating behavior, interactions including sex and AS (as both continuous and categorical) were calculated. Regression models were then examined for each hypothesis first including AS as a categorical variable and then repeated with AS examined as a continuous variable. BMI was mean centered for all analyses, as was ASI total score in all cases in which it was examined continuously. Given our relatively small sample size, all significance tests were also complimented by effect sizes as informed by Cohen (1994). In cases in which significant AS results were found, we also examined AS subscales to determine which sub-dimension most contributed to the effects.

Results

Preliminary Analyses

All data was examined for outliers; only one was detected. For maximum consecutive time spent in the vigorous heart rate range, one participant's data was greater than three standard deviations above the mean for this variable; therefore, data from this participant was excluded for analyses examining this variable. The sample was predominantly female (62.5%) with a mean age of 43 (SD = 15). There were no significant differences in the sex distribution across the four AS by weight groups (Chi-square (3, N = 32) = 2.40, p = .49) nor were there age differences between those with high (M = 43.35, SD = 16.7) and low AS (M = 43.13, SD = 14.3; t (30) = -0.04, p = .97; d = .01). Ninety-seven percent of the sample identified as non-Hispanic with 59.4% identified as Caucasian, 31.3% as African American, 6.3% as Asian, and 3.1% as other. There were no significant differences in race distribution across the four AS by weight groups (Chi-square (3, *N* = 32) = 5.46, *p* = .14). Participants consumed a mean of 1,828 calories per day during the three-day monitoring period (range 892 – 3,546; *SD* = 619) with no significant differences observed between normal weight and obese participants (*t* (30) = 0.28, *p* = .78; *d* = .10). Likewise, appropriate to our selection method for low and high ASI scores, there was no mean difference in ASI scores across the normal weight and obese samples, with a mean ASI score of 20.8 (*SD* = 11.1). Demographic information is presented in Table VI.

Negative affect episodes (operationalized above) were reported by 71.9% of the sample across the three days of observation; 3 participants reported 1 significant affect shift, 10 reported 2 shifts, 6 reported 3 shifts, 3 reported 4 shifts, and 1 reported 6 shifts. The total number of negative affect shifts was not significantly different between the normal weight (*M* = 1.94, *SD* = 1.29) and obese samples (*M* = 1.75, *SD* = 1.77; *t* (30) = 0.34 *p* = .73; *d* = .12). In terms of baseline negative mood, the weight groups did not differ in BDI total scores examining the two weeks prior to study participation (normal weight: *M* = 14.56, *SD* = 9.25; obese: *M* = 9.25, *SD* = 7.16; *t* (30) = 1.22, *p* = .23; *d* = .45). There were also no differences in average negative affect as measured by the PANAS negative affect scale across the monitoring period (normal weight: *M* = 14.55, *SD* = 4.64; obese: *M* = 12.55, *SD* = 2.61; *t* (30) = 1.51, *p* = .13; *d* = .55). With regard to expectancy that eating can relieve a negative mood state, there were no significant differences but trends reflecting moderate effect sizes toward greater expectancies for the higher BMI groups (*F* (1, 28) = 2.44, *p* = .13; d = .59), high vs. low AS groups (*F* (1, 28) = 1.89, *p* = .18; *d* = .52) and the interaction of these variables (*F* (1, 28) = 0.42, *p* = .52; *d*

= .50). There was also no difference between the sexes (t (30) = 0.42, p = .68; d = .15) on this scale of the Eating Expectancy Inventory.

Anxiety Sensitivity and Total Calories Consumed Across the Monitoring Period

We first examined the effects of AS and BMI on total calories consumed across the monitoring period. BMI, AS category and their interaction were entered into a regression predicting total calories consumed. Contrary to our hypothesis, results revealed no significant effect of BMI (β = .02; df = 1, 28; t = 0.13; p = .90; d = .05), AS category (β = -.02; df = 1, 28; t = -0.08; p = .94 d = .03), or their interaction (β = -.11; df = 1, 28; t = -0.57; p = .57, d = .23) in predicting total calories consumed. The same model was then run examining AS as a continuous variable with no differences in results emerging with effect sizes in the small range for each predictor as well.

In a regression examining the effects of sex, AS category, and their interaction on total calories consumed, only sex (β = .54; df = 1, 28; t = 3.50; p < .01, d = 1.32) emerged as a significant predictor of total calories consumed while the interaction term (β = -.27; df = 1, 28; t = -1.69; p = .10, d = .64) reflected a non-significant trend with an effect size in the moderate range. This trend became significant when the same model was examined with AS as a continuous variable; results revealed both a significant effect for sex (β = .49; df = 1, 28; t = 3.30; p < .01, d = 1.25) as well as a significant interaction of ASI total score and sex (β = -.74; df = 1, 28; t = -2.24; p = .03, d = 0.85). To better understand the direction of this interaction, correlations between ASI total score and total calories consumed were examine for each sex with women demonstrating moderate effect sizes toward a positive correlation (r = .35, p = .13) and men demonstrating a moderate-to-large effect size toward a negative correlation (*r* = -.41, *p* = .19); see Figure II. To determine whether a particular ASI subscale was driving these effects, we examined the same model replacing ASI total score with each subscale score; only the interaction of AS physical concern subscale and sex emerged as significant (β = -.63; *df* = 1, 28; *t* = -2.24; *p* = .03, *d* = 0.85); neither the interaction of sex and AS mental concern subscale ((β = -.41; *df* = 1, 28; *t* = -1.68; *p* = .10, *d* = 0.63) nor sex and AS social concern subscale (β = -.60 ; *df* = 1, 28 ; *t* = -1.51; *p* = .14, *d* = 0.57) reached significance, but effect sizes were in the moderate range.

Anxiety Sensitivity and Calories Consumed in the Context of Negative Affect States

We examined the role of AS category, BMI and their interaction in predicting average consumption changes following epochs of negative affect. Contrary to our hypothesis, results revealed a moderate effect size for AS category that did not reach significance (β = .31; *df* = 1, 19; *t* = 1.40; *p* = .18; *d* = .64), and no effects for BMI (β = 01; *df* = 1, 19; *t* = 0.05; *p* = .96; *d* = .02), or the AS by BMI interaction (β = .04; *df* = 1, 19; *t* = 0.16; *p* = .87, *d* = .07) in predicting average change in calories consumed following negative affective episodes. Results of the same model examining AS as a continuous variable yielded similar result with effect sizes in the medium range for ASI total and the small range for BMI and the interaction term. We also examined the role of sex using a similar model that included AS category, sex and their interaction. Once again, there was a moderate-to-large effect size for AS category that did not reach significance (β = .35; *df* = 1, 19; *t* = 1.64; *p* = .12, *d* = .75), and no significant effect for sex (β = -.12; *df* = 1, 19; *t* = 0.59; *p* = .56; *d* = .27) or the sex by AS interaction (β = .29;

df = 1, 19; *t* = 1.37; *p* = .19, *d* = .63) in predicting average changes in eating behavior following instances of negative affect. No differences in results were found when the same model was examined with AS as a continuous variable, with effect sizes for ASI total score and the interaction term also in the moderate range.

Given the moderate-to-large effect sizes observed, and a lack of established norms for determining exactly how strong of an affective shift might be necessary to produce maladaptive eating behavior, we also examined the role of AS in predicting average change in calories consumed following each participant's greatest shift to negative affect over the 3-day monitoring period as compared to the average eating during identical times when no such affect shift occurred. In our initial examination of calories consumed following the greatest shift to negative affect, AS category, BMI, and their interaction were entered into a regression as predictors. AS category approached significance at a trend level, (β = .39; *df* = 1, 19; *t* = 1.89; *p* = .07, *d* = .80) reflecting a large effect size indicating higher AS was associated with greater calories consumed, while BMI (β = .05; *df* = 1, 19; *t* = -0.26; *p* = .80, *d* = .12) and their interaction (β = -.19; *df* = 1, 19; *t* = -0.93; *p* = .37; *d* = .43) were not significant. When the same model was run replacing BMI with sex, AS category emerged as a significant predictor of calories consumed (β = .43; *df* = 1, 19; *t* = 2.05; *p* = .05; *d* = .94) with an effect size in the large range. Given that selection of co-variates appeared to influence significance of AS main effects, we examined AS category independently. When considered alone, the difference between AS categories was significant (*t* (21) = -2.13, *p* = .045; *d* = .93), such that those with high AS *increased* their intake following their worst episode of negative affect an average of 171 calories

(*SD* = 381) whereas those with low AS *reduced* their intake by an average of 120 calories (*SD* = 258). We also examined the association between AS subscales and change in calories consumed following worst episode of negative affect to determine if a particular subscale was driving effects. Results indicated a moderate but non-significant effect for AS social concern subscale (r = .36, p = .10), and very small effects for the AS mental concern (r = -.01, p = .97) and AS physical concern (r = .08, p = .73) subscales.

Anxiety Sensitivity and Physical Activity as Measured by Actigraphy

As only four participants completed any measurable vigorous activity based on vector counts recorded by the ActiTrainer device, we focused our attention on differences in activity categorized as moderate by device settings. To examine AS effects on moderate physical activity, AS category, BMI and their interaction were used to predict percentage of time spent engaged in moderate physical activity as recorded by the ActiTrainer device across the 3-day monitoring period. Results revealed no significant effects for AS category or BMI, but the AS category by BMI interaction was significant (β = -.41; df = 1, 28; t = -2.41; p = .02, d = .91). To better understand the nature of this interaction, we examined differences in moderate activity between each AS category in the normal weight and obese samples. Results indicated that in normal weight individuals, high AS was associated with greater moderate physical activity (M = 3.38, SD= 1.77) than low AS (M = 2.0, SD = 1.31; t (14) = -1.77, p = .10; d = .95), whereas in the obese sample, high AS was associated with less moderate activity (M = 1.89, SD = 1.69) than low AS (M= 3.14, SD = 1.21; t (14) = 1.65, p = .12; d = .88) reflecting effect sizes in the large range for both differences. When AS was examined as a continuous variable, results revealed a strong effect size for the interaction term that approached but did not reach significance (β = -.75; *df* = 1, 28; *t* = -1.81; *p* = .08, *d* = .68). To examine whether a particular ASI subscale was driving effects, we repeated the above model, replacing AS with each subscale. The interaction of AS mental concern subscale and BMI was significant (β = -.64; *df* = 1, 28; *t* = -2.49; *p* = .02; *d* = .95) whereas the interaction of AS physical concern subscale and BMI did not reach significance but yielded effects in the moderate range (β = -.52; *df* = 1, 28; *t* = -1.36; *p* = .19; *d* = .51). The interaction of the AS social concern subscale and BMI was not significant with effect size in the small range (β = -.46; *df* = 1, 28; *t* = -0.78; *p* = .44; *d* = .29).

Anxiety Sensitivity and Physical Activity as Measured by Heart Rate

For heart rate data, we examined the effects of AS and BMI on total time spent across the monitoring period in moderate or greater and vigorous heart rate ranges. In regression analyses including AS category (β = -.01; *df* = 1, 20; *t* = -0.04; *p* = .97; *d* = .02) and BMI (β = - .07; *df* = 1, 20; *t* = -0.30; *p* = .77; *d* = .13), main effects were small, but their interaction (β = -.34; *df* = 1, 20; *t* = -1.57; *p* = .13; *d* = .70) reflected a moderate-to-large effects size for prediction of total time spent in the vigorous heart rate range. For maximum amount of consecutive minutes spent in the vigorous heart rate range (as opposed to total time spent in this range across the monitoring period), AS category, BMI, and their interaction were entered into a regression model, excluding the aforementioned outlier for this dependent variable, with results indicating that the interaction term (β = -.38; *df* = 1, 19; *t* = -1.75; *p* = .09; *d* = .80) again approached but did not reach significance. To examine the nature of this interaction trend, we split the sample by weight groups with results indicating no significant effects of AS category on maximum consecutive time spent in the vigorous heart rate range for normal weight participants with only a small-to-moderate effects size (low AS, $M = 2.33$, $SD = 3.0$; high AS, $M = 4.80$, $SD = 9.1$; $t(9) = -0.63$, $p = .54$; $d = .42$). In obese participants, comparison of maximum consecutive time spent in the vigorous heart rate range also did not indicate differences that reached significance, however, effect size was in the very large range indicating that both high AS and obese BMI was associated with less time persisting in the vigorous heart rate range (low AS, $M = 4.80$, $SD = 5.8$; high AS, $M = 0.86$, $SD = 1.46$; $t(10) = 1.75$, $p = .11$; $d = 1.11$). When AS was examined as a continuous variable, results revealed similar trends. Identical analyses were repeated examining moderate-or-greater heart rate ranges with no significant predictors found.

Discussion

As interest has grown in understanding psychological factors that predict weight gain, AS has emerged as one such factor that could explain both eating behaviors and exercise avoidance in a subset of the population. Indeed, both self-report and experimental studies have demonstrated a link between AS and maladaptive eating behavior as well as distress during, and avoidance of, physical activity (Anestis et al., 2007, Anestis et al., 2008; Fulton et al., 2012; Hearon et al., 2012; Moshier et al., 2012; Smits et al., 2010). In the current study, we were able to extend these findings beyond the constraints of self-report and laboratory settings by examining the role of AS in eating behavior and exercise avoidance in a naturalistic setting.

Previous research supports a role for AS in amplifying the experience of negative affect and the tendency to seek out immediate relief in the form of avoidance-based strategies such as substance use (McHugh & Otto, 2011; Zvolensky & Otto, 2007). In the case of weight management difficulties, AS may serve as risk factor for engaging in maladaptive eating behavior particularly in the context of negative affect as well as avoidance or premature discontinuation of physical activity as the associated sensations may be interpreted as particularly distressing.

Consistent with our hypotheses, we found a significant sex by AS interaction such that high AS predicted greater calories consumed over the three-day monitoring period in women, but not men. We also found trends reflecting medium effect sizes for differences in calories consumed following negative affect shifts observed in the naturalistic study. These effects were intensified for participants' greatest negative affect shifts. For these more-intense emotional shifts, large effect sizes were found for the predictive influence of AS category such that those with high AS reported consuming significantly more calories, increasing their intake by approximately 170 calories in the two hours following the affect shift, as compared to a mean reduction in calories by those low in AS. One way to interpret these findings is in terms of self-control fatigue: specifically, that self-control over behaviors an individual wishes to regulate is finite and can become increasingly fatigued by stressors over the course of the day (Baumeister, Vohs, & Tice, 2007; Muraven & Baumeister, 2000). Accordingly, the loss of dietary restraint could be viewed as a self-control lapse. The differential effect across the sexes may be due to differences in rates of eating restraint: a higher percentage of women in the American population report dieting and attempts at dietary restraint than men (Bish, Blanck, Serdula, Marcus, Kohl, & Khan, 2005). Accordingly, if AS amplifies the affective response to daily stressors for women, they may be more prone to lapses in self-control over consumption: in our study, reflected by higher calorie consumption among women with high AS. Our data are also consistent with an affect-regulation model of eating behavior (Hawkins & Clement, 1984) in which individuals purposely seek out comfort from food. With this model, individuals who experience an amplification of negative affect due to elevated AS may purposely use eating as a means of actively coping with negative affect. This is consistent with the work of Tice and colleagues (2001) demonstrating prioritization of short-term affect regulation in the face of emotional distress over long-term self-regulation goals. As both men and women in this sample reported similar expectancy that eating can help regulate negative affect, it is not surprising that sex differences were not observed with regard to eating following the worst episode of negative affect. Our data fits the self-control fatigue and the affect-regulation models equally, and without assessing intention to regulate affect with eating, we are unable to differentiate between these models.

With regard to the role of AS in physical activity, we found a significant interaction between AS and BMI such that obese individuals with high AS engaged in less moderate physical activity as assessed by actigraphy. This finding suggests that AS can help identify those obese individuals who find physical activity particularly distressing and engage in less physically demanding activity overall. However, we also unexpectedly found a large effect for high AS predicting greater moderate-intensity activity in the normal weight group, indicating that among normal-weight individuals, AS may drive some health behaviors. One possible explanation for this finding relates to the association between AS and health anxiety. AS has emerged as a significant predictor of hypochondria, and an even better predictor of attentional bias toward health-related threat cues than specific measures of health anxiety (Lees, Mogg & Bradley, 2005; Otto, Domopulus, McLean, Pollack & Fava, 1998; Otto, Pollack, Sachs & Rosenbaum, 1992). As such, high AS may drive attention to relevant health behaviors such as moderate activity. Nonetheless, the fear of symptoms may become salient at higher levels of exertion, particularly for obese individuals. Indeed, Smits and colleagues (2010) reported that AS was associated with greater distress during *moderate-intensity* exercise in participants with higher BMI. Likewise, normal weight and obese individuals also differ in the amount of exertion that leads to negative affect during exercise, with obese individuals experiencing negative affect at lower levels of exertion (Ekkekakis, Lind, & Vazou, 2009). Accordingly, avoidant responses to moderate exercise likewise appear to be evident only in obese individuals in our sample. Notably, avoidance of exercise is evident more generally when vigorous levels of exercise are examined (Moshier et al., 2012), suggesting that at the higher levels of exercise, AS has a more uniform predictive effect across weight groups. Our data captured too few episodes of vigorous exercise to confirm this hypothesis within the current data set.

When examined as a whole, our results highlight the effect of AS on both caloric intake and expenditure in terms of moderate physical activity levels. As hypothesized, the predictive significance of AS was specific to weight range for the physical activity findings, but contrary to hypothesis, cut across weight groups for the eating behavior findings. However, even though AS appears to exert the same effect across BMI levels for eating behaviors, elevated AS scores have been found to be more characteristic of overweight and obese individuals. For example, our research group found a significant difference between ASI scores of overweight/obese vs. normal weight participants with effect sizes in the moderate-to-large range (Hearon et al., 2012), a finding consistent with the higher rates of anxiety and mood disorders reported for obese individuals (Petry et al., 2008). Accordingly, the effect of AS on emotional eating patterns may have a role in the onset and/or maintenance of obesity given the greater representation of AS in overweight samples.

In contrast to the eating outcomes, the link between AS and reduced physical activity was specific to the obese sample. This interaction with BMI status is consistent with the results of Smits and colleagues (2010), who found that those with both high AS and BMI reported the greatest distress during a treadmill exercise. Indeed, when exercise intensity is held constant overweight/obese samples report greater physical discomfort and perceived exertion than normal weight controls (Deforche, De Bourdeaudhuij, & Tanghe, 2006; Ekkekakis & Lind, 2006; Hulens et al., 2003) indicating that obese individuals are more likely to find exercise distressing than normal weight individuals, and the aversiveness of this experience may be amplified by AS for these individuals.

There were several limitations in the current study that warrant further discussion. First, our sample size was relatively small limiting our power to detect effects below a moderate-to-large range. This limitation was most pronounced with regard to eating in the context of negative affect states, as nine participants in our sample reported no such affect shifts, thereby reducing our sample size even further. In addition, due to our small sample size, significant AS effects were only noted for one of the two methods used for examining this construct, categorical or continuous. However, in all cases effect size comparisons were used to ensure that AS effects trended in the same direction and demonstrated similar levels of effect across categorical and continuous analyses. Also, although we were able to avoid some of the limitations associated with self-reported eating behavior and pathology as well as the social demands inherent in the experimental setting, it is still possible that asking participants to record food consumed and complete affect monitoring throughout the day may have increased awareness and changed subsequent eating behavior. In addition, the short duration of this study does not allow for examination of AS effects on weight over time. For instance, a longitudinal study may provide insight into whether those in the elevated AS but normal weight are more likely to develop weight management difficulties over time than those with low AS. Therefore, future studies would benefit from the examination of a larger sample size over the course of a longer monitoring period. Finally, at times, data interpretation was dependent on factors shown to be important in other studies. For example, knowledge of the degree of current eating restraint (dieting) and the degree to which individuals explicitly ate for mood-regulation purposes would have helped us clarify whether the observed eating behavior was better explained by lapses in self-control as compared to eating as a means of coping with negative affect. These two factors emerged as important variables to consider in future studies of the role of AS in eating behaviors.

In summary, we have provided evidence that AS is linked to the two major contributors to weight management difficulties, increased consumption of calories and lack of sufficient physical activity. As AS can be modified relatively rapidly with cognitive-behavior therapy emphasizing interoceptive exposure (see Craske et al, 2006; Smits, Berry, Tart, & Powers, 2008), if our findings are further replicated, integration of such interventions in weight management programs may be warranted for these individuals.

Chapter 6. General Discussion

The goal for the current series of studies was to examine the role of AS in objectively measured eating and exercise. AS has demonstrated promise as a factor that may influence both maladaptive eating behavior and avoidance of physical activity; however, previous investigations relied heavily on self-report rather than objective measures. The current investigations examined the role of AS in eating and exercise behavior in the laboratory setting and then extended these findings to the naturalistic setting. Using these methods, we were able to enhance the understanding of AS as a factor that may contribute to the development and maintenance of weight-management difficulties. Because AS is modifiable through behavioral treatment (Craske et al, 2006; Smits, Berry, Tart, & Powers, 2008), the importance of clarifying its role in potentially negating weight-management efforts is of potential importance to prevention or treatment efforts. Conclusions are detailed below.

AS and Eating Behavior

Extending earlier self-report studies that noted an association between AS and pathological eating behavior (Anestis et al. 2007; 2008; Fulton et al., 2012), Studies 1 and 3 of the current project provided further support for this association. In the study outlined in Chapter 2, the AS mental concern subscale as well as the expectancy that eating leads to loss of control, interacted to predict greater calories consumed in overweight/obese participants when negative affect was induced. However, when the role of AS was examined in eating behavior in the naturalistic setting (Chapter 5), results revealed a main effect of high AS in predicting greater calories consumed across the three-day monitoring period in women and fewer calories in men that was not dependent on weight group. Additionally in the study described in Chapter 5, there was a main effect for AS that was not limited to a particular sex or weight group in predicting calories consumed following the worst episode of negative affect, such that those with high AS increased their caloric intake by approximately 170 whereas low AS individuals decreased their intake.

The difference in findings between these two studies highlights the incongruence of naturalistic versus laboratory-based examinations of eating behavior as well as differences in sampling. The study described in Chapter 2, conducted in a laboratory setting and using an experimentally–induced affect manipulation, did not allow examination of eating behavior over an extended period of time; whereas, the naturalistic study (Chapter 5) examined total calorie consumption over a three-day period as well as eating in the context of naturally occurring negative affect. Studying individuals away from a laboratory setting may have provided freedom from experimental factors that could limit or reduce maladaptive eating behavior. For instance, although participants were left alone with food in the laboratory-based study detailed in Chapter 2, they may still have limited their consumption due to the social demands of this setting. That is, knowing the experimenter would return and see approximately how much food was consumed may have lead to increased efforts to control consumption to manage social impressions. In addition, the study required deception and the use of a sham taste test to encourage eating. By providing participants with a "goal" for their eating behavior (i.e., filling out the taste test rating form), we may have inadvertently introduced an alternative means of coping with the negative affect through distraction. This would not have occurred in the naturalistic setting where participants were able to freely respond to negative affect with eating behavior. Additionally, given that AS findings were specific to the AS mental concern subscale in the laboratory-based study, it is possible that the type of affect induction may influence the specific dimension of distress intolerance that predicts eating behavior. For instance, in the laboratory-based study, a combination of boredom and frustration was targeted, and AS mental control concerns may be specific to those affective states, whereas, in the naturalistic setting, participants were likely exposed to a broader range of situations that could trigger a different affective response, such as sadness or anxiety. Therefore, it is not surprising that AS as a whole may have predicted eating more generally in the context of potentially varying types of negative affect.

In addition, differences in recruitment strategy may also have played a role in differences in the nature of AS prediction in the two studies. In the study described in Chapter 2, AS was allowed to freely vary between weight groups with results indicating significantly higher AS in the overweight/obese sample than the normal weight sample. This is consistent with epidemiological studies that indicate higher instances of mood and anxiety disorders, which are often characterized by elevations in AS, among obese individuals (Petry et al., 2008). Also, the normal weight group was compared to a sample of individuals with BMI in both the overweight and obese range (BMI > 25). Conversely, to better examine extremes of AS and weight, the naturalistic study (Chapter 5) purposely recruited equal numbers of participants across AS and weight groups with BMI classification restricted to normal weight and obese status, potentially limiting the bias toward elevated AS among obese individuals. Therefore, even if AS effects on eating are consistent across weight groups, obese individuals may be at greater risk for AS-driven maladaptive eating behavior given greater likelihood of elevations in this construct within this population. However, despite the subtle differences in findings between studies, overall results indicate that high AS is associated with greater calorie consumption, particularly in the context of negative affect.

We have hypothesized two possible ways AS may influence consumption: 1) purposely eating to manage negative affect (see Hawkins & Clement, 1984; Tice et al. 2001), and 2) eating as the result of a self-control lapse due to depletion of self-control resources (see Baumeister, Vohs, & Tice, 2007; Muraven & Baumeister, 2000). Consistent with the work of Tice and colleagues (2001), in the context of negative affect, individuals will forgo long-term self-regulation goals in an attempt to manage this affect in the short-term; however, the individual must actually believe that her attempts to manage affect have the potential to succeed. In this case, AS may lower the threshold for individuals to forgo long-term self-regulatory goals such as adopting a healthy diet in favor of the short-term comfort provided by food. Additionally, maladaptive eating may be influenced by a lapse in the self-control system, as research indicates that self-control over behaviors an individual wishes to regulate can become depleted with repeated use (Baumeister, Vohs, & Tice, 2007; Muraven & Baumeister, 2000). Consequently, for those individuals purposely trying to exert control over their eating behavior, the amplification of negative affect by AS, may represent an additional stressor on the self-control system, thereby depleting resources necessary to exert control over intake. Further research suggests that these theories may not be mutually exclusive as prioritizing short-term affect regulation over long-term self-regulation goals such as dieting often leads to additional negative affect (e.g., purposely eating chocolate cake to feel better leads to feeling sad and guilty for failing at a diet). In turn, managing this additional negative affect can increase stress on self-control resources and lead to additional eating due to depletion of resources to exert control over this behavior (Tice and Bratslavsky (2000). Because the current studies did not assess in-the-moment intention to use eating as an affect regulation strategy or intention to restrict caloric intake, we cannot reliably distinguish between these two possible explanations for the increase in eating behavior observed by those with elevated AS, or whether both were acting simultaneously.

AS and Physical Activity

Consistent with previous self-report findings that indicated high AS was associated with less physical activity overall and experimental findings indicating that AS effects on exercise may be greatest among those with higher BMI (McWilliams & Asmundson, 2001; Sabourin et al. 2001; Moshier et al., 2012; Smits et al., 2010), in Chapter 5 we report a significant interaction between high AS and BMI such that individuals elevated on both constructs reported less time engaged in moderate-intensity physical activity across a three-day monitoring period as measured by actigraphy, whereas the normal weight group demonstrated the opposite. Also, despite limitations of sample size for heart-rate data, an interaction was observed at a trend level whereby obese individuals with high AS maintained a vigorous age-adjusted maxim heart rate range for the smallest amount of time.

In addition, the study described in Chapter 3 of the current project, which described a laboratory-based exercise challenge, helped to further clarify the process by which AS may influence individuals to avoid physical activity. Although our findings did not replicate Smits and colleagues' (2010) findings of greater distress during exercise among those with high AS and BMI, we did find that AS may exert an influence through affect changes associated with exercise. In this study, normal weight participants who perceived their exertion as greatest experienced a significant increase in positive affect from pre to 10-minutes post exercise across AS ranges. Conversely, in obese individuals with elevated AS, perceived exertion was associated with a decrease in positive affect. Therefore, it may not be increased distress during exercise alone as noted by Smits and colleagues (2010) that attenuated the desire to exercise among individuals with high AS, but also a failure to experience affective benefits following exercise. Given the findings of Miller and colleagues (2005) that indicated affect changes *after* exercise are mediated by enjoyment ratings *during* exercise, one hypothesis is that elevated AS leads obese individuals to experience less enjoyment when exercising at moderate intensity that prohibits them from also experiencing the expected affect improvements following the workout, particularly when they interpret the workout as more strenuous.

The BMI-specific findings with regard to high AS and avoidance of moderate-intensity physical activity in the naturalistic study described in Chapter 5 are consistent with the hypothesis that those with high AS and BMI may represent a subsample of the population that finds physical activity less rewarding, and in some cases, more distressing than other individuals. Together, the findings of the laboratory-based and naturalistic physical activity studies suggest that reducing AS may be a useful intervention strategy for helping obese individuals elevated on this construct better enjoy, and hence better maintain, their physical activity.

Compensatory Eating and Halo Effects

In Chapter 4 of the current project, we examined the role of AS in compensatory eating (CE) following the exercise challenge as well as halo effects. Despite previous findings suggesting that CE may represent one of the reasons using physical activity alone as a weight management strategy often fails (Ross & Janssen, 2001; King et al., 2008; Pomerleau et al., 2004), we did not observe AS effects on eating during the sham taste test, which occurred 30 minutes after moderate-intensity exercise. This indicates AS amplification of negative affect during exercise may not be a factor in increased eating following exercise.

In addition, we did not replicate the significant findings of Chernev (2010) in which pairing an image of an “unhealthy” food item with a “healthy” side dish lead to lower calorie estimates than when the “unhealthy” item was presented alone. In fact, for one set of images, small effect sizes in the opposite direction were found, calling into question the reliability of halo findings in this context. We also did not note halo effects from rating images before versus after exercise. This failure to detect significant findings may be due to the small sample size used in the current study; in contrast Chernev (2010) examined halo effects in more than 900 individuals. The influence of possible moderators such as current dieting status also warrants further investigation, as this was shown to increase halo effects.

Clinical Implications

The results of the current series of studies have several important implications for clinical practice and weight management interventions. First, evidence across our studies suggests that AS represents a double-edged risk factor, influencing both maladaptive eating behavior as well as exercise avoidance with some indication that these effects may be greatest among obese individuals. This suggests that having both elevated BMI and AS may put this subset of individuals at increased risk for failure of weight management interventions. Since AS can be easily measured through self-report, weight management intervention may first benefit from adding this screening to help identify those individuals at the greatest risk for engaging in maladaptive coping strategies such as eating in response to negative affect or exercise avoidance. Pending further study, screening for elevated AS may also serve as a useful tool in primary care settings to identify normal weight individuals who may be at increased risk for developing obesity over time.

Second, given that AS is modifiable, identification of elevations in this variable suggests that interoceptive exposure may be a useful addition to weight management interventions. Although originally developed for use with the anxiety disorders (e.g., Craske & Barlow, 2007), such exposure can be used with both somatic (e.g., shortness of breath, racing heart) and emotional (e.g., frustration, anxiety) distress to improve tolerance. Indeed, lowering this sensitivity may help obese individuals better adhere to both prescribed calorie restriction and increased physical activity. Study of the potential efficacy of this approach is encouraged.

Conclusions and Future Directions

The current series of studies has clarified our understanding of the role of AS in influencing both eating and exercise behavior with a number of important future directions evident. First, given the relatively small sample size of our studies, replication in larger populations is warranted. This will allow for further detection of effects beyond the moderate range as well as improved power to better investigate three-way interactions.

Second, further studies are required to determine the exact mechanisms through which AS influences eating and exercise behavior. In the case of eating behavior, we identified two possible ways AS may influence consumption, 1) purposely eating to manage the hypothesized amplification of negative affect or 2) eating as the result of a lapse in the self-control system brought on by the need to use this system throughout the day to manage amplified negative affect. Indeed, to distinguish between these two explanations or determine whether both are simultaneously influencing eating behavior, in-the-moment intention to eat as a means of managing negative affect and intention to attempt caloric restriction is required. For exercise behavior, as the laboratory-based physical activity study (Chapter 3) demonstrated that individuals with both elevated AS and BMI may be less likely to experience the expected increase in positive affect following exercise they perceive to be more strenuous while in all other groups greater perceived exertion was associated with a greater increase in positive affect, investigation of possible mechanisms for this difference are necessary. Indeed, our results did not replicate those of Smits and colleagues (2010) who noted increased distress during exercise among this sample; therefore, it may not be distress alone that contributes to a failure to increase positive affect among these individuals following exercise, but another mechanism such as low enjoyment during exercise as proposed by Miller and colleagues (2005). With regard to AS and physical activity, the naturalistic study (Chapter 5) also noted an inverse relationship for moderate-intensity physical activity as measured by actigraphy, whereby, normal weight individuals with high AS showed increased activity and obese individuals showed less. We hypothesized that this may be due to differences in threshold between the weight groups as to when AS effects on exercise become most salient. Given that Smits and colleagues (2010) only noted increased distress during moderate-intensity exercise in those with both elevated AS and BMI, whereas Moshier and colleagues (2012) reported a universal decrease in vigorous-intensity activity in those with high AS across weight groups, AS may exert differing effects on the weight groups for moderate-intensity activity which level out in the context of vigorous-intensity activity. However, future investigations are needed within the same sample to clarify the possibly differing effects across activity intensity levels.

Third, as the naturalistic study (Chapter 5) was the only sample to include equal distribution of AS and weight groups, it was the only study where examination of AS as a categorical rather than continuous variable was possible given our limited sample size across studies. As general AS research, as well as studies specific to exercise behavior have supported a taxonomic as well as continuous structure for this variable (see Bernstein et al., 2006; Broman-Fulks et al., 2008; Schmidt, Kotov, Lerew, Joiner, & Ialongo, 2005; Zvolensky, Forsyth, Bernstein, & Leen-Feldner, 2007; Moshier and colleagues 2012; Chapter 5 of the current project), research is needed to determine whether there is indeed a specific score that most increases vulnerability to maladaptive eating and exercise avoidance.

Finally, pending further replication of our results in larger samples, investigations are needed to determine whether AS represents a specific risk factor for the development of obesity over time as well as whether targeted treatments that reduce this sensitivity, such as interoceptive exposure, may serve as a beneficial addition to weight management interventions for individuals with high BMI who are elevated on this construct.

In summary, research has consistently identified AS as a predictor of avoidance-based maladaptive coping strategies. The current series of studies, in conjunction with previous reports, provides evidence that these effects likely extend to maladaptive eating and exercise avoidance. Indeed, within this series of studies, we have provided support for the hypothesis that AS may represent a double-edged risk factor particularly among obese individuals for engaging in maladaptive eating behavior as well as avoidance of physical activity.

Table I

Demographics and Questionnaire Totals (First Study, Chapter 2)

Variable	N	Mean (Std. Dev.)/ %
Age	42	40 (15.4)
Sex (% female)	42	47.6%
Ethnicity (% Non- Hispanic)	42	83.3%
Race	42	
% Caucasian		57.1%
% African-American		28.6%
% Asian		4.8%
% Other		9.5%
BMI	42	33.7 (6.1)
ASI total score	42	16.0 (10.4)
EES total score	42	48.9 (18.11)
EEI Scale 1	42	59.3 (26.0)
EEI Scale 2	42	31.3 (7.3)
EEI Scale 3	42	12.2 (6.8)
EEI Scale 4	42	8.3 (2.7)
EEI Scale 5	42	15.2 (6.9)

Note. ASI: Anxiety Sensitivity Index, EES: Emotional Eating Scale,
EEI: Eating Expectancy Inventory, Scale 1 (eating to manage negative affect), Scale 2 (eating as a reward), Scale 3 (eating leads to feeling out of control), Scale 4 (eating enhances cognitive competence), Scale 5 (eating helps alleviate boredom).

Table II

Correlations among ASI total, EEI scales & EES scales (First Study, Chapter 2)

Variables	ASI Total
EEI Scale 1	.55**
EEI Scale 2	.38*
EEI Scale 3	.52**
EEI Scale 4	.22
EEI Scale 5	.38*
EES Total	.40**
EES Anger	.36*
EES Anxiety	.33*
EES Depression	.43**

Note. ASI: Anxiety Sensitivity Index, EES: Emotional Eating Scale, EEI: Eating Expectancy Inventory, Scale 1 (eating to manage negative affect), Scale 2 (eating as a reward), Scale 3 (eating leads to feeling out of control), Scale 4 (eating enhances cognitive competence), Scale 5 (eating helps alleviate boredom); *$p < .05$, **$p < .01$.

Table III

Demographics and Questionnaire Totals (Second Study, Chapter 2)

Variable	N	Mean (Std. Dev.)/ %
Age	57	37 (14.3)
Sex (% female)	57	45.0%
Ethnicity (% Non-Hispanic)	57	96.5%
Race	56	
% Caucasian		66.7%
% African-American		21.1%
% Asian		7.1%
% Other		3.6%
BMI	55	27.24 (6.4)
ASI total score	57	15.8 (8.1)
AS-MC	57	1.8 (2.0)
AS-PC	57	7.0 (5.6)
AS-Soc	57	5.9 (1.7)
EEI Scale 1	57	46.6 (21.0)
EEI Scale 3	57	8.4 (4.7)

Note. ASI: Anxiety Sensitivity Index, AS-MC: Anxiety Sensitivity Index Mental Concern Subscale, AS-PC: Anxiety Sensitivity Index Physical Concern Subscale, AS-Soc: Anxiety Sensitivity Index Social Concern Subscale, EEI: Eating Expectancy Inventory, Scale 1 (eating to manage negative affect), Scale 3 (eating leads to feeling out of control).

Table IV

Summary of Regressions Predicting Calories Consumed
(Second Study, Chapter 2)

Predictor variable		β	*t*	*p*
1)	Sex	0.22	1.52	0.13
	BMI	-0.05	-0.31	0.76
	EEI Scale 1	0.21	0.89	0.38
	AS-PC	-0.29	-1.00	0.32
	EEI Scale 1 x AS-PC x BMI	0.30	0.76	0.45
2)	Sex	0.25	1.78	0.08
	BMI	-0.10	-0.71	0.48
	EEI Scale 3	0.13	0.72	0.47
	AS-MC	-0.50	-2.13	**0.04**
	EEI Scale 3 x AS-MC x BMI	0.66	2.47	**0.02**

Note: BMI: Body Mass Index, EEI scale 1: Eating Expectancy Inventory (Eating to manage negative affect), AS-PC: Anxiety Sensitivity Index Physical Concern Subscale, EEI scale 3: Eating Expectancy Inventory (Eating leads to feeling out of control), AS-MC: Anxiety Sensitivity Index Mental Concern Subscale.

Table V

Demographic and Questionnaire Scores (Chapters 3 &4)

Variable Mean (Std. Dev.)/ %	Low AS, Normal BMI	Low AS, Obese BMI	High AS, Normal BMI	High AS, Obese BMI
N	9	8	13	8
Age	24 (9)	25 (6)	20 (1)	36 (10)
Sex (% female)	56%	75%	92%	50%
BMI	23.3 (2.6)	34.5 (3.0)	21.6 (1.4)	33.7 (4.5)
ASI Total Score	8.7 (3.0)	6.8 (3.8)	20.2 (4.8)	25.0 (9.8)
BDI	4.0 (5.4)	3.75 (5.2)	7.2 (6.4)	9.5 (7.3)
Moderate Exercise	844 (829)	427 (449)	455 (1056)	280 (308)
Vigorous Exercise	1507 (1146)	1275 (1639)	1095 (890)	710 (1029)

Note. ASI: Anxiety Sensitivity Index, BMI: Body Mass Index, BDI: Beck Depression Inventory; Moderate Exercise: Baseline Self-reported Metabolic Equivalents; Vigorous Exercise: Baseline Self-reported Metabolic Equivalents.

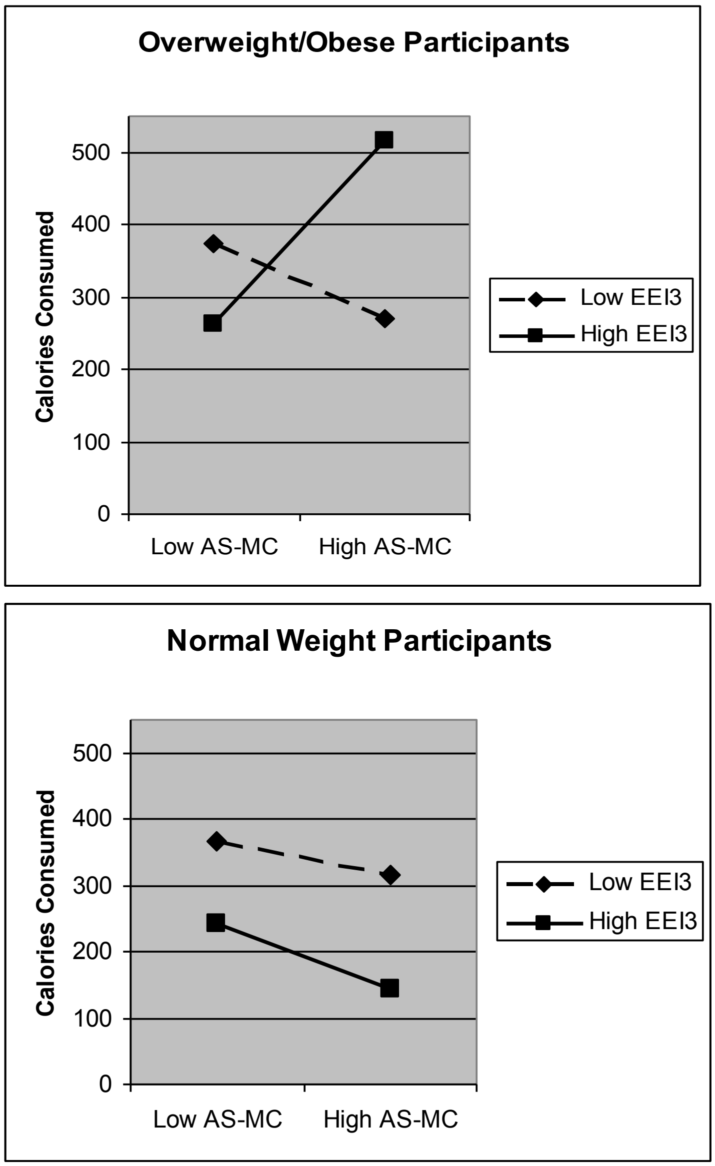
Table VI

Demographic and Questionnaire Scores (Chapter 5)

Variable Mean (Std. Dev.)/ %	Low AS, Normal BMI	Low AS, Obese BMI	High AS, Normal BMI	High AS, Obese BMI
N	8	7	8	9
Age	42 (16)	45 (13)	35 (17)	50 (13)
Sex (% female)	75%	43%	75%	56%
BMI	21.8 (2.2)	34.2 (4.0)	22.4 (1.3)	35.4 (5.0)
ASI Total Score	12.8 (2.2)	9.7 (5.8)	29.0 (7.2)	29.4 (8.9)
EEI Scale 1	43.6 (24.0)	51.0 (15.1)	49.5 (18.0)	67.3 (29.2)
BDI	12.6 (19.7)	5.1 (6.3)	16.5 (12.2)	12.4 (6.3)
Moderate Exercise	410 (561)	863 (1098)	297 (335)	291 (426)
Vigorous Exercise	1145 (1674)	954 (1064)	846 (1077)	1371 (2470)

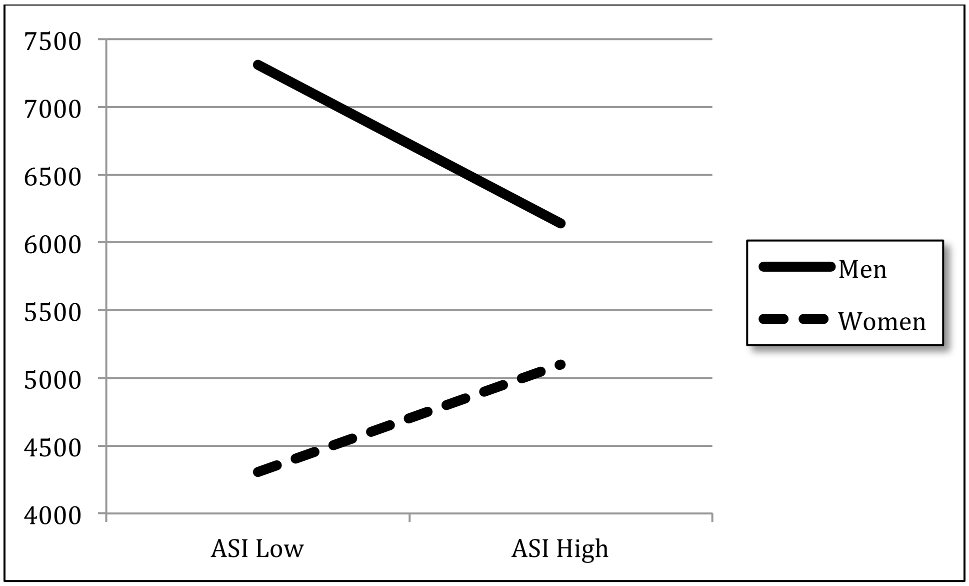
Note. ASI: Anxiety Sensitivity Index, BMI: Body Mass Index, EEI: Eating Expectancy Inventory, Scale 1 (eating helps manage negative affect), BDI: Beck Depression Inventory; Moderate Exercise: Baseline Self-reported Metabolic Equivalents; Vigorous Exercise: Baseline Self-reported Metabolic Equivalents.

Figure 1. The Effect of the Three-way Interaction of BMI x AS-MC x EEI Scale 3 on Calories Consumed (Second Study, Chapter 2).



Note: Normal Weight: Body Mass Index < 25, Overweight/Obese: Body Mass Index ≥ 25, High EEI3: Eating Expectancy Inventory Scale 3 Score ≥ M (8.37), Low EEI3: Eating Expectancy Inventory Scale 3 Score < M (8.37), High AS-MC: Anxiety Sensitivity Index Mental Concern Subscale ≥ M (1.77), Low AS-MC: Anxiety Sensitivity Index Mental Concern Subscale < M (1.77), Calories Consumed: Number of calories eaten during food exposure.

Figure 2. Differences in caloric intake between men and women with high and low AS across the 3-day monitoring period (Chapter 5).



Note: ASI Low: ASI total score < 20; ASI High: ASI total score ≥ 20.

References

Agras W.S. & Telch C.F. (1998). The effects of caloric deprivation and negative affect on binge eating in obese binge-eating disordered women. *Behavior Therapy*, 29, 491–503. doi:10.1016/S0005-7894(98)80045-2

Albarracin, D. Wang, W., & Leeper, J. (2009). Immediate increase in food intake following exercise messages. *Obesity, 17*, 1452-1452. doi: 10.1038/oby.2009.16

American College of sports medicine (2006). *ACSM's Guidelines for Exercise Testing and Prescription,* 7th edition. Philadelphia: Lippincott, Williams and Wilkins.

Anestis, M.D., Selby, E.A., Fink, E.L., & Joiner, T.E. (2007). The multifaceted role of distress intolerance in dysregulated eating behaviors. *International Journal of Eating Disorders, 40*, 718-726. doi: 10.1002/eat.20471

Anestis, M.D., Holm-Denoma, J.M., Gordon, K.H., Schmidt, N.B., & Joiner, T.E. (2008). The role of anxiety sensitivity in eating pathology. *Cognitive Therapy and Research, 32*, 370-385. doi: 10.1007/s10608-006-9085-y

Arnow, B., Kenardy, J., & Agras, W.S. (1995). The Emotional Eating Scale: The development of a measure to assess coping with negative affect by eating. *International Journal of Eating Disorders, 18,* 79-90. doi:10.1002/1098-108X(199507)18:1<79:AID EAT2260180109>3.0.CO;2-V

Asmundson, G. J. G., Norton, P. J., & Veloso, F. (1999). Anxiety sensitivity and fear of pain in patients with recurring headaches. *Behaviour Research and Therapy, 37*, 703–713. doi.org/10.10162FS0005-796728982900172-7

Bartholomew, J.B., Morrison, D., & Ciccolo, J.T. (2005). Effects of acute exercise on mood and well-being in patients with major depressive disorder. *Medicine and Science in Sports and Exercise, 37*, 2032-2037. doi:10.12492F01.mss.0000178101.78322.dd

Baumeister, R.F. (1990). Self-inference processes: The Ontario symposium. Vol. 6. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.; 1990. *Anxiety and deconstruction: On escaping the self*; pp. 259–291.

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current Directions In Psychological Science, 16*, 351-355. doi:10.1111/j.1467-8721.2007.00534.x

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for Beck Depression Inventory-II*. San Antonio, TX: Psychological Corporation.

Berger, B. & Motl, R. (2000). Exercise and mood: A selective review and synthesis of research employing the profile of mood states. *Journal of Applied Sport Psychology, 12*, 69-92. doi.org/10.10802F10413200008404214

Bernstein, A., Zvolensky, M. J., Kotov, R., Arrindell, W. A., Taylor, S., Sandin, B., Schmidt, N. B. (2006). Taxonicity of anxiety sensitivity: a multi-national analysis. *Journal of Anxiety Disorders, 20*, 1-22. doi: S0887-6185(04)00131-8 [pii] 10.1016/j.janxdis.2004.11.006

Bish, C.L., Blanck H.M., Serdula, M.K., Marcus, M., Kohl, H.W., & Khan, L.K. (2005). Diet and physical activity behaviors among Americans trying to lose weight: 2000

Behavioral risk factor surveillance system. *Obesity Research, 13*, 596-607. doi.org/10.10382Foby.2005.64

Blair, S.N., & Morris, J.N. (2009). Healthy hearts--and the universal benefits of being physically active: physical activity and health. *Annals of Epidemiology, 19*, 253-256. doi.org/10.10162Fj.annepidem.2009.01.019

Blundell, J.E., & King, N.A. (1998). Effects of exercise on appetite control: Loose coupling between energy expenditure and energy intake. *International Journal of Obesity and Related Metabolic Disorders. 22,* S22-S29.

Blundell, J.E., Stubbs, R.J., Golding, C., Croden, F., Alam, R., et al. (2005). Resistance and susceptibility to weight gain: individual variability in response to a high-fat diet. *Physiology and Behavior, 86*, 614-622. doi:10.10162Fj.physbeh.2005.08.052

Borg, G. (1998). Borg's perceived exertion and pain scales. Champaign, IL: Human Kinetics.

Boutelle, K.N., Jeffery, R.W., & French, S.A. (2004). Predictors of vigorous exercise adoption and maintenance over four years in a community sample. *The International Journal of Behavioral Nutrition and Physical Activity, 1*, 13.

Broman-Fulks, J. J., Deacon, B. J., Olatunji, B. O., Bondy, C. L., Abramowitz, J. S., & Tolin, D. F. (2010). Categorical or dimensional: a reanalysis of the anxiety sensitivity construct. *Behavior Therapy, 41*(2), 154-171. doi: S0005-7894(09)00075-6 [pii]10.1016/j.beth.2009.02.005

Carter, M.M., Miller, O., Sbrocco, T., Suchday, S., Lewis, E.L. (1999). Factor structure of the Anxiety Sensitivity Index among African American college students. *Psychological Assessment, 11,* 525-533. doi:10.10372F2F1040-3590.11.4.525

Centers for Disease Control and Prevention. (2000). Prevalence of leisure-time physical activity among overweight adults—United States, 1998. *Morbidity and Mortality Weekly Report, 49*, 326–330.

Centers for Disease Control and Prevention. (2010). *Prevalence of Overweight, Obesity, and Extreme Obesity Among Adults: United States, Trends 1960–1962 Through 2007–2008.*

Centers for Disease Control and Prevention. (2012). *Prevalence of Overweight, Obesity, and Extreme Obesity Among Adults: United States, Trends 1960–1962 Through 2007–2009.*

Cepeda-Benito, A., Gleaves, D.H., & Williams, T.L. (2000). The development and validation of the State and Trait Food-Cravings Questionnaires. *Behavior Therapy, 31*, 151-173. doi:10.1016/S0005-7894(00)80009-X

Chandon, P., & Wansink, B. (2007). The biasing health halos of fast-food restaurant health claims: Lower calorie estimates and higher side-dish consumption intentions. *Journal of Consumer Research, 34,* 301-314. doi: 10.10862F519499

Chernev, A. (2010). The dieter's paradox. *Journal of Consumer Psychology. 21*, 178-183. doi:10.10162Fj.jcps.2010.08.002

Chernev, A., & Gal, D. (2010). Categorization effects in value judgments: Averaging bias in evaluating combinations of vices and virtues. *Journal of Marketing Research, 47*, 738−747. doi:10.10162Fj.jcps.2010.08.002

Chua, J.L., Touyz, S., Hill, A.J. (2004). Negative mood-induced overeating in obese binge eaters: An experimental study. *International Journal of Obesity, 28*, 606-610. doi:10.1038/sj.ijo.0802595

Cohen, J. (1994). The earth is round (p < .05). *American Psychologist, 49*, 997-1003.

Craske, M.G., Roy-Byrne, P., Stein, M. B., Sullivan, G., Hazlett-Stevens, H., Bystritsky, A.,& Sherbourne, C. (2006). CBT intensity and outcome for panic disorder in a primary care setting. *Behavior Therapy, 37,* 112-119. doi:10.1016/j.beth.2005.05.003

Crawford, J.R., & Henry, J.D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 43*, 245-265. doi:10.1348/0144665031752934

Courbasson, C.M., Rizea, C., Weiskopf, N. (2008). Emotional eating among individuals with concurrent eating and substance use disorders. *Journal of Mental Health and Addiction, 6*, 378-388. doi:10.1007/s11469-007-9135-z

Davis, R. & Jamieson, J. (2005). Assessing the functional nature of binge eating in the eating disorders. *Eating Behaviors, 6,* 345-354. doi:10.1016/j.eatbeh.2005.02.001

Deboer, L.B., Tart, C.D., Presnell, K.E., Powers, M.B., Baldwin, A.S., & Smits, J.A. (2012). Physical activity as a moderator of the association between anxiety sensitivity and binge eating. *Eating Behaviors, 13,* 194-201. doi:10.10162Fj.eatbeh.2012.01.009

Deforche, B. I., De Bourdeaudhuij, I. M., & Tanghe, A. P. (2006). Attitude toward physical activity in normal-weight, overweight, and obese adolescents. *Journal of Adolescent Health, 38,* 560–568.

Delinsky, S.S. & Wilson, G.T. (2008). Weight gain, dietary restraint, and disordered eating in the freshman year of college. *Eating Behaviors, 9*, 82-90. doi:10.1016/j.eatbeh.2007.06.001

DeMartini, K.S., & Carey, K.B. (2011). The role of anxiety sensitivity and drinking motives in predicting alcohol use: A critical review. *Clinical Psychology Review, 31,*169. doi:10.1016/j.cpr.2010.10.001

Dishman, R.K., & Buckworth, J. (1996). Increasing physical activity: a quantitative synthesis. *Medicine and Science in Sports and Exercise, 28*, 706-719. doi:10.10972F00005768-199606000-00010

Dobkin, P.L., Abrahamowicz, M., Fitzcharles, M.A., Drista, M., da Costa, D. (2005). Maintenance of exercise in women with fibromyalgia. *Arthritis and Rheumatism, 53,* 724-731. doi:10.10022/art.21470

Ehlers, A. (1995). A one-year prospective study of panic attacks: clinical course and factors associated with maintenance. *Journal of Abnormal Psychology, 104*, 164-172.

Ekkekakis, P., Backhouse, S.H., Gray, C., & Lind, E. (2008). Walking is popular among adults but is it pleasant? A framework for clarifying the link between walking and affect as illustrated in two studies. *Psychology of Sport and Exercise, 9*, 246-264. doi:10.1016/j.psychsport.2007.04.004

Ekkekakis, P., & Lind, E. (2006). Exercise does not feel the same when you are overweight: The impact of self-selected and imposed intensity on affect and exertion. *International Journal of Obesity, 30,* 652–660. doi:10.1038/sj.ijo.0803052

Ekkekakis, P., Lind, E., & Vazou, S. (2009). Affective response to increasing levels of exercise intensity in normal weight, overweight, and obese women middle-aged women. *Obesity, 18*, 79-85. doi:10.1038/oby.2009.204.

Evers, C., de Ridder, T. & Adriaanse, M. (2009). Assessing yourself as an Emotional Eater: Mission Impossible? *Health Psychology, 28*, 717-725. doi:10.1037/a0016700

Epstein, L.H., & Wing, R.R. (1980). Aerobic exercise and weight. *Addictive Behaviors, 5*, 371-388. doi: 10.1016/F0306-460328802990011-8

Flegal, K.M., Carroll, M.D., Ogden, C.L., & Johnson, C.L. (2002). Prevalence and trends in obesity among US adults, 1999-2000. *Journal of the American Medical Association, 288,* 1723-1727. doi:10.1001/jama.288.14.1723

Fulton, J.J, Lavender, J.M., Tull, M.T., Klein, A.S., Muehlenkamp, J.J., & Gratz, K.L. (2012). The relationship between anxiety sensitivity and disordered eating: The mediating role of experiential avoidance. *Eating Behaviors, 13*, 166-169. doi:10.1016/j.eatbeh.2011.12.003

Garner, D. M., Olmsted, M. P., Bohr, Y., & Garfinkel, P. E. (1982). The eating attitudes test: Psychometric features and clinical correlates. *Psychological Medicine, 12*, 871–878. doi:10.1017/S0033291700049163

Garner, D. M., Olmstead, M. P., & Polivy, J. (1983). Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. *International Journal of Eating Disorders, 2,* 15–34. doi:10.1002/1098-108X(198321)2:2/15

Garrow, J.S., & Summerbell, C.D. (1995). Meta-analysis: effect of exercise, with or without dieting, on the body composition of overweight subjects. *European Journal of Clinical Nutrition, 49*, 1-10.

Grilo, C.M., Masheb, R.M., & Wilson, G.T. (2001). Subtyping binge eating disorder. *Journal of Clinical and Consulting Psychology, 69*, 1066-1072. doi:10.1037//0022-006X.69.6.1066

Goldberg, J.H., & King, A.C. (2007). Physical activity and weight management across the lifespan. *Annual Review of Public Health, 28*, 145-170. doi:10.1146/annurev.publhealth.28.021406.144105

Greaves, C.J., Sheppard, K.E., Abraham, C., Hardeman, W., Roden, M. et al. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health, 11*, 119. doi:10.1186/1471-2458-11-119

Hale, B.S., Koch, K.R., & Raglin, J.S. (2002). State anxiety responses to 60 minutes of cross training. *British Journal of Sports Medicine, 36*, 105-107. doi:10.1136/bjsm.36.2.105

Havermans, R.C., Giesen, J., Houben, K., Jansen, A. (2011). Weight, gender, and snack appeal. *Eating Behaviors, 12,* 126-130. doi:10.1016/j.eatbeh.2011.01.010

Hawkins, R.C. & Clement, P.F. (1984). Binge eating: Measurement problems and a conceptual model. In: Hawkins RC, Fremouw WJ, Clement PF, editors. *The binge purge syndrome: Diagnosis treatment, and research (pp. 229-251)*. New York: Springer.

Hayes, S. C., Strosahl, K. D., Wilson, K. G., Bissett, R. T., Pistorello, J., & Toarmino, D. (2004). Measuring experiential avoidance: A preliminary test of a working model. *The Psychological Record, 54,* 553–578.

Hearon, B.A., Utschig, A. C., Smits, A.J., Moshier, S.J., & Otto, M.W. (in press). The Role of Anxiety Sensitivity and Eating Expectancy in Maladaptive Eating Behavior. *Cognitive Therapy and Research*.

Herman, C.P. & Polivy, J. (1980). A boundary model for the regulation of eating. In: Stunkard A.B., Stellar E., editors. *Eating and its disorders (pp*. 141-156). New York: Raven Press.

Hetherington, M.M., Altemus, M., Nelson, M.L., Bernat, A.S., Gold, P.W. (1994). Eating behavior in bulimia nervosa: Multiple meal analyses. *The American Journal of Clinical Nutrition, 60,* 864–873.

Hohlstein, L.A., Smith, G.T., Atlas, J.G. (1998). An application of expectancy theory to eating disorders: Development and validation of eating and dieting expectancies. *Psychological Assessment, 10*, 49-58. doi:10.1037//1040-3590.10.1.49

Hudson, J.I., Hiripi, E., Pope, H.G., Kessler, R.C. (2007). The Prevalence and Correlates of Eating Disorders in the National Comorbidity Survey Replication. *Biological Psychiatry, 61,* 348-358. doi:10.1016/j.biopsych.2006.03.040

Hulens, M., Vansant, G., Claessens, A. L., Lysens, R., & Muls, E. (2003). Predictors of 6-minute walk test results in lean, obese, and morbidly obese women. *Scandinavian Journal of Medicine and Science in Sports, 13*, 98–105. doi:10.1034/j.1600-0838.2003.10273.x

Jansen, A., Vanreyten, A., van Balveren, T., Roefs, A., Nederkoorn, C. (2008). Negative affect and cue-induced overeating in non-eating disordered obesity. *Appetite, 51*, 556-562. doi:10.1016/j.appet.2008.04.009

Johnson, K., Mullin, J.L., Marshall, E.C., Bonn-Miller, M.O., Zvolensky, M. (2010). Exploring the meditational role of coping motives for marijuana use in terms of the relationship between anxiety sensitivity and marijuana dependence. *The American Journal on Addictions, 19*, 277-282.

Kaye, W.H., Gwirtsman, H.E., George, D.T., Weiss, S.R., Jimerson, D.C. (1986). Relationship of mood alterations to bingeing behaviour in bulimia. *British Journal of Psychiatry, 149*, 479–485. doi:10.1192/bjp.149.4.479

King, A. C., Kiernan, M., Oman, R. F., Kremer, H. C., Hull, M., & Ahn, D. (1997). Can we identify who will adhere to long-term physical activity? Signal detection methodology as a potential aid to clinical decision making. *Health Psychology, 16*, 380–389.

King, A., Marcus, B., Ahn, D., Dunn, A., Rejeski, W., Sallis, J., et al. (2006). Identifying sub- groups that succeed or fail with three levels of physical activity intervention: The Activity Counseling Trial. *Health Psychology, 25*, 336 – 347. doi:10.1037/2/0278-6133.16.4.380

King, N.A., Caudwell, P., Hopkins, M., Byrne, N.M., Colley, R., Hills, A.P., Stubbs, J.R., & Blundell, J.E. (2007). Metabolic and behavioral compensatory responses to exercise interventions: barriers to weight loss. *Obesity, 15*, 1373-83. doi:10.1038/oby.2007.164

King, N.A., Hopkins, M., Caudwell, P., Stubbs, R.J., &Blundell, J.E. (2008). Individual variability following 12 weeks of supervised exercise: identification and characterization of compensation for exercise-induced weight loss. *International Journal of Obesity, 32*, 177-84. doi:10.1038/sj.ijo.0803712

Kinne, S., Patrick, D.L., & Maher, E.J. (1999). Correlates of exercise maintenance among people with mobility impairments. *Disability and Rehabilitation, 21*, 15-22. doi:10.1080/096382899298052

Kirkcaldy, B. C., & Shephard, R. J. (1990). Therapeutic implications of exercise. *International Journal of Sport Psychology, 21*, 165–184.

Knight, L. J., & Boland, F. J. (1989). Restrained eating: An experimental disentanglement of the disinhibiting variables of perceived calories and food type. *Journal of Abnormal Psychology, 98*, 412−420. doi:10.1037/2/0021-843X.98.4.412

Lees, A., Mogg, K., & Bradley, B. P. (2005). Health anxiety, anxiety sensitivity, and attentional biases for pictorial and linguistic health-threat cues. *Cognition and Emotion, 19*, 453-462. doi:10.1080/02699930441000184

Leitzmann, M.F., Park, Y., Blair, A., Ballard-Barbash, R., Mouw, T., Hollenbeck, A.R., & Schatzkin, A. (2007). Physical activity recommendations and decreased risk of mortality. *Archives of Internal Medicine, 167*, 2453-2460. doi:10.1001/archinte.167.22.2453

Lynch W.C., Everingham A., Dubitzky J., Hartman M., Kasser T. (2000). Does binge eating play a role in the self-regulation of moods? *Integrative Physiological & Behavioral Science*, *35*, 298–313. doi:10.1007/BF02688792

Marcus, B.H., Selby, V.C., Niaura, R.S., & Rossi, J.S. (1992). Self-efficacy and the stages of exercise behavior change. *Research Quarterly for Exercise and Sports, 63*, 60-66. doi:1080/02701367.1992.10607557

Martin, J.E., & Dubbert, P.M. (1985). Adherence to exercise. *Exercise and sports science reviews, 13*, 137-167. doi:10.1249/00003677-198500130-00007

Martins, C., Morgan, L., & Truby, H. (2008). A review of the effects of exercise on appetite regulation: an obesity perspective. *International Journal of Obesity, 32,* 1337-1347. doi:10.1038/ijo.2008.98

Martins, C., Truby, H., Morgan, L.M. (2007). Short-term appetite control in response to a 6-week exercise programme in sedentary volunteers. *British Journal of Nutrition, 98,* 834-842. doi:10.1017/S000711450774922X

McHugh, R.K., Murray, H.W., Borges, A.M., Siwiec, S. & Otto, M.W. (2013). Distress intolerance moderates the association between negative affect and delayed discounting. Unpublished Manuscript.

McHugh, R.K., & Otto, M.W. (2011). Domain-general and domain-specific strategies for the assessment of distress intolerance. *Psychology of Addictive Behaviors, 25*, 745-749. doi:10.1037/a0025094

McNally, R.J. (1996). Anxiety Sensitivity is distinct from trait anxiety. In R.M. Rapee (Ed.), *Current controversies in the anxiety disorders* (pp. 214-227). New York:Guilford Press.

McNally RJ. (2002). Anxiety sensitivity and panic disorder. *Biological Psychiatry, 52*, 938–946. doi:10.1016/S0006-3223/28(02)2901475-0

McWilliams, L. A., & Asmundson, G. J. (2001). Is there a negative association between anxiety sensitivity and arousal-increasing substances and activities? *Journal of Anxiety Disorders, 15*, 161-170. doi: S0887-6185(01)00056-1

Miller, B.M., Bartholomew, J.B., & Springer, B.A. (2005). Post exercise affect: The effect of mode preference. *Journal of Applied Sport Psychology, 17,* 263-272. doi:10.1080/10413200500313503

Moshier, S.J., Hearon, B.A., Calkins, A.C., Szuhany, K.L., Utschig, A.C., Smits, J.A.J., & Otto, M.W. (in press). Clarifying the Link between Distress Intolerance and Exercise: Elevated Anxiety Sensitivity Predicts Less Vigorous Exercise. *Cognitive Therapy and Research*.

Muraven, M., & Baumeister, R.F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126*, 247-259. doi:10.1037//0033-2909.126.2.247

Neuhouser, M. L., Di, C., Tinker, L. F., Thomson, C., Sternfeld, B., Mossavar-Rahmani, Y., Stefanick, M. L., Sims, S., Curb, J. D., Lamonte, M. Seguin, R., Johnson, K. C., & Prentice R. L. (2013). Physical Activity Assessment: Biomarkers and Self-Report of Activity-Related Energy Expenditure in the WHI. *American Journal of Epidemiology, 177*, 576-585. doi:10.1093/aje/kws269

Nocon, M., Hiemann, T., Muller-Riemenschneider, F., Thalau, F., Rolls, S. & Willich, S.N. (2008). Association of physical activity with all-cause and cardiovascular mortality: a systematic review and meta-analysis. *European Journal of Cardiovascular Prevention and Rehabilitation, 15*, 239-246. doi:10.1097/HJR.0b013e3282f55e09

Ocañez, K. S., McHugh, R., & Otto, M. W. (2010). A meta-analytic review of the association between anxiety sensitivity and pain. *Depression and Anxiety, 27*, 760-767.

Ojanen, M. (1994). Can the true effects of exercise on psychological variables be separated from placebo effects? *International Journal of Sport Psychology, 25*, 63–80.

Otto, M. W., Demopulos, C. M., McLean, N. E., Pollack, M. H., & Fava, M. (1998). Additional findings on the association between anxiety sensitivity and hypochondriacal concerns: Examination of patients with major depression. *Journal of Anxiety Disorders, 12*, 225-232. doi:10.1016/S0887-6185(98)00011-5

Otto, M. W., Pollack, M. H., Fava, M., Uccello, R., & Rosenbaum, J. F. (1995). Elevated anxiety sensitivity index scores in patients with major depression: Correlates and changes with antidepressant treatment. *Journal of Anxiety Disorders, 9*, 117–223. doi:10.1016/0887-6185(94)00035-2

Otto, M. W., Pollack, M. H., Sachs, G. S., & Rosenbaum, J. F. (1992). Hypochondriacal concerns, anxiety sensitivity, and panic disorder. *Journal of Anxiety Disorders, 6*, 93-104. doi:10.1016/0887-6185(92)90008-U

Otto MW, Powers MB, Fischmann D. (2005). Emotional exposure in the treatment of substance use disorders: Conceptual model, evidence, and future directions. *Clinical Psychology Review 25*, 824– 839. doi:10.1016/j.cpr.2005.05.002

Paffenbarger, R.S., Hyde, R.T., Wing, A.L., & Hsieh, C.C. (1986). Physical activity, all-cause mortality, and longevity of college alumni. *New England Journal of Medicine, 314*, 605-613. doi:10.1056/NEJM198603063141003

Peterson, R.A. & Reiss S. (1992). Anxiety Sensitivity Index Manual, revised. Worthington, OH: International Diagnostic Systems.

Peterson, R.A. & Reiss, S. (1993). *Anxiety Sensitivity Index Revised Test Manual.* Worthington, OH: IDS Publishing.

Petry, N.M., Barry, D., Pietrzak, R.H., & Wagner, J.A. (2008). Overweight and obesity are associated with psychiatric disorders: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Psychosomatic Medicine, 70*, 288–29. doi:10.1097/PSY.0b013e3181651651

Pomerleau, M., Imbeault, P., Parker, T., & Doucet, E. (2004). Effects of exercise intensity on food intake and appetite in women. *American Journal of Clinical Nutrition, 80,* 1230-1236.

Raglin, J. S., & Morgan, W. P. (1985). Influence of vigorous exercise on mood state. *Behavior Therapist, 8*, 179–183.

Rapee, R., & Medoro, L. (1994). Fear of physical sensations and trait anxiety as mediators of the response to hyperventilation in nonclinical subjects. *Journal of Abnormal Psychology, 4*, 693-699. doi:10.1037//0021-843X.103.4.693

Reiss S. (1991). The expectancy model of fear, anxiety, and panic. *Clinical Psychology Review, 11*, 141–153. doi:10.1016/0272-7358/2891/2990092-9

Reiss S., Peterson R.A., Gursky D.M., & McNally R.J. (1986). Anxiety sensitivity, anxiety frequency and the prediction of fearfulness. *Behavior Research and Therapy, 24,* 1–8. doi:10.1016/0005-7967(86)90143-9

Reiss, S., Peterson, R., Taylor, S., Schmidt, N. B., & Weems, C. F. (2008). *Anxiety Sensitivity Index consolidated user manual: ASI, ASI-3, and CASI.* . Worthington, OH: International Diagnostic Systems.

Rozin, P., Ashmore, M., & Markwith, M. (1996). Lay American conceptions of nutrition: Dose insensitivity, categorical thinking, contagion, and the monotonic mind. *Health Psychology, 15*, 438−447. doi:10.1037//0278-6133.15.6.438

Ross, R. & Janssen, I. (2001). Physical activity, total and regional obesity: dose-response considerations. *Medicine and Science in Sports and Exercise, 33*, S521-S527. doi:10.1097/00005768-200106001-00023

Sabourin, B. C., Hilchey, C. A., Lefaivre, M.-J., Watt, M. C., & Stewart, S. H. (2011). Why Do They Exercise Less? Barriers to Exercise in High-Anxiety-Sensitive Women. *Cognitive Behaviour Therapy, 40*, 206-215. doi: 10.1080/16506073.2011.573572

Schmidt, N. B., Lerew, D. R., & Jackson, R. (1997). The role of anxiety sensitivity in the pathogenesis of panic: Prospective evaluation of spontaneous panic attacks during acute stress. *Journal of Abnormal Psychology, 106*, 355-364. doi:10.1037/h0090325

Schmidt, N.B., & Joiner, T.E. (2002). Structure of the Anxiety Sensitivity Index psychometrics and factor structure in a community sample. *Journal of Anxiety Disorders, 16*, 33-49. doi:10.1016/S0887-6185(01)00087-1

Schmidt, N. B., Kotov, R., Lerew, D. R., Joiner, T. E., & Ialongo, N. S. (2005). Evaluating latent discontinuity in cognitive vulnerability to panic: A taxometric investigation. *Cognitive Therapy and Research, 29*, 673–691. doi:10.1007/s10608-005-9632-y

Schmidt, N. B., Zvolensky, M. J., & Maner, J. K. (2006). Anxiety sensitivity: prospective prediction of panic attacks and Axis I pathology. *Journal of Psychiatric Research, 40*, 691-699. doi:10.1016/j.jpsychires.2006.07.009

Shephard, R. J., Cox, M. H., & Simper, K. (1981). An analysis of "Par-Q" responses in an office population. *Canadian Journal of Public Health, 72*, 37–40.

Simons, J.S., & Gaher, R.M. (2005). The distress tolerance scale: Development and validation of a self-report measure. Motivation and Emotion, 29, 83–102. doi:10.1007/s11031-005-7955-3

Simmons, J.R., Smith, G.T., & Hill, K.K. (2001). Validation of eating and dieting expectancy measures in two adolescent samples. *International Journal of Eating Disorders, 31,* 461-473. doi:10.1002/eat.10034

Smits, J.A.J., Berry, A.C., Rosenfield, D., Powers, M.B., Behar, E., & Otto, M.W. (2008). Reducing anxiety sensitivity with exercise. *Depression & Anxiety, 25*, 689-699. doi:10.1002/da.20411

Smits, J. A., Tart, C. D., Presnell, K., Rosenfield, D., & Otto, M. W. (2010). Identifying Potential Barriers to Physical Activity Adherence: Anxiety Sensitivity and Body Mass as Predictors of Fear During Exercise. *Cognitive Behaviour Therapy, 39*(1), 28-36. doi: 10.1080/16506070902915261

Strong, D. R., Lejuez, C. W., Daughters, S., Marinello, M., Kahler, C. W., & Brown, R. A. (2003). The computerized mirror-tracing task, version 1. Unpublished manual.

Taylor, S., Koch, W.J., & Crockett, D.J. (1991). Anxiety sensitivity, trait anxiety, and the anxiety disorders. *Journal of Anxiety Disorders, 5*, 293–311. doi:10.1016/0887-6185/2891.2990030-W

Taylor, S., Koch, W.J., Woody, S.R., & McClean, P. (1997). Anxiety sensitivity and depression: How are they related? *Journal of Abnormal Psychology, 105*, 474–479. doi:10.1037//0021-843X.105.3.474

Tice, D. M., & Bratslavsky, E. (2000). Giving in to feel good: The place of emotion regulation in the context of general self-control. *Psychological Inquiry, 11*, 149-159. doi:10.1207/S15327965PLI1103_03

Tice, D. M., Batslavsky, E., & Baumeiser, R. F. (2001). Emotional distress regulation takes precedence over impulse control. If you feel bad, do it! *Journal of Personality and Social Psychology, 8*, 53-67. doi: 10.1037//0022-3514.80.1.53

Wansink, B., & Chandon, P. (2006). Can 'Low-Fat' Nutrition Labels Lead to Obesity? *Journal of Marketing Research, 43,* 605-617. doi:10.1509/jmkr.43.4.605

Watson D., Clark L. A., & Tellegen A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063-1070. doi:10.1037//0022-3514.54.6.1063

Williams, D. M., Dunsiger, S., Ciccolo, J. T., Lewis, B. A., Albrecht, A. E., & Marcus, B. H. (2008). Acute affective response to a moderate-intensity exercise stimulus predicts physical activity participation 6 and 12 months later. *Psychology of Sport and Exercise, 9*, 231-245. doi: 10.1016/j.psychsport.2007.04.002

Wolpe, J. (1958). Psychotherapy by reciprocal inhibition. Palo Alto, CA: Stanford University Press.

World Health Organization (2009) Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. Geneva: World Health Organization.

Wertenbroch, K. (1998). Consumption self-control by rationing purchase quantities of virtue and vice. *Marketing Science, 17*, 317–337. doi:10.1287/mksc.17.4.317

Zinbarg, R.E., & Barlow, D.H. (1996). Structure of anxiety and the anxiety disorders: A hierarchical model. *Journal of Abnormal Psychology, 105*, 181-193. doi:10.1037//0021-843X.105.2.181

Zinbarg, R.E., Barlow, D.H., & Brown, T.A. (1997). Hierarchical structure and general factor saturation of the Anxiety Sensitivity Index: Evidence and implications. *Psychological Assessment, 9*, 277-284. doi:10.1037//1040-3590.9.3.277

Zvolensky, M. J., Forsyth, J. P., Bernstein, A., & Leen-Feldner, E. W. (2007). A concurrent test of the anxiety sensitivity taxon: Its relation to bodily vigilance and perceptions of control over anxiety-related events in a sample of young adults. *Journal of Cognitive Psychotherapy, 21*, 72–90. doi:10.1891/088983907780493322

Zvolensky, M.J., Feldner, M.T., Leen-Feldner, E., Bonn-Miller, M.O., McLeish, A.C., & Gregor, K. (2004). Evaluating the role of anxiety sensitivity in smoking outcomes expectancies among regular smokers. *Cognitive Therapy and Research, 28*, 473-486. doi:10.1023/B:COTR.0000045559.73958.89

Zvolensky, M. J., Goodie, J. L., McNeil, D. W., Sperry, J. A., & Sorrell, J. T. (2000). Anxiety sensitivity in the prediction of pain-related fear and anxiety in a heterogeneous chronic pain population. *Behaviour Research and Therapy, 39*, 683 – 696. doi:10.1016/S0005-7967/2800/2900049-8

Zvolensky M.J., Lejuez C.W., Kahler C.W., Brown R.A. (2003). Integrating an interoceptive exposure-based smoking cessation program into the cognitive-behavioral treatment of panic disorder: Theoretical relevance and case demonstration. *Cognitive and Behavioral Practice, 10*, 347-357. doi:10.1016/S1077-7

Zvolensky, M.J., McNeil, D.W., Porter, C.A., & Stewart, S.H. (2001). Assessment of anxiety sensitivity in young American Indians and Alaska Natives. *Behaviour Research and Therapy, 39*, 477-193. doi:10.1016/S0005-7967(00)00010-3

Zvolensky, M. J., & Otto, M. W. (2007). Affective intolerance, sensitivity, and processing: Advances in clinical science introduction. *Behavior Therapy, 38*, 228-233. doi: 10.1016/j.beth.2007.01.002229(03)80052-4

Curriculum Vitae

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