CAN HEART RATE VARIABILITY BIOFEEDBACK MITIGATE THE NEGATIVE CONSEQUENCES OF A SOCIAL COMPARISON CHALLENGE?

by

O. Eduardo Roldan

M.A. (Clinical Psychology), Lakehead University, Canada, 2008

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN CLINICAL PSYCHOLOGY AT LAKEHEAD UNIVERSITY

Department of Psychology, Lakehead University

Acknowledgements

The completion of this project was only possible through the support and guidance of various individuals. I would first like to thank Dr. Ron Davis for his time, diligence, and most importantly, his patience throughout this process. Furthermore, I would like to thank all of committee members for their feedback. A special thank you to Jenny Morgan for all of her hard work with data collection and extraction. I would like to acknowledge all of my fellow lab members who helped with editing and who also provided feedback throughout the writing process.

I would especially like to thank my family and friends for all of their support over the last 8 years. To my wife and son, thank you for being patient and accepting the many hours I spent in front of the computer. Your understanding and love provided me with the motivation to complete this project. To my parents, thank you for instilling a sense of curiosity that continues to drive my thirst for knowledge. To my siblings, your support and ability to make me laugh provided me with an escape from any stress that I was experiencing. Finally, to the guys in my cohort and to my many friends in Thunder Bay that housed, fed, and supported me, your presence next to me throughout this process made the experience that much more meaningful.

Abstract

The present study sought to explore the ability of a single session of heart rate variability biofeedback (HRV BF) to mitigate the negative responses to a social comparison challenge. One hundred and fourteen undergraduate females were randomly assigned to one of three conditions: high-HRV BF, low-HRV BF, and no-BF. Following a single 15-min BF session, whereby they followed their assigned instructional set, participants viewed fashion magazine images while instructed to compare themselves to the models based on appearance characteristics. Consistent with previous findings, the social comparison challenge increased negative mood and body dissatisfaction across the sample as a whole. The effect of the social comparison challenge on negative mood was moderated by dispositional body concerns, with those higher on this dimension experiencing greater negative mood after viewing the images. In addition, time spent engaged in social comparison processing was related to more negative responses. The main finding indicated that HRV BF was not effective in reducing negative reactions for the average participant; however, resting HRV moderated the effectiveness of the intervention. Specifically, those with low intrinsic HRV benefitted the most from the HRV BF and experienced the least negative mood reactivity in response to the images. Results are discussed in terms of their relevance to the social comparison literature as well as to the future implementation and application of HRV BF.

Table of Contents

List of Tables

List of Figures

List of Appendices

Can Heart Rate Variability Biofeedback Mitigate the Negative Consequences of a Social Comparison Challenge?

A message that holds a great deal of importance within Western societies is the notion of what is attractive and beautiful. Contemporary standards depict the ideal female form as being white, young, tall and thin (Fouts & Burggraf, 1999, 2000; Levine & Chapman, 2011). However, the predominant view within body image literature is that the current standards for female appearance promote a degree of thinness that is impossible for most individuals to achieve in a healthy manner (Brown & Dittmar, 2005; Spitzer, Henderson, & Zivian, 1999; Sypeck, Gray, & Ahrens, 2004; Thompson, Heinberg, Altabe, & Tantleff-Dunn, 1999; Want, 2009). Furthermore, while the idealized prototypical body for women has become thinner over the last few decades (Cash, Morrow, Hrabosky, & Perry, 2004; Monteath & McCabe, 1997; Stice, 1994), the population's body weight has increased (Vanasse, Demers, Hemiari, & Courteau, 2006). Halliwell and Dittmar (2006) believe that this discrepancy is manifested in many women's self-concepts, particularly with regard to how they view their actual bodies in comparison to the ideal. Various researchers have postulated that such body self-discrepancies have a large bearing on self-concept and self-esteem, which in turn impact psychological functioning and may promote unhealthy body shape behaviours (Anton, Perri, & Riley, 2000; Shorter, Brown, Quinton, & Hinton, 2008; Sohn, 2010; Strauman, Vookles, Berenstein, Chaiken, & Higgins, 1991). Indeed, studies have shown that having negative feelings about one's body is linked to negative affect and low self-esteem which ultimately make one more vulnerable to depression (Dakanalis & Riva, 2013; Koenig & Wasserman, 1995; Marcotte, Fortin, Potvin, & Papillon, 2002; Rierdan & Koff, 1997; Stice, Cameron, Killen, Hayward, & Taylor, 1999).

The emphasis on physical attractiveness appears to have negative consequences on how females view themselves in Western cultures. For example, Feingold and Mazzella (1998) conducted a meta-analysis of gender differences in attractiveness and body image using 222 studies and found a striking increase in the number of females who are dissatisfied with their body image over the span of three decades. These types of findings have fuelled proposals that being dissatisfied with one's body is the norm for females in Western society (Rodin, Silberstein, & Striegel-Moore, 1984), with a recent study finding support for the pervasiveness of this sentiment (Tantleff-Dunn, Barnes, & LaRose, 2011).

A considerable amount of research attention, both from empirical and clinical perspectives, has focused on body image concerns experienced by females in Western society (for a review see Cash & Pruzinsky, 2002). Body image is defined as a concept incorporating self-perceptions and attitudes concerning one's physical appearance, including the size, shape, weight, and form of one's physical figure (e.g., Cash, 2004; Cash & Brown, 1987; Slade, 1988; Thompson et al., 1999). Furthermore, body image is thought to be "influenced by a variety of historical, cultural and social, individual and biological factors" (Slade, 1988, p. 502) and is reflected in attitudes and behaviours towards the body. Body image has been linked to a variety of factors such as self-esteem, happiness, interpersonal confidence, eating and exercise behaviours, sexual experiences, and emotional stability (Ackard, Kearney-Cooke, & Peterson, 2000; Horacek et al., 2002; Stokes & Frederick-Recascino, 2003).

It also appears that when individuals have a negative body image it puts them at risk for developing mental health concerns. For example, body shape and weight dissatisfaction have been linked to psychological problems such as eating disorders (EDs) and depression (Benas, Uhrlass, & Gibb, 2010; Cash & Pruzinsky, 2002; Stice & Bearman, 2001). Benas and colleagues (2010) have suggested that the relationship between body dissatisfaction and depression stems from the combination of a high level of body dissatisfaction with the experience of weight-related teasing, which causes an increase in low mood. On the other hand, Stice and Bearman (2001) contend that body dissatisfaction often results from females not being able to meet the thin ideal, especially through unsuccessful dieting attempts. Consequently, females will feel as if they have failed and thus experience depressive symptoms (Stice & Bearman, 2001).

The pervasiveness of body dissatisfaction is concerning given the suggestion that it actually signals a prodromal stage of EDs (Stice, Ng, & Shaw, 2010). Eating pathology, which includes both threshold and subthreshold EDs, is one of the most prevalent psychological problems faced by females (Thompson & Stice, 2001). Eisenberg, Nicklett, Roeder, and Kirz (2011) found that out of close to 700 female undergraduate students, 13.5% reported experiencing ED symptoms. Berg, Frazier, and Sherr (2009) found that 49% of their female nonclinical college sample ($N = 324$) reported engaging in disordered eating behaviour at least once per week. On the other hand, Ricciardelli and McCabe (2001) estimated that as many as 55% of children are dissatisfied with their own weight, which is problematic as findings suggests this dissatisfaction can be relatively stable across the lifespan (Heatherton, Mahamedi, Striepe, Field, & Keel, 1997; Tiggemann, 2004). Often these problems are chronic, and are associated with decreased psychosocial functioning and an increased risk for suicide (Favaro & Santonastaso, 1997) as well as depression, anxiety, substance use, and health problems (Johnson, Cohen, Kasen, & Brook, 2002; Stice et al., 1999).

The feeling of failure that many females experience speaks to the value placed on appearance within contemporary society. However, it is not only a negative self-perception of one's body that can be detrimental to one's well-being. In truth, how others perceive one's appearance can also lead to negative consequences across various domains. Often the state of one's body serves as a very clear indicator of success or failure, as being thin is deemed beautiful and a sign of success whereas being overweight is stigmatized as a sign of laziness or failure (Dakanalis & Riva, 2013; Monteath & McCabe, 1997). Furthermore, obese women have been found to experience decreased opportunities across professional and personal domains when compared to under- and normal-weight peers (Puhl & Brownell, 2001). This is even more salient given that recent statistics reveal that 69% of American adults are now considered overweight or obese (Flegal, Carroll, Kit, & Ogden, 2012). On the other hand, individuals who are deemed 'attractive' by today's standards are judged to be more competent in their profession, to experience more success as a result in their careers, and to be treated more fairly by others (Langlois et al., 2000). These attractive individuals are also regarded with esteem and assumed to possess greater positive characteristics (Rodin et al., 1984).

As previously mentioned, the thin ideal is one that is often not realistic, as Want (2009) notes, "to the extent that media portrayals are artificially manipulated to appear especially thin and attractive, they represent a standard that no-one, not even the models or actors in the portrayals themselves, can hope to achieve in everyday life" (p. 265). Even with some awareness that the media images often represent unobtainable images that have been altered or manipulated, the depictions still impact how some individuals construct their own body views, (Strahan, Wilson, Cressman, & Buote, 2006; Tiggemann, 2005). Therefore, despite being unrealistic, the goal of being thin carries an inordinate amount of perceived benefits such that females often accept and internalize this ideal. However, females often struggle to meet the desired ideal, which is believed to contribute to the development of negative body image as well as body dissatisfaction and problematic dieting behaviours (Tiggemann, 2005). Females may even turn to other unhealthy means to achieve an ideal weight. For example, Jeffers, Benotsch, and Koester (2013) surveyed undergraduate students and found that over 13% of the females reported taking prescription stimulants as a way to lose weight.

Several theories have been proposed to account for the importance of appearance in Western society. One framework that has been looked at repeatedly in the body image literature is the sociocultural perspective (e.g., Stice, 1994; Thompson et al., 1999).

Sociocultural Theory

Sociocultural theories attempt to explain individual values and behaviours within the cultural milieu that shapes these beliefs (Jackson, 1992). With regards to physical attractiveness, greater importance is placed on the appearance of females compared to that of males. This represents a notion that is dictated by the principles held within Western society, as Jackson notes, "physical attractiveness itself has no inherent value. The culture imparts value to it and in a way that depends on gender" (p. 36). In reviewing the sociocultural theoretical framework, Tiggemann (2011) describes how society's standard for beauty is transmitted via several means such as media, parents, and peers. Due to these influences, some females strive to attain this beauty ideal, with the resultant (dis)satisfaction based to how closely they resemble the standard (e.g., Halliwell & Dittmar, 2006; Heron & Smyth, 2013; Tiggemann, 2011).

With respect to the role of family, findings have noted that comments and behaviours by parents, especially mothers, can have negative influences on how females view their own bodies (Smolak, Levine, & Schermer, 1999). This has been associated with greater depressive symptomatology as well as higher incidence of weight control behaviours (Bauer, Bucchianeri, & Neumark-Sztainer, 2013). Furthermore, females who develop eating pathology often have parents who are more likely to criticize and tease them about their appearance (Annus, Smith, Fischer, Hendricks, & Williams, 2007; Smolak et al., 1999), and who encourage dieting behaviours (Helfert & Warschburger, 2011; Wertheim, Martin, Prior, Sanson, & Smart, 2002).

The role of peers in the development of body image concerns has also been examined with findings noting that females are especially vulnerable to the influence of their friends (Helfert & Warschburger, 2013). Peer influence on body image can happen directly through such things as weight-related teasing (Lampard, MacLehose, Eisenberg, Neumark-Sztainer, & Davison, 2014; Menzel et al., 2010; Phares, Steinberg, & Thompson, 2004), as well as indirectly through the prospect of being negatively evaluated by one's peers (Michael et al., 2014). Peer interactions also influence body concerns through 'fat talk' which refers to negative conversation regarding food, weight, and/or one's body (Nichter & Vuckovic, 1994). Rudiger and Winstead (2013) proposed that this type of conversation occurs on a daily basis as a result of the existing body dissatisfaction that permeates society and as a way for individuals to fit in within this climate of dissatisfaction. Recently, Salk and Engeln-Maddox (2011) found that over 90% of their female undergraduate sample reported engaging in fat talk with moderate frequency. This is especially relevant to the body image literature, where the majority of studies have focused on female university students.

The role of media in determining the beauty standards has received substantial research attention (Heinberg, 1996; Thompson & Heinberg, 1999). Findings of correlational (e.g., Botta 2003; Levine & Murnen, 2009) as well as experimental (e.g., Anschutz, Spruijt-Metz, Van Strien, & Engels, 2011) and meta-analytic studies (Grabe, Ward, & Hyde, 2008; Groesz, Levine, & Murnen, 2002; Want, 2009) have found a link between exposure to media images and body image disturbance. However, not all females experience body image concerns or body dissatisfaction; therefore, researchers have attempted to identify factors that make some individuals more or less susceptible to the pressures of society. Two crucial factors that have been identified include: internalization of the thin deal (Cattarin, Thompson, Thomas, & Williams, 2000; Halliwell & Dittmar, 2004; Karazsia, van Dulmen, Wong, & Crowther, 2013; Polivy & Herman, 2002; Thompson & Stice, 2001; Yamamiya, Cash, Melnyk, Posavac, & Posavac, 2005; Yamamiya, Shroff, & Thompson, 2008) and the tendency to engage in social comparisons (e.g., Keery, van den Berg, & Thompson, 2004; Shroff & Thompson, 2006; Tiggemann & McGill, 2004; Tiggemann & Slater, 2004; Vartanian & Dey, 2013). Women who are more invested in the societal beauty ideal are more likely to readily engage in social comparison, often making unhealthy evaluations based on the activation of the self-ideal discrepancy (Levine & Chapman, 2011). Therefore, researchers have focused on the process of social comparison as a way to examine how media influences individuals.

Social Comparison

Festinger's (1954) social comparison theory proposes that individuals are motivated to evaluate their opinions and abilities by comparing themselves to others, especially when no objective criteria exist. When an individual makes comparisons to others, their ensuing reactions are dependent on the direction of the comparison. A comparison to someone who is worse off on the characteristic being evaluated is referred to as a downward comparison and is often associated with an increase in subjective well-being. On the other hand, a comparison to someone who is better off on the dimension under evaluation is deemed an upward comparison and is linked to decreases in well-being (Morrison et al., 2004). Presently, popular media provides abundant examples of the idealized female form. These images serve as an avenue for upward comparisons (Want, 2009).

The larger the disparity between one's appearance and that of the comparison standard, the greater the level of dissatisfaction that will result (e.g., Bessenoff, 2006; Stokes & Frederick-Recascino, 2003). In addition, the impact of social comparison will also be larger for those individuals who set a higher level of importance upon their appearance (e.g., Ip & Jarry, 2008). This is especially important in today's thin pursuing climate, as media portrayals are becoming thinner and more unobtainable through natural means (e.g., Thompson & Heinberg, 1999). Fashion magazines are recognized as one of the more prominent purveyors of this artificial thin ideal (e.g., Harper & Tiggemann, 2008; Sypeck et al., 2004). Previous research has found that viewing fashion magazines predicts body dissatisfaction (Botta, 2003; Harrison & Cantor, 1997), drive for thinness (Harrison & Cantor, 1997), and ED symptomatology (Stice & Shaw, 1994). Laboratory studies have found that even acute exposure to magazine images and other forms of media consistently leads to poorer body image in female participants (e.g., Stapel & Blanton, 2004; Stice & Shaw, 1994; Tiggemann, Slater, Bury, Hawkins, & Firth, 2013; Yamamiya et al., 2005). This exposure has been linked to negative changes in body dissatisfaction, mood, and perceptions of physical attractiveness (Friederich et al., 2010; Hawkins, Richards, Granley, & Stein, 2004; Lopez-Guimera, Levine, Sanchez-Carracedo, & Fauquet, 2010; Groesz et al., 2002).

Various meta-analyses have been conducted to investigate the overall effect of media on women's self-images. Groesz et al. (2002) concluded that, despite some conflicting outcomes, participants viewing thin media pictures experience an increase in negative body image. A more recent investigation also found a significant harmful effect of media on females' body satisfaction (Grabe et al., 2008). In addition, Want (2009) concluded that exposure to thin ideal media resulted in a small-to-medium detrimental effect on female appearance satisfaction. Want determined that two factors significantly moderated the effect sizes: participants' preexisting appearance concerns and the instructions used in the inductions. More specifically, individuals with higher levels of concerns about their appearance found social comparison more aversive compared to those with lower appearance concerns. These results are consistent with previous research that found that higher levels of body concerns makes individuals more prone to the effects of social comparison (e.g., Groesz et al., 2002). With respect to process instructions, Want's results showed higher effect sizes when participants were instructed to focus on distracter variables (i.e., aesthetics of picture, lighting, creativity) than when they were given direct instructions to compare themselves to the targets. These findings are in direct contrast to other studies that have found that explicit versus implicit instructions during a social comparison task result in more aversive consequences (Cattarin et al., 2000; Tiggemann & McGill, 2004; Tiggemann, Polivy, & Hargreaves, 2009).

Tiggemann and Polivy (2010) investigated the role of social comparison processing on women's reactions to advertisements featuring models representing the thin ideal. The authors attempted to ascertain the amount and nature of processing which females engaged in during a social comparison task as a way to account for individual differences. Specifically, the study used 7-point Likert scales asking the extent to which individuals: (a) thought about the features of the advertisements, (b) compared themselves to the females in the advertisements, and (c) compared themselves to the females in the advertisements solely on appearance. The findings indicated that regardless of the instructions given to them, the more participants engaged in appearance comparisons, the greater the body dissatisfaction and the lower mood they experienced.

To review, females are repeatedly reminded of the thin ideal through several means including print media. As a result of the pervasiveness of these sociocultural messages, women have been found to experience greater subjective distress (Juster et al., 2011). For females who are invested in achieving society's thin ideal and who are prone to engaging in social comparisons, seeing repeated images of the idealized form can prompt a sense of disappointment, most often manifested through negative affect, body dissatisfaction, and shame. Therefore, this suggests that for some individuals, seeing frequent images of thin models may cause them to experience psychological stress on a regular basis. Consequently, how these females respond when faced with a stressor or when experiencing negative affective states becomes important considerations in this area of body image research.

Stress and Emotion Regulation in Eating Pathology

Over and above one's susceptibility to engage in social comparisons, how an individual regulates his or her emotions may contribute to the development of eating pathology. Sim and Zeman (2006) have hypothesized that normative levels of body dissatisfaction may be differentiated from clinically significant eating disturbance on the basis of difficulties with emotional processing. Indeed, difficulties regulating emotions have been identified as important factors in the development and maintenance of EDs (e.g., Berking & Wupperman, 2012; Fairburn, Cooper, & Shafran, 2003; Fox & Power, 2009; Gilboa-Schechtman, Avnon, Zubery, & Jeczmien, 2006; Harrison, Sullivan, Tchanturia, & Treasure, 2009, 2010; Holliday, Uher, Landau, Collier, & Treasure, 2006; Masuda, Hill, & Tone, 2012; Merwin et al., 2013). Stress has also been identified as an important factor in the development of EDs (Ball & Lee, 2000) including, bulimia nervosa (e.g., Smyth et al., 2007), anorexia nervosa (Slade, 1982; Tozzi, Sullivan, Fear, McKenzie, & Bulik, 2003), and binge eating disorder (Koo-Loeb, Pedersen, & Girdler, 1998; Pinaquy, Chabrol, Simon, Louvet, & Barbe, 2003). Emotion regulation represents an individual's ability to influence how emotions are experienced as well as expressed (Gross, 2002; Kashdan & Rottenberg, 2010), and is necessary to maintain mental health (Gross &

Munoz, 1995; Kashdan & Rottenberg, 2010). In particular, difficulties regulating, processing, and recognizing emotions have all been found in individuals with EDs (Bydlowski et al., 2005; Harrison et al., 2009, 2010). For example, women with anorexia nervosa have been found to engage in more worry and rumination compared to healthy controls, which predicts disordered eating symptomatology (Startup et al., 2013).

Other researchers found that women with EDs experienced greater amounts of state anger, yet were less likely to actually display this anger (Fox & Harrison, 2008; Waller et al., 2003). However, supressing emotions may minimize how the feelings are expressed, but it does not decrease how the emotions are experienced (Gross, 2002). Often by trying to avoid a certain reaction, the opposite consequence occurs and the feelings may be more pronounced (e.g. Merwin, Rosenthal, & Coffey, 2009). Furthermore, suppression can initiate a second emotion, such as guilt, and it is this feeling which Corstorphine (2006) argues is the actual cause of distress in those with EDs. Women displaying eating pathology are also more likely to engage in the avoidance of emotions when compared to healthy controls (Corstorphine, Mountford, Tomlinson, Waller, & Meyer, 2007; Evers, Stok, de Ridder, 2010; Schmidt & Treasure, 2006; Wildes, Ringham, & Marcus, 2010). The non-acceptance of negative emotions has been linked to the development of dietary restraint (Merwin, Zucker, Lacy, & Elliot, 2010). Specifically, Merwin and colleagues found that individuals with anorexia nervosa reported having difficulty understanding and accepting emotional experiences.

Eating disturbances have been found to be preceded by elevated stress and negative affect (e.g. Smyth et al., 2007). Stress may also trigger eating disordered behaviour in nonclinical individuals who may have a predisposed personality highlighted by perfectionism and low self-esteem (Sassaroli & Ruggiero, 2005). Moreover, exposure to stress has been found to influence eating patterns both in human (e.g., Epel, Lapidus, McEwen, & Brownell, 2001; Torres & Nowson, 2007) and animal models (e.g., Hagan et al., 2002; Teegarden & Bale, 2008). Specifically, stress can increase feelings of hunger as well as the desire to binge (Cattanach, Malley, & Rodin, 1988; Lattimore & Caswell, 2004; Groesz et al., 2012; Tuschen-Caffier & Vögele, 1999), and it is the most commonly reported trigger of binge episodes (Gluck, Geliebter, & Lorence, 2004). Furthermore, an increased level of negative affect often precedes binge eating episodes and “emotional eating” (Bohon & Stice, 2012; Davis & Jamieson, 2005; Eldredge & Agras, 1996; Levine & Marcus, 1997; Pike et al., 2006; Telch & Agras, 1996; Tyrka, Waldron, Graber, & Brooks-Gunn, 2002). This is significant given that women suffering from eating disturbances have been found to experience higher rates of negative affect compared to females with other psychological disorders (Pike et al., 2008). Pike and colleagues (2006) found that individuals with binge eating disorder were more likely to experience a variety of stressors prior to engaging in problematic eating practises such as bingeing, purging, or excessive dieting. The authors also found that experiences involving critical comments about weight and shape as well as stress related to work and/or school made individuals more susceptible to developing problematic eating behaviours. Similar patterns of stressful experiences have been found to occur prior to the onset of anorexia and bulimia (Jacobi, Hayward, de Zwaan, Kraemer, & Agras, 2004).

Much of the research on stress and eating pathology has focused on hormonal responses. Investigations have found that individuals suffering from EDs display abnormal hormone responses to stressors, such as exaggerated cortisol responses (e.g., Abell et al., 1987; Bailer & Kaye, 2003; Ginty, Phillips, Higgs, Heaney, & Carroll, 2012; Gluck, Geliebter, Hung, & Yahav, 2004; Koo-Loeb, Costello, Light, & Girdler, 2000; Koo-Loeb et al., 1998). An individual’s interpretation and perception of a stressor also determines how eating patterns are impacted (Hay & Williams, 2013). In particular, if the stressor is deemed a threat to the self, there is an increase in cortisol as well as enhanced feelings of hunger and a need to feed (Adam & Epel, 2007). Researchers have postulated that cortisol promotes the overeating of "comfort foods" by stimulating reward systems that attenuate the effects of the original stressor (Adam & Epel, 2007; Dallman et al., 2003; Epel et al., 2001; Gluck, 2006).

Thus, engagement in disordered eating may serve a "self-medicating" function to regulate and cope with emotions (Bizik et al., 2013; Cooper, Wells, & Todd, 2004; Dallman et al., 2003; Steinglass et al., 2010). For example, binge eating may help an individual to focus on something other than upsetting thoughts or as a way to alleviate distress (Baumeister & Heatherton, 1996; Heatherton & Baumeister, 1991). It has been suggested that individuals with anorexia nervosa restrict their food intake as a way to manage or reduce the negative affect they experience (Kaye, Wierenga, Bailor, Simmons, & Bischoff-Grethe, 2013). The inability to regulate emotions can lead to inappropriate arousal and/or can contribute to difficulties responding to stressors appropriately (Wang & Saudino, 2011). This makes individuals more susceptible to social and physiological problems as well as more likely to experience feelings of distress (e.g., Aldao, Nolen-Hoeksema, & Schweizer, 2010; Haynos & Fruzzetti, 2011). Therefore, as a way to avoid negative experiences, individuals restrict their everyday involvements in an attempt to ensure predictability (Merwin et al., 2011). Merwin and colleagues (2011) have proposed a theory of anorexia nervosa characterized by psychological inflexibility, which they defined as an inability to respond appropriately when faced with unpleasant thoughts, feelings, and sensations. This rigidity is important in that psychological flexibility has been linked to improved health. Hayes, Luoma, Bond, Masuda, & Lillis (2006) propose that individuals are healthier when they have the capacity to respond in accordance with environmental demands. The opposite is an inflexible response pattern that often results in individuals avoiding or trying to control their experiences to prevent negative emotions (Wendell, Masuda, & Le, 2012).

A logical extension of the dangers of psychological rigidity would be that of physiological inflexibility. For individuals with body image concerns, repeated exposure to thin ideal images may cause their physiological system to be in a state of chronic activation, even if the threat itself is relatively minor (Adam & Epel, 2007). This chronic activation can have implications for the individual. For example, Rosenberg et al. (2012) found that obese individuals with binge eating disorder experienced a blunted cortisol response to a Trier Social Stress Test (TSST) compared to control and other obese individuals who did not binge. The authors postulated that the blunted cortisol response may be due to prolonged reactivity resulting in decreased ability to regulate stress responses, thus making individuals more susceptible to allostatic load. Allostatic load is the cost to the body for adapting to adverse psychological/physical situations and is often used to mean a system that is overtaxed (McEwen & Stellar, 1993; Halmi, 2009). When the system enters this state of overload, four different types of results can occur: repeated activation of physiological systems, an inability to habituate to stressors, prolonged stress responses, and inadequate or inappropriate responses to the trigger (Juster et al., 2011). Typically this state starts with the overstimulation of the stress response, which eventually leads to an imbalanced system and increases risk of disease and death (Bizik et al., 2013). Therefore, psychological inflexibility may overwork the physiological system, causing it to malfunction.

However, one thing that is missing from the literature is the exploration of whether the relationship is perhaps reversed. That is, it is possible that having rigid physiological reactions to stressors drives psychological inflexibility. Yet, an area that has received little attention is the physiological functioning of individuals who experience difficulties regulating emotions. This is especially surprising given that the ability to appropriately regulate one's emotions is dependent on being able to modify physiological arousal on a moment-to-moment basis (Gross, 1998). This arousal is based on the performance of the autonomic nervous system (ANS; Appelhans & Luecken, 2006). Specifically, a flexible autonomic system is required to optimally control the physiological arousal that accompanies emotions. The more flexible the system, the better an individual is able to respond appropriately to environmental demands. On the other hand, the more rigid the ANS is the less likely an individual will respond with emotions that are suitable for the situation at hand (Appelhans & Luecken, 2006; Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). A brief description of the physiological systems involved in emotion regulation will be described, followed by an examination of an approach used to manipulate one's ANS.

The Role of the Autonomic Nervous System and Heart Rate Variability in Emotion Regulation

The ANS is comprised of two branches: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). The SNS serves an excitatory role and is predominantly responsible for the fight or flight response. The PNS functions as an inhibitory system that inhibits or reduces levels of activity and promotes restoration (Thayer & Brosschot, 2005). The systems often work in concert, frequently in a reciprocal fashion. When SNS activity increases, PNS decreases, and vice versa. However, this is not always the case and the systems can work independent of each other or both can move in the same direction (Berntson, Cacioppo, & Quigley, 1993). El-Sheikh and colleagues (e.g., El-Shiekh et al., 2009; El-Shiekh & Erath, 2011) have proposed that when the systems work in a nonreciprocal fashion it indicates a dysregulated ANS.

In times of stress, the SNS typically becomes dominant and leads to an increase in heart rate (HR) which indicates arousal in anticipation of a threat. In times of safety and stability, the PNS promotes maintenance and low levels of arousal. The slowing down component of the PNS is mediated by the vagus which is the tenth cranial nerve (Beauchaine, 2001). In psychology, measurement of PNS activity has been done predominantly via the heart. This is due to the important role the heart plays in relation to various factors as well as to how easily and noninvasively it can be assessed (Martens, Greenberg, & Allen, 2008). One measure that has received attention as a way to gauge an individual’s ANS functioning is heart rate variability (HRV). This is because HRV reflects the continuous interaction between the SNS and the PNS. Since HRV gives a measure of ANS functioning, it has also emerged as an objective evaluation of an individual’s emotion regulation (Appelhans & Luecken, 2006; Denson, Grisham, & Moulds, 2011).

HRV provides a measure of the variation across time of the period between successive heartbeats, which is referred to as the inter-beat intervals (IBI; Acharya, Joseph, Kannathal, Lim, & Suri, 2006). An individual’s heart rhythm is regulated by the influence of the ANS on the primary pacemaker of the heart, the sinoatrial node (SA; Appelhans & Luecken, 2006). The SA node is responsible for producing the action potentials that cause the contractions that constitute a heartbeat. Whenever the SNS is activated, it causes the SA node to increase its rate of action potentials that results in an increase in HR. In contrast, whenever the PNS is activated the SA node decreases its rate of firing and HR is depressed. Thus, the two autonomic branches interact to influence the moment-to-moment changes in IBIs. As a result, during times when HR is elevated, the period between consecutive heartbeats is diminished, and there exists low HRV. Conversely, during occasions when HR is decreased the time between heartbeats is longer and, therefore, there is high HRV (Appelhans & Luecken, 2006). It should be noted that increases in HR do not always result from SNS activity as it can also result from decreased parasympathetic inhibition or by what is called vagal withdrawal. This is because, while both the SNS and PNS exert influence over HR, at rest it is the PNS that is dominant (Berntson et al. 1997). Therefore, actual HR at rest is maintained much slower than the intrinsic firing rate of the SA via parasympathetic inhibitory effects (Appelhans & Luecken, 2006).

The two branches of the ANS influence cardiac functioning using different mechanisms that result in distinctive rates of action. The sympathetic influence on cardiac activity is mediated by norepinephrine and takes longer to affect cardiac functioning. Conversely, the parasympathetic influence occurs via acetylcholine, which allows for rapid effects. It is this ability to respond quickly that allows the PNS to be responsible for the HRV associated with the respiratory cycle. This type of HRV has been coined respiratory sinus arrhythmia (RSA). Parasympathetic influence over RSA is thought to be mediated via the vagus nerve (Pu, Schmeichel, & Demaree, 2009). During inspiration, vagal influence on HR is disrupted which withdraws parasympathetic inhibitory effects and results in HR increasing. Exhalation serves to reinstate the parasympathetic influence on cardiac activity and HR once again decreases. Hence, RSA refers to this variation in HR that is caused by respiration. Only the PNS has the ability to influence cardiac activity at this rapid pace, and therefore RSA is seen as an index of PNS effect on HRV. Thus, RSA has been used in the literature as an index of cardiac vagal tone, which is defined as the control or influence of the vagus nerve on the heart (Berntson et al., 1993; Porges, Doussard-Roosevelt, & Maiti, 1994; Pu et al., 2009).

Investigators have attempted to establish a connection between vagal tone and emotion regulation. Pu and colleagues (2009) found evidence that cardiac vagal control predicted the amount of negative emotional expression in response to viewing an aversive film. The findings indicted that those with higher levels of resting HRV had better control over their reactions. Specifically, they were rated as displaying less outward negative expressions in response to the films. Pu and colleagues proposed that higher resting HRV indicated a greater capacity for controlling one's emotions, even when faced with spontaneous stimuli. More recent findings by Denson and colleagues (2011) have linked the use of a more adaptive emotion regulation strategy to higher HRV. In particular, participants were asked to either suppress their emotions or to reappraise their reactions after viewing an anger inducing video. The results indicated that utilizing the more adaptive reappraisal strategy was linked to an increase in HRV with no change in self-reported anger. However, those participants told to suppress their emotions experienced a significant increase in self-reported anger and no change in HRV. Schneiderman, Zilberstein-Kra, Leckman, and Feldman (2011) also found support for the relationship between HRV and emotion regulation. The authors investigated the autonomic reaction of 112 young adults to both negative and positive films. Participants had HRV measured at baseline while watching neutral films and during negative and positive clips. The results indicated that individuals who reported greater emotional distress displayed the most physiological distress, indicated by greater vagal withdrawal. These results are consistent with other findings wherein decreased HRV is observed in response to stressful events (Elliot, Payen, Brisswalter, Cury, & Thayer, 2011; Hansen, Johnsen, & Thayer, 2003), and experimental inductions of anxiety, worry, and fear (Kreibig, 2010; Thayer, Friedman & Borkovec, 1996).

Two main theories associate ANS functioning with emotion regulation and stress reactivity: Porges' polyvagal theory (Porges, 1995), and Thayer and colleagues' neurovisceral integration theory (Thayer & Lane, 2000). The polyvagal theory attempts to link the evolution of the ANS to how emotions are experienced and expressed, as well as to how behaviours are regulated. According to this theory, the key aspect of the ANS is the vagal brake, which serves to either inhibit or disinhibit vagal influence on the heart in response to environmental stimuli. So in times of safety, the influence of the vagus on the pacemaker is augmented, which leads to the slowing of the heart. In addition, the fight or flight responses of the SNS are inhibited and the activity of the hypothalamic-pituitary adrenal (HPA) axis is diminished. On the other hand, when a threat is detected, the influence of the vagus can be rapidly withdrawn, which enables an increase in cardiac functioning. If the threat persists, the SNS fight or flight responses can be triggered (Porges, 1995, 2007). According to Porges, the ability of the vagus to inhibit SNS responses is what allows individuals to engage in social interactions. However, when the PNS is deficient, an individual is more likely to engage in fight or flight type responses due to reduced vagal tone (Borkovec, Ray, & Stöber, 1998).

The polyvagal theory proposes that the vagus withdraws when the organism needs to respond to a stressor or threat (Martens et al., 2010). Thus, if an individual feels secure, there is high vagal tone, and if the person feels threatened, lowered vagal tone allows for the activation of a stress response. Consistent with these proposals, findings have shown that individuals who experience lower incidence of anxiety disorders (e.g., Cohen et al., 1997), less depressive symptoms (e.g., Chambers & Allen, 2002), and less negative reactivity to threatening stimuli (e.g., Demaree, Robinson, Everhart, & Schmeichel, 2004) all exhibit higher vagal tone.

Alternatively, the neurovisceral integration theory emphasizes two important concepts (Appelhans & Luecken, 2006; Thayer & Lane, 2000). The first is in line with the polyvagal theory and maintains that the ANS has a direct influence on cardiac functioning. The second notion is that the ANS is itself monitored by the central autonomic network (CAN). The CAN is comprised of various brain structures including cortical, limbic, and brainstem areas. In essence, the CAN serves to manage incoming information regarding internal and external conditions in order to adjust physiological arousal appropriately. This is done through influence of the vagus nerve on the SA node, which affects heart rate (Appelhans & Luecken, 2006; Thayer & Lane, 2000; Uijtdehaage & Thayer, 2000). Therefore, according to this theory, the role of the CAN is to provide flexible, dynamic responses that are appropriate to the environmental demands (Thayer et al., 2012). Thayer and colleagues contend that this capacity can be indexed by HRV (Thayer et al., 2012; Thayer & Brosschot, 2005; Thayer & Lane, 2009). According to the neurovisceral integration model, low HRV can be considered a possible marker for psychopathology (Thayer & Lane, 2000). For example, anxiety disorders are said to occur due to the failure of CAN to inhibit responses. In essence, individuals with anxiety experience threat responses that are too easily triggered and difficult to deactivate, which leads to prolonged states of vigilance and worry (Appelhans & Luecken, 2006; Friedman, 2007). Consistent with this notion, anxiety is characterized by low vagal tone, increased sympathetic activity (Friedman, 2007), and lower overall HRV (e.g., Gaebler, Daniels, Lamke, Fydrich, & Walter, 2013).

While there are differences between the two theories, they both propose that greater vagal control of heart function allows individuals to better respond to environmental conditions. The system can become destabilized, however, by locking into a particular pattern and thereby making it less likely to respond appropriately to changing stimuli. Thus, a healthy system is exhibited by greater HRV whereas an unhealthy system has decreased HRV that reflects the dysregulation of the whole system.

As previously mentioned, Merwin and colleagues (2011) have proposed a theory of anorexia nervosa based on the notion of psychological rigidity. According to the theory, individuals try to control their everyday experiences to avoid encountering stressful situations that they are unable to respond to appropriately. Similarly, reduced physiological flexibility, as evidenced by reduced HRV, also has important implications for how an individual can respond to stressors and threats. Martens et al. (2008) have attempted to link psychological and physiological constructs as a way to explain how individuals respond to threats to the self. Specifically, they propose that vagal tone and self-esteem serve to protect individuals from threat responses.

Vagal Tone and Self-Esteem as Buffers of Threat

According to Martens and colleagues (2008), maximizing self-esteem and cardiac vagal tone can serve to mitigate an individual's response to stress. Specifically, Martens et al. proposed that self-esteem and cardiac vagal tone influence each other, and that they both serve as buffers of threat. This theory is based on parallels found between the self-esteem and cardiac vagal tone literature. The authors refer to various self-esteem theories in support of their hypothesis (Martens et al., 2008). In particular, the authors referred to terror management theory (Pyszczynski, Solomon, Greenberg, & Stewart-Fouts, 1995) which proposes that self-esteem serves to buffer anxiety. This notion is founded in the belief that one's self-esteem develops into an anxiety buffering entity via early childhood experiences. In short, the theory proposes that self-esteem becomes associated with feelings of security, which leads to reduced responding to threats. Therefore, if an individual feels a high level of self-esteem they are likely to feel secure and be less vulnerable to feeling threatened (Martens et al., 2008).

The authors also referred to self-affirmation theory (Steele, 1988), which proposes that threats to one's self jeopardize an essential need to feel that one is good and moral. According to this theory, if an individual has a high level of self-esteem it functions as a resource to protect against threats to specific components of the self. Both terror management theory and self-affirmation theory suggest that having a strong sense of self-esteem allows individuals to feel more sheltered and as a result less reactive to possible threats to the self (Martens et al., 2008).

A review of the literature reveals support for the notion that high self-esteem predicts attenuated threat responding. DeLongis, Folkman, and Lazarus (1988) assessed married couples over 6 months and found that participants low in self-esteem displayed a greater link between the amount of stress and level of illness they experienced. Further support is provided by a study looking at perceived discrimination. Corning (2002) found that while women with low self-esteem responded to being the target of discrimination with distress, females with higher levels of self-esteem showed lower levels of distress in comparison. Furthermore, Greenberg and colleagues (1992) directly tested the relationship between self-esteem and threat. This study found that individuals who received a boost in self-esteem via positive bogus feedback concerning their personality displayed reduced levels of anxiety in response to a graphic video when compared to those who did not receive the self-esteem boost. In addition, Rector and Roger (1997) investigated the effects of self-esteem manipulations on heart rate during a public speaking task. The study revealed that a boost in self-esteem did not result in any heart rate changes when no stressor was introduced. However, once the public speaking task commenced, those who had received a self-esteem boost did not display the increase in heart rate experienced by those without inflated self-esteem. Overall, these findings appear to support the notion that higher self-esteem serves to buffer against threat responding. Martens et al. (2008) further proposed that cardiac vagal tone played a similar role.

To review, PNS activity and vagal tone are linked. The greater the PNS influence, which is indicative of higher vagal tone, the greater the protection against excitatory responses (Martens et al., 2008). During times of uncertainty and possible threat, the default response is sympathoexcitatory preparation of the fight or flight response. However, if this state of uncertainty and the resultant excitatory effects are prolonged, it can lead to excessive wear and tear on the body and possible development of disease (McEwen, 1998, 2007; Thayer & Brosschot, 2005; Thayer & Ruiz-Padial, 2006). Consequently, there is a need for some protection against unnecessary threat responding, which higher vagal tone appears to provide. Thus, Martens and colleagues (2008) contend that vagal tone serves much like self-esteem to provide a sense of security from threat responding. In other words, vagal tone is seen as a physiological construct that is closely intertwined with the concept of self-esteem.

According to the theory proposed by Martens et al. (2008), an increase in self-esteem or vagal tone should ensure more protection against stress responses. Some preliminary evidence suggests that manipulating self-esteem does indeed impact HRV in the manner predicted (Martens et al. 2008). More specifically, in an earlier study, Martens, Allen, Greenberg, and Johns (2006) manipulated participants' self-esteem by giving them either negative or positive bogus feedback regarding their personalities. The negative feedback caused lower RSA than the positive feedback, irrespective of baseline RSA. Further, the better participants felt after the positive feedback, the higher their RSA. However, the effect of vagal tone manipulation on self-esteem and stress response has not been examined. The advancement of newer technology has allowed for manipulations of HRV to be done in a nonintrusive and simple manner. Therefore, investigating its effects has become easier to accomplish.

Heart Rate Variability Biofeedback

As previously outlined, HRV is linked to emotion regulation and autonomic balance (e.g., Appelhans & Luecken, 2006; Schneiderman et al., 2011). For example, correlations have been found between higher vagal tone and positive characteristics such as flexibility and adaptability (Thayer & Lane, 2000) and emotion regulation (Volokhov & Demaree, 2010). Consistent with Martens and colleagues' (2008) hypothesis that increasing vagal tone may lead to decreased stress responding, Wheat and Larkin (2010) have also turned their attention to manipulating HRV as a way to promote health. In particular, these investigators focused their attention on the application of HRV biofeedback (HRV BF). The premise of HRV BF is to teach individuals to maximize their own HRV and, by extension, to augment their vagal tone (Rene, 2008). Consistent with both the polyvagal and neurovisceral theories outlined above, greater control of cardiac functioning via the vagus should decrease the occurrence of inappropriate and/or overly prolonged physiological responses to stressors. Moreover, lower HRV has been linked to greater susceptibility to stress and disease (Wheat & Larkin, 2010). Specifically, individuals suffering from various conditions have a preponderance of sympathetic rather than parasympathetic control (i.e. lower vagal tone and lower HRV). This includes depression, generalized anxiety disorder, panic disorder, post-traumatic stress disorder, and psychopathology in adults (Beauchaine, 2001; Cohen et al., 2000; Cohen et al., 1997; Mezzacappa et al., 1997; Nugent, Bain, Thayer, Sollers, & Drevets, 2011; Thayer et al., 1996; Vella & Friedman, 2007). By extension, this would suggest that enhancing HRV should improve an individual's ability to manage stress by increasing the adaptability of their physiological system.

In the recent past, support for the efficacy of HRV BF has emerged for a variety of health problems. Specifically, HRV BF has been found to help treat asthma, anxiety, fibromyalgia, depression, posttraumatic stress disorder, and heart disease (Del Pozo, 2002; Hassett et al., 2007; Karavidas et al., 2007; Lagos et al., 2008; Lehrer et al., 1997; Rene, 2008; Siepmann, Aykac, Unterdorfer, Petrowski, & Mueck-Weymann, 2008; Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009). Furthermore, HRV BF has been found to increase performance at work and in sports (Lagos et al., 2008; McCraty, Atkinson, & Tomasino, 2003; Strack, 2003) and to improve insomnia (McLay & Spira, 2009). Following a recent meta-analysis of HRV BF, Wheat and Larkin (2010) concluded that “HRV BF should be considered seriously as a viable avenue through which to supplement traditional treatments of various illnesses.” (p.237).

HRV BF is designed to minimize an individual’s autonomic reactivity by helping to regulate homeostatic mechanisms (Sherlin, Gevirtz, Wyckoff, & Muench, 2009). Vaschillo, Vaschillo, and Lehrer (2006) hypothesize that therapeutic effects linked to HRV BF are due to the exercising of autonomic reflexes. In particular, the authors identify the baroreflexes which control, and are controlled by, the sympathetic and parasympathetic systems. In short, baroreceptors are used by the cardiovascular system to maintain optimal arterial blood pressure. When blood pressure increases the system uses the baroreceptors to activate parasympathetic activation and sympathetic inhibition. On the other hand, when blood pressure drops, the baroreceptors serve to trigger parasympathetic inhibition and sympathetic activation (Grippo & Johnson, 2002; Thayer et al., 2012). Thus, HRV BF is thought to exercise the baroreflexes in much the same way that muscular exercises train reflexes and improve their efficiency. Vaschillo and colleagues (2006) propose that this exercise improves the modulatory function of these reflexes and consequently produces a higher degree of regulation among the two systems.

The process of training individuals on HRV BF involves having them slow down their breathing to a rate unique to themselves (Sherlin et al., 2009; Sherlin, Muench, & Wyckoff, 2010). Research has shown that for most individuals the breathing frequency that maximizes their HRV is at 0.1 Hz which coincides with approximately 6 breaths/min [60 s] (Lehrer, Vaschillo, & Vaschillo, 2000). Once an individual finds his or her unique breathing rate, it is deemed the individual's "resonant frequency" and represents the covarying of the person's HR with respiration. In other words, a resonance exists between respiratory and baroreflex rhythms which allows for increased HRV (Lehrer et al., 2003; Lehrer et al., 2000; Zucker et al., 2009). Findings by Song and Lehrer (2003) demonstrate that slower breathing rates are associated with greater HRV. The authors investigated the effects of different breathing rates on HRV in a small group of females (n = 5). The findings indicated that HRV was highest at 4 breaths/min and lowest when it reached double-digit breaths/min.

Sherlin and colleagues (2009) set out to test the acute effects of a portable HRV BF tool on responses to a cognitive stressor. The study specifically used an over-the-counter device called the StressEraser® (Helicor, 2006). The instrument displays an HRV wave on its screen that allows for the real-time monitoring of pulse-by-pulse activity. The device functions by having participants place their finger on an infrared sensor which allows for the reading of their cardiac output. The study investigated whether using this device would benefit users following a single, brief 15-min training session. Participants were randomly assigned to either a 15-min HRV BF group or a 15-min passive BF control group. The aim of the study was to compare these two conditions on state anxiety, HR, and Stroop task performance. Individuals in the HRV BF group were instructed to slow their rate of breathing to their resonant frequency by following the prompts provided by the StressEraser® device. Participants were told to inhale until their HR peaked, which is indicated on the device via a triangle marker. The participants were then told to exhale as the wave fell and to start inhaling again once the wave began its ascent.

Following these directions allows for HR and respiration to covary in synchrony (Sherlin et al., 2009). The StressEraser® also has the added bonus that it provides the participant with feedback concerning the quality of their HRV wave. Whenever the HRV wave exceeds a certain wavelength threshold, the device rewards the user with a point. Thus, this allows for an actual measurement of how efficient a user is in maximizing his or her HRV, with a higher number of points indicating greater efficiency.

In order to provide a comparable control, the passive BF group used an electronically altered StressEraser® unit. This unit still provided participants with a wave that responded to their physiology, however, it used a smoothed wave that displayed HR over 10-s intervals rather than in real time. Participants were instructed to watch the wave and to "let go" of stressful thoughts to allow for the syncing of their mind with their circulation. These participants were not given any instructions on how to manipulate the wave or instructions with regards to their breathing rate. Overall, the findings indicated that the HRV BF group had significantly reduced HR when compared to the control group in response to the laboratory-induced stressor involving the Stroop task. Both groups were found to improve state anxiety; however, the HRV BF group had the added benefit of reducing HR stress reactivity. The results provide support for brief HRV BF training to help reduce how individuals respond to one kind of stressor. Subsequent studies by Prinsloo and colleagues (Prinsloo, Derman, Lambert, & Rauch, 2013a, 2013b; Prinsloo, Rauch, Karpul, & Derman, 2013; Prinsloo et al., 2011) have also found positive results after a single session with the StressEraser®. However, the Prinsloo studies examined work-related stress; the question remains as to the efficacy of HRV BF in the face of other forms of stress.

To summarize thus far, Martens and colleagues (2008) contend that having high self-esteem and greater vagal tone both serve as buffers against threat responding. The authors postulate that if one variable is manipulated the other should also change. In addition, they propose that self-esteem and vagal tone interact particularly when a person's self-concept or self-esteem is under threat. Previous research has focused on manipulating self-esteem and seeing how this impacts individuals' responses to stress. However, given easily accessible and user friendly devices such as the StressEraser®, it is now possible to maximize one's HRV and thereby increase vagal tone. Thus, it is possible to investigate how increasing an individual's HRV affects his or her threat responding.

Present Study

The universal presence of mass media ensures that a beauty standard that is both unrealistic and unhealthy is continuously being transmitted to women through the use of digitally altered pictures and underweight models. As a result, women are bombarded with images they invariably compare themselves to via the process of social comparison. Social comparison theory (Festinger, 1954) proposes that individuals are often motivated to compare themselves to others; therefore, when females are exposed to images depicting female bodies below the average weight and size, they experience an upward comparison. This is likely to leave many females feeling inadequate as they are unlikely to meet the standard of "beauty" depicted. Laboratory findings have shown that social comparison tasks are generally experienced as psychologically stressful by females (Grabe et al., 2008; Groesz et al., 2002; Myers & Crowther, 2009; Want, 2009); thus, providing support for the notion that thin images elicit an upward comparison representing a threat to the self.

While studies examining the psychological impact of thin ideal images are plentiful, there is limited research on the physiological responses to social comparison. However, given the demonstrated adverse psychological responses, an accompanying stress-related physiological reaction would also be expected. According to Martens et al. (2008), increased vagal tone should have threat buffering effects. HRV BF is one way that an individual's vagal tone could be maximized. New research into HRV BF has found support for the acute stress buffering effects of a portable device designed to help minimize stress reactivity (Sherlin et al., 2009). The present study investigated whether the well-documented aversive responses to a social comparison challenge could be diminished by training individuals via this HRV BF device to increase their vagal tone. Furthermore, two different instructional sets manipulating HRV were compared to a control condition on the resultant HRV, negative mood, body dissatisfaction, and appearance self-esteem, following a social comparison challenge.

The present study provided a novel approach to exploring the potential beneficial effects of HRV BF on females' reactions to social comparison. Participants in the study were randomly assigned to one of three different conditions prior to being exposed to a social comparison challenge: high-HRV BF, low-HRV BF, and no-BF. By manipulating participants' HRV, the present study investigated whether this physiological factor influenced how females experienced a very specific stressor. Specifically, does the effect of temporarily increasing HRV inoculate one from the subsequent deleterious consequences of social comparison? Based on the findings outlined previously, it was hypothesized that the high-HRV BF condition would report attenuated negative reactions to thin image advertisements relative to the other two conditions as measured by HRV, body dissatisfaction, negative mood, and appearance self-esteem. It was postulated that having participants breathe at, or near, their resonant frequency of approximately 6 breaths/min would increase their resilience to threats to the self. Therefore, they would experience smaller drops in HRV and appearance self-esteem while displaying smaller increases in negative mood and body dissatisfaction in response to the social comparison challenge. Moreover, given that findings have shown that lower HRV makes individuals more susceptible to stressors, it was hypothesized that the low-HRV BF condition would find the social comparison challenge the most distressing as evidenced by a higher degree of body dissatisfaction and negative mood, as well as lower appearance self-esteem and lower resultant HRV. Finally, the no-BF condition was predicted to find the social comparison challenge moderately distressing and to show slightly less negative responses than those of the low-HRV BF condition.

Another objective of the present study was to investigate the moderating effects of preexisting body image concerns upon the psychological and physiological impact of a social comparison challenge. Consistent with previous findings (Cahill & Mussap, 2007; Posavac, Posavac, & Posavac, 1998; Want, 2009), it was hypothesized that individuals' propensity for body image concerns would impact the negative consequences of the social comparison challenge regardless of assigned condition. Specifically, it was predicted that individuals with higher dispositional body concerns would experience more negative responses to the social comparison challenge.

A third purpose of the present study was to investigate the social comparison processing that female participants engaged in while viewing the media images depicting thin models. To review, Tiggemann and Polivy (2010) found that individuals who compared themselves to the females in advertisements based on appearance, as opposed to individuals who paid more attention to other aspects of the advertisements, experienced greater body dissatisfaction and lower mood following the social comparison challenge. In their discussion, the authors recommended that future studies attempt to use multi-item measures to better explore the cognitive processing that occurs during a social comparison challenge. Therefore, the present study used multiple items investigating the general features of the advertisements and the specific characteristics of the models that participants may have focused on. Specifically, in order to investigate the degree to which participants focused on the features of the advertisements, they were asked the extent to which they thought about how interesting the advertisements were, how attractive they found the layouts of the advertisements, and how well the advertisements promoted their products. In addition, participants were asked the extent to which they compared themselves to the females in general, the extent to which they compared themselves to the models based on appearance, the extent to which they compared themselves to the models based on body shape, and the extent to which they compared themselves to the females based on body weight. These last four items were used to measure the degree to which participants focused on appearance characteristics of the advertisements. Consistent with the findings of Tiggemann and Polivy, it was hypothesized that individuals who spent more time comparing themselves to the models on appearance characteristics would experience greater body dissatisfaction and negative mood, as well as lower appearance self-esteem, when compared to those who focused on general features of the advertisements.

In summary, the main hypotheses of the present study were as follows:

1. Individuals in the high-HRV BF condition would experience attenuated negative responses to the social comparison challenge when compared to those in the low-HRV BF and no-BF conditions. Furthermore, it was predicted that irrespective of BF condition, individuals with higher dispositional body concerns would experience greater negative mood and body dissatisfaction with concomitant decreases in appearance self-esteem as the result of the social comparison challenge.

2. It was predicted that the more participants compared themselves to the models in the advertisements based on appearance characteristics, the worse their subsequent negative mood, body dissatisfaction, and appearance self-esteem would be.

Method

Participants

One hundred and twenty-nine female students enrolled in psychology courses at Lakehead University were recruited for the study via mass email (Appendix A). The email provided potential participants with a link to www.surveymonkey.com, where an information letter and a consent form were made available (Appendix B). As part of the consent procedure, participants were fully informed about the nature of the study as well as the option to withdraw at any point. The study was described as being interested in participants' general responses to media advertisements. Other than gender, no exclusion criteria were used. Once participants provided electronic consent, they proceeded to complete the battery of online questionnaires. For their participation in the study, participants received 2 bonus marks towards their final grade.

Thirteen participants were removed from analysis due to issues with their cardiac recordings. Of these, 10 participants were removed from analysis due to technical issues such as equipment failure (i.e., detachment of electrode) or other factors that interfered with the recordings such as excessive bodily movement. Three other participants were excluded from analysis due to excessive ectopic beats (representing more than 15% of total beats in each recording block). Of the remaining 116 participants, two were removed from analysis due to having substantial sections of the psychological variables missing. In total, 114 participants were included in the final analysis. The participants ranged in age from 17 to 48 years with a mean of 20.7 years (SD = 5.41). The sample was predominantly Caucasian (87.7%) followed by

Aboriginal/First Nations (5.3%), South Asian (1.8%), African-Canadian (0.9%), East Asian (0.9%), Middle Eastern (0.9%) and other (1.7%). The majority of the sample reported being single (87.3%), while a few reported being either married or in a common law relationship (8.5%) or as being either divorced or separated (3.4%). Of the 114 participants, 109 (95.6%) reported being enrolled in full-time studies, while five (4.4%) reported being enrolled in part-time studies.

Materials

Demographics Questionnaire (Appendix C). This questionnaire asked participants for basic demographic information including age, ethnicity, marital status and academic status. As well, participants were asked to report their height and weight.

Eating Disorder Examination-Questionnaire (EDEQ; Fairburn & Beglin, 1994; Appendix D). The EDEQ is a self-report questionnaire about eating attitudes and behaviours. Participants were asked to rate their attitudes and behaviours over the past 28 days. The EDEQ is comprised of 36 items that make up four subscales: Dietary Restraint, Eating Concern, Weight Concern, and Shape Concern. Overall, the EDEQ has good reliability with internal consistency alpha coefficients ranging from .78 to .93 (Luce & Crowther, 1999). With regard to validity, correlations between the EDEQ and the clinician administered Eating Disorder Examination range from .68 for the Eating Concerns subscale to .78 for the Shape Concerns subscale (Mond, Hay, Rodgers, Owen, & Beumont, 2004).

The EDEQ typically uses a 7-point forced-choice rating scheme for these subscales. However, due to an error during the development of the online version of the measure, the last eight items used a 4-point rather than the standard 7-point Likert scale. For this study, participants' Weight Concerns and Shape Concerns subscales were averaged and used as a measure of dispositional body concerns (EDEQ-WS). Higher scores on the EDEQ-WS indicate greater body concerns. This measure was previously found to be internally consistent over the 13 items ($\alpha = .93$; Roldan, 2008). Using a median split of 1.79 on the scale resulted in low- and high-dispositional body concerns groups containing 56 and 58 participants, respectively.

Visual Analogue Scales (VASs; Appendix E). VASs are simple tools used to measure subjective experience that have been found to be valid and reliable across both clinical and research settings (McCormack, Horne, & Sheather, 1988). In addition, VASs have the advantage that they are sensitive to small changes and can be completed quickly (Tiggemann & Polivy, 2010). VASs consist of a 100 mm line anchored at both ends with verbal descriptions or numbers representing the two extremes of the dimension being measured. Participants were required to mark a line at the appropriate point between the two extremes as a representation of how they were feeling. The scales were quantified by measuring the distance from the minimal end point to the mark made by the participant, as a value on a 100-point scale. The present study utilized eight VASs used by Heinberg and Thompson (1995) and replicated by various researchers (Harper & Tiggemann, 2008; Tiggemann & Polivy, 2010; Tiggemann et al., 2009) to measure negative mood and body dissatisfaction pre- and post-social comparison in the laboratory session. Participants were asked to indicate how they were feeling in the moment by placing a mark on the 100 mm line with the endpoints labelled *none* and *very much,* for the mood dimensions of anxious, depressed, happy, angry, and confident; as well as on the body satisfaction dimensions of fat, physically attractive, and satisfied with body size and shape. An overall score for negative mood was calculated by averaging the five mood items with the positive mood items reverse coded. The body satisfaction items were averaged, with the physically attractive and satisfied with body size and shape items both reverse coded, to calculate a body dissatisfaction score. Higher scores on these dimensions represent greater negative mood and body dissatisfaction.

The measures investigating the processing that participants engaged in during exposure to the advertisements were also presented as VASs. The VASs were adapted from previous studies (Tiggemann et al., 2009; Tiggemann & Polivy, 2010). In total, there were seven scales, with three asking about general features of the advertisements and four about specific appearance characteristics. Specifically, participants were asked how much thought they gave to (a) how interesting the advertisements were, (b) the layout of the advertisements, and (c) how well the advertisements promoted the product they were selling. The anchors were labelled 0 = *no thought* and 100 = *a lot of thought*. In addition, participants were asked to what extent they (a) compared themselves to the women in the advertisements, (b) compared themselves to the women in the advertisements based on appearance, (c) compared themselves to the women in the advertisements based on body shape, and (d) compared themselves to the women in the advertisements based on body weight. The appearance measures were anchored with *no comparison* on one end and *a lot of comparison* on the other end. The three feature VASs were averaged to calculate a feature processing score; the four appearance VASs were averaged to calculate a social comparison processing score. Higher scores on the scales indicated more time spent engaged in that particular form of processing.

S**tate Self-Esteem Scale** (SSES; Heatherton & Polivy, 1991; Appendix F). The SSES is designed to measure an individual's self-esteem in the moment and has been used as a means to measure self-esteem following experimental manipulations. The measure consists of 20 items related to self-esteem across three scales: Performance (e.g., "I feel confident about my abilities"), Social (e.g., "I feel concerned about the impression I am making"), and Appearance (e.g., "I am pleased with my appearance right now"). Each item on the SSES is scored on a 5-point Likert scale ranging from 1 (*not at all*) to 5 (*extremely*). Heatherton and Polivy validated the SSES using a college sample and found it to be internally consistent (α = .92). In the present study the SSES was administered prior to the laboratory session and again post-social comparison challenge. The scale of primary interest was the Appearance scale which served as a measure of state appearance self-esteem, with higher scores indicating greater esteem.

Apparatus

StressEraser®. All participants used a tool called the StressEraser® (Helicor, Inc., New York, NY), which is a handheld portable biofeedback device used for relaxation training and stress reduction. The tool displays an HRV wave in real time. By placing their fingers on an infrared sensor, users can have their cardiac output monitored by the device. The StressEraser® provides HRV feedback through visual cues when the user changes respiration depth and frequency. The correlation between the device and electrocardiogram (ECG) data has been found to be near unity (i.e., .99 - 1.0; Heilman, Handelman, Lewis, & Porges, 2008).

Electrocardiogram. In order to collect ECG data, each participant had a set of snap-on Ag-AgCl electrodes placed below the right clavicle and below the left rib cage. In addition, a ground electrode was placed on the right leg of each participant. An alcohol solution was used to clean all the areas prior to applying the electrodes. Shielded wires connected the electrodes to a 72-channel amplifier. The data was sampled at 1024 Hz via ASA software (Version 7.9; Advanced Neuro Technology, Enschede, Netherlands) running on a PC.

For the ECG data, 5-min recording blocks were taken for the baseline, BF, social comparison, and recovery phases (see timeline below). For the BF phase, ECG data between min 9 and 14 were used. For the social comparison phase, the data between min 4 and 9 were analyzed. Every recording was saved as an individual file for each participant. These recordings were then imported into QRSTool (version 1.2.2, available from psychofizz.org) by following the procedure outlined by Allen, Chambers, and Towers (2011). QRSTool is an interface that allows for the extraction of ECG data. The recordings were manually examined for recording errors and ectopic beats. Using both manual and automatic r-r wave interval detection procedures within QRSTool, IBIs were created. This is done by training the program to detect valid r-waves over a 30 s period for each of the recordings. Once the morphology of a typical beat for each subject is identified, the program identifies additional r-waves.

In total, 114 females completed the study which resulted in a total of 456 5-min recordings, of which 15.1% had errors detected (i.e., missed, extra, and/or ectopic beats), that were successfully corrected according to the standard error correction protocol of the QRST software (Allen, Chambers, & Towers, 2007). Once the integrity of the files was verified, the IBIs for each block were imported into CMetX (version 2.63; Allen et al., 2011). CMetX is designed to provide metrics of cardiac chronotropy using an IBI series as a sample. CMetX converted the IBI series into a time-series sampled at 10 Hz, before filtering the series using a 241-point optimal finite impulse filter with half-amplitude frequencies of 0.12 and 0.40 Hz.

The cardiac metric used for the present study was root mean square of the successive differences (RMSSD), which is a time-domain measure of HRV that examines the differences between neighbouring r-r intervals (Carrasco, Gaitán, González, & Yánez, 2001; Penttilä et al., 2001). RMSSD correlates highly with spectral high frequency power (mean $r = .85$; Berntson, Lozano, & Chen, 2005), which has been associated with vagal activity (Berntson et al., 1997). An added benefit of RMSSD is that it is easy to compute (Guzik et al., 2007; Penttilä et al., 2001).

Respiration rate. All participants were fitted with a respiratory belt transducer that was connected to the amplifier (Respiband; SensorMedics Corporation, Yorba Linda, CA). The belt transducer went over their clothes and around the upper part of the ribcage. This device was used to monitor whether the different instructional sets resulted in distinct respiration rates (RRs) as intended. RRs for the participants were calculated by manually counting the peak and valley of each breath cycle.

Experimental Tasks

BF instructions. The BF instructions were chosen based on the results of a pilot study (see Appendix G for detailed results). In total there were three experimental conditions; high-HRV BF, low-HRV BF, and no-BF. See appendix H for the BF instructional sets.

High-HRV BF. The high-HRV BF condition was instructed to monitor their breathing while using the StressEraser® in order to find their resonant frequency, which theoretically would maximize their HRV. The instructions were based on the procedure followed by Sherlin and colleagues (2009) in combination with the directions provided by the StressEraser® owner's manual (Helicor, 2006). Specifically, participants were instructed to produce slow and gentle breaths by using the features on the device which indicated when to inhale and exhale. Furthermore, participants in this condition were told that the StressEraser® scored each breathing cycle, with greater efficiency in using the device resulting in a greater accumulation of points. Therefore, participants in this condition were explicitly told that the purpose of the exercise was to maximize the points they accumulated on the StressEraser®.

Low-HRV BF. Participants in this condition were given directions asking them to take short and shallow breaths while focusing on the wave. The instructions were designed to produce a higher respiration rate which Song and Lehrer (2003) previously showed led to decreased HRV. In addition, these individuals were told to minimize the points they accumulated on the StressEraser®, and they were not informed about the device's feedback features designed to help maximize HRV.

No-BF. Participants in this condition did not receive any instructions on how to use the StressEraser®. Instead participants in this condition had the device's monitor facing away from them during the entire 15-min HRV recording session.

Thin media images. Harper and Tiggemann (2008) proposed that fashion magazines were more likely to feature thin idealized women in their advertisements when compared to other types of magazines. Therefore, an original sample of 60 advertisements was chosen that represented the thin ideal by depicting at least three-quarters of the body of a thin and attractive female model. The advertisements were selected from nine popular women's fashion magazines published between November 2010 and February 2011. Images were taken from magazines such as *Vanity Fair, Vogue, Bazaar, Flare, Marie Claire* and *Elle*. In order to determine the final advertisements that were used in the social comparison phase, a convenience sample of nine females in their 20s was asked to rate each of the advertisements on four 7-point Likert scales taken from Harper and Tiggemann. The scales inquired on the effectiveness of the advertisement, the appeal of the advertisement, the physical attractiveness of the model, and the extent to which the female represented the thin ideal. The 20 advertisements with the highest combined scores on the attractiveness and thinness scales were chosen for the study. These advertisements were scanned and converted to digital images. The digital images were then displayed as part of a slideshow on a 72-inch Samsung television. See Appendix I for a sample of the media images used.

Procedure

Prior to coming to the laboratory, participants were directed to complete the online battery of questionnaires that included demographic information, the EDEQ, and the SSES. Once the online questionnaires were completed, participants used an online scheduler (http://www.sona-systems.com/) to book the 1-hr laboratory session held within the Department of Psychology. The laboratory session was scheduled within a week from the completion of the online questionnaires.

Upon arrival to the laboratory, participants were greeted by a female researcher and provided with a brief overview of the laboratory session. Participants were then given instructions on how to attach the electrodes for the ECG data. Once the electrodes were in place, participants were seated and asked to remain still while listening to a 5-min clip from the Canadian Broadcasting Corporation's radio series *Age of Persuasion*. The program was used because its premise is to examine the impact of media and advertising on everyday life, which is consistent with the general theme of the present study. It also provided a way to engage participants during the first recording. Participants were instructed to avoid moving in order to minimize the recording artefacts. This phase was intended to serve as a measure of resting RMSSD (baseline phase).

Following the baseline phase, participants were randomly assigned to one of the three instructional conditions: high-HRV BF, low-HRV BF, or no-BF. Figure 1 depicts the experimental timeline for the two BF conditions. Figure 2 displays the experimental timeline for those in the no-BF condition. The two BF conditions were given 15-min tutorials on how to use the StressEraser® following their respective instructions (tutorial phase). The no-BF condition continued to listen to an additional 15-min clip from *Age of Persuasion*. Following the 15-min phase, all participants were asked to complete the eight VASs used by Heinberg and Thompson (1995). Once the participants in the BF conditions completed the VAS, they were asked to partake in an actual 15-min BF session using the technique outlined during the tutorial (BF phase).

The no-BF condition proceeded directly to the next phase of the experiment, which was the social comparison challenge. During the social comparison challenge all participants viewed a 10-min slideshow depicting the 20 media images, with each image being shown on the screen for 30 s. For the first 15 s only the specific image was on the screen. During the final 15 s of each image the following instructions also appeared on screen: "How much do you like your own body compared to woman in the ad?"; "How physically attractive are you compared to the woman in the ad?"; and, "How thin are you compared to the woman in the ad?" (Tiggemann & Polivy, 2010, p. 358). Participants were solely asked to think about their answer to the above questions, as no actual response was necessary (social comparison phase).

Following the social comparison challenge, all participants completed the eight VASs used earlier in the procedure. They also completed the seven VASs exploring the type of processing they engaged in as well as the SSES for the second time. All participants were then instructed to sit as still as possible and listen to a final 5-min clip from *Age of Persuasion* (recovery phase). Following the recovery phase, participants were debriefed (Appendix J).

Results

Analytic Strategy

The first hypothesis was explored through analysis of variance (ANOVA). Two of the main assumptions of ANOVA are the normal distribution of the data and homogeneity of variance. To check for normality, z_{Skewness} = skewness – 0/SE_{Skewness} was examined for all

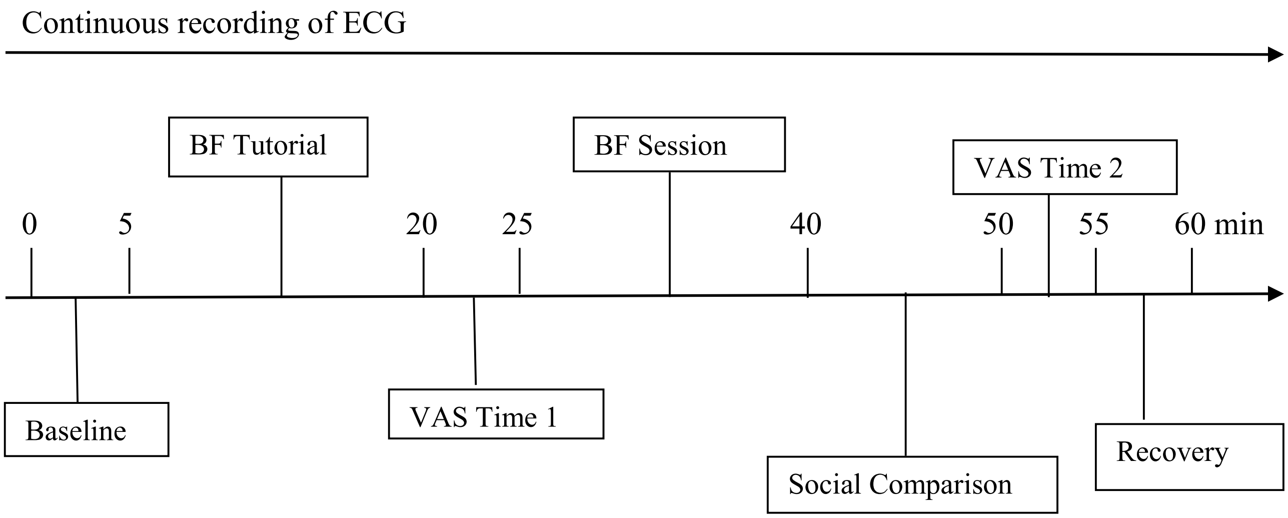


Figure 1. Experimental timeline in minutes for the two BF conditions.

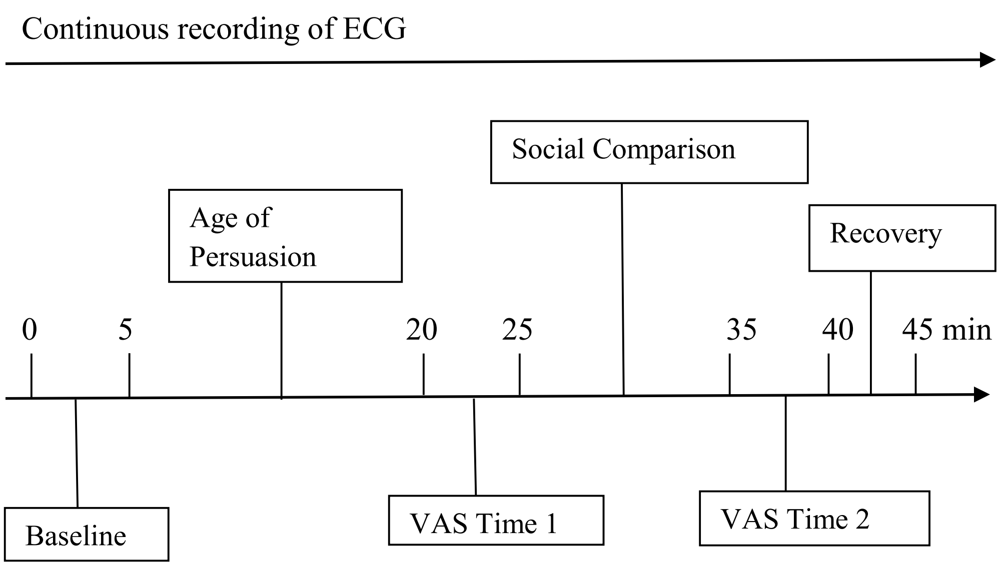


Figure 2. Experimental timeline in minutes for the no-BF condition.

variables. Skewness that exceeded ±1.96 (consistent with $p < .05$) identified variables that were then transformed using the methods described by Tabachnick and Fidell (2007) in order to reduce skewness to an acceptable level. Homogeneity of variance was assessed using Levene's test which detects significant differences between group variances. Repeated measures ANOVAs were also utilized which carry an additional assumption of sphericity. However, for these analyses the multivariate test statistic was used as it is not dependent on this assumption. Specifically, Wilks' Λ and the associated *F* statistics are reported. Finally, Box's *M* test was used to test for homogeneity of covariance matrices, with $p < .001$ values indicating a violation of this assumption (Tabachnick & Fidell, 2007).

Given that specific *a priori* hypotheses were made concerning how the experimental manipulation would impact participants' HRV, a series of planned contrasts were carried out to identify significant differences between conditions. The planned contrasts enable the analysis of only two amounts of variance at a time. By isolating two portions of the variance, any significant results allow the determination of where the actual differences exist (Field, 2013). The specific planned contrasts used in the study compared high-HRV BF to the other two conditions combined. When multiple ANOVAs were conducted, family-wise Type I error rate of $\alpha = .05$ was maintained by setting Bonferroni adjusted per-comparison error rates to α/n, where n = the number of ANOVAs conducted. Whenever any of the aforementioned assumptions were violated, particular remedies were implemented, which are outlined when appropriate.

The second hypothesis was investigated through hierarchal regression which enters predictor variables into a regression equation in blocks. This allows for the determination of the additional variance each block accounts for above and beyond previously entered predictors (Norman & Streiner, 2008). In essence, this approach allows for the examination of the effect of a predictor variable(s) while controlling for other variables. This is achieved by calculating the change in adjusted R^2, or the amount of variability in the outcome accounted for by the predictors after adding subsequent blocks of predictors into the regression model (Field, 2013). In the present study, it was hypothesized that the extent to which individuals engaged in social comparison processing would predict increases in negative mood and body dissatisfaction, while simultaneously causing decreases in appearance self-esteem. Therefore, the relevant baseline values for each of these criterion variables were entered in the first block of the equation before entering both the feature and social comparison processing variables in the second block.

A series of exploratory analyses were conducted using moderated multiple regressions (MMRs). MMR analysis allows researchers to examine whether a moderating effect is present within the sample, which then enables inferences to be made about the population (Aguinis, 2004). Specifically, moderated analysis allows researchers to examine whether the effects of a predictor variable on an outcome variable is dependent on a third variable or set of variables (Hayes, 2013). MMR uses an ordinary least-squares (OLS) regression equation to test the prediction of an outcome variable Y. In total, three MMR analyses were conducted.

The first MMR was a moderated moderation model. A moderated moderation model, also known as a three-way interaction, investigates whether the moderation of a variable's effect by another variable is itself moderated. Therefore, the model used included two moderating variables. Specifically, the regression equation predicts the outcome variable Y from the predictor X and the hypothesized moderators M and W, as depicted in the following equation:

$$Y = a + b_1X + b_2M + b_3W + e$$

where a is the least squares estimate of the intercept, and the b values are the least-squares estimates of the population regression coefficients that test potential main effects of X, M, and W in predicting Y. The residual error term is e (Aguinis, 2004).

In order to examine the 3 two-way interaction effects, product terms (e.g., X × M) must be created between the predictor variable and each of the moderators and added to the regression model. The equation illustrating this model is as follows:

$$Y = a + b_1X + b_2M + b_3W + b_4X \times M + b_5X \times W + b_6M \times W + e$$

where b_4, b_5, and b_6 are the least-squares estimates of the population regression coefficients for the product terms for each of the two-way interactions (Aguinis, 2004).

However, the effect of X on Y can also depend multiplicatively on M and W, which represents a moderated moderation or three-way interaction (Hayes, 2013). Therefore, a product term between the predictor and both moderators is created (X × M × W) in order to test for a higher order three-way interaction. This equation tests whether the interaction effect of the two predictors (e.g., X and M) on Y is moderated by the third predictor (W) (Aguinis, 2004). The equation illustrating this model is as follows:

$$Y = a + b_1X + b_2M + b_3W + b_4X \times M + b_5X \times W + b_6M \times W + b_7 X \times M \times W + e$$

where b_7 represents the least-squares estimate of the population regression coefficient for the final product term representing the three-way interaction.

The specific moderated moderation model tested the prediction of negative mood reactivity (Y) from dispositional body concerns (X), experimental condition (M), and resting HRV (W). Negative mood reactivity was defined as post- minus pre-social comparison challenge negative mood scores. EDEQ-WS served as a measure of dispositional body concerns. The experimental condition moderator compared those who received the high-HRV BF intervention versus those in the no-BF condition. Finally, participants' ln RMSSD during the baseline phase of the experiment was used as their resting HRV measure, and acted as the second moderator. Baseline negative mood scores served as the covariate. The first MMR model is depicted in Figure 3.

Finally, two additional MMR analyses were conducted. Both analyses utilized simple moderation models which estimate the prediction of an outcome variable Y from a predictor X and a putative moderator M, as depicted in the following equation:

$$Y = a + b_1X + b_2M + e$$

where a is the least squares estimate of the intercept, b_1 is the least-squares estimate of the

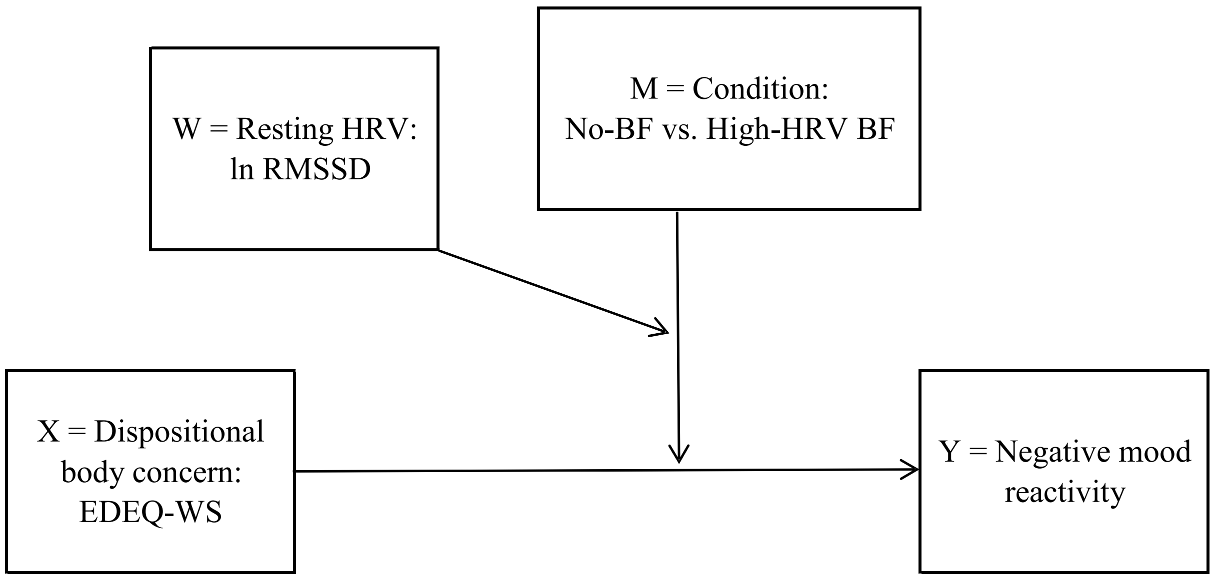


Figure 3. Moderated moderation model of the effects of dispositional body concerns upon negative mood reactivity as moderated by condition and resting HRV. M and W = moderator variables; X = predictor variable; Y = outcome variable. Adapted from *Introduction to mediation, moderation, and conditional processing analysis: A regression-based approach* (p. 308), by A.F. Hayes, 2013, New York: The Guilford Press.

population regression coefficient for X, b_2 the least-squares estimate of the population regression coefficient for M, and e is the residual term (Aguinis, 2004).

The final equation again included a variable formed by using the product between the predictor and moderator (X × M). Therefore the equation illustrating the model, known as the simple linear moderation model, is as follows:

$$Y = a + b_1X + b_2M + b_3X \times M + e$$

where b_3 is the least-square estimate of the population regression coefficient for the product term.

The second exploratory MMR model examined whether negative mood reactivity could be predicted from the amount of time participants spent engaged in social comparison processing and resting ln RMSSD. The third model assessed whether EDEQ-WS moderated any relationship between social comparison processing and negative mood reactivity. Both models are depicted in Figure 4.

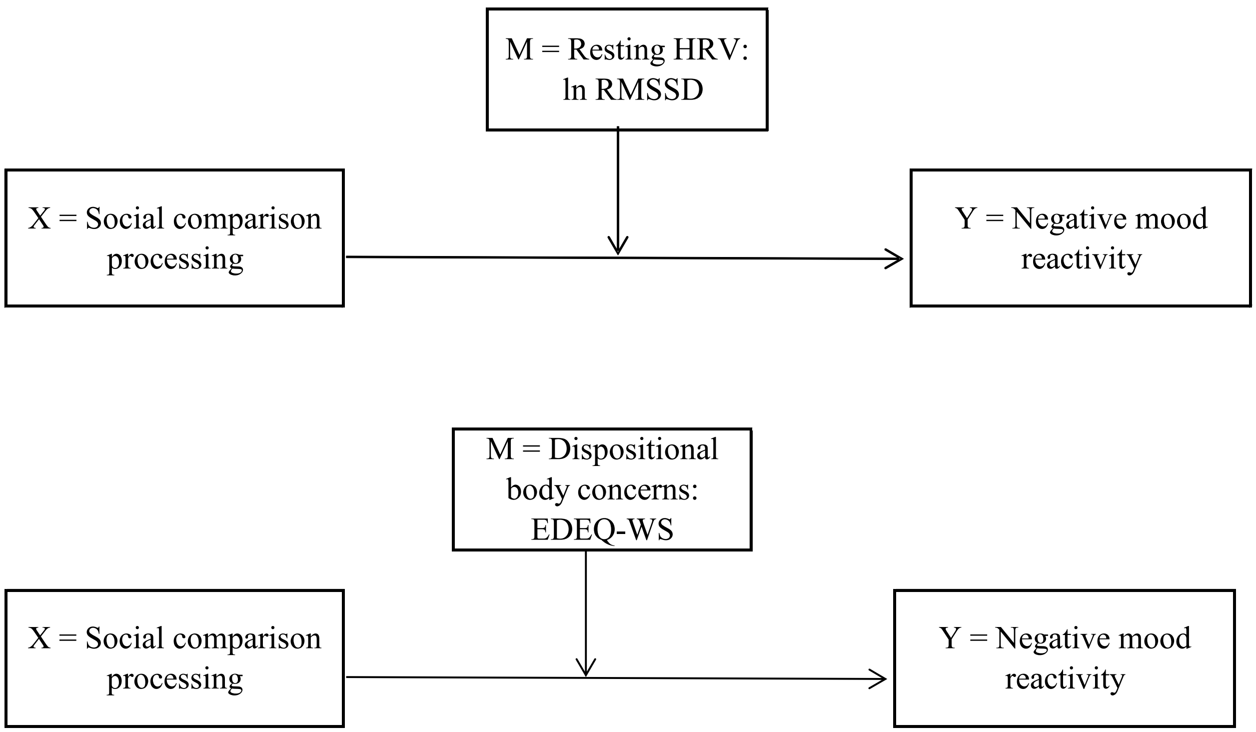


Figure 4. Moderation model of the effects of social comparison processing upon negative mood reactivity as moderated by resting ln RMSSD (top-panel) and by EDEQ-WS (bottom-panel).

All of the MMRs were conducted using the PROCESS macro for SPSS (Hayes, 2013). PROCESS uses an ordinary least squares path analysis framework to estimate conditional main effects of variable X on Y, and moderator effects for M and W. PROCESS calculates unstandardized regression coefficients for conditional main effects as well as for two- and three-way interaction effects. These coefficients describe the relationship between a predictor and criterion variable in terms of the original units of measurement (Lewis-Beck, Bryman, & Liao, 2004). All regression coefficients are reported in unstandardized form.

Regression assumptions and best practises. Hierarchal regression and MMR share many of the same assumptions. By ensuring these assumptions are met, more accurate conclusions can be made regarding the analysis. These assumptions and how they were tested are listed below:

1. The error terms need to be independent for both hierarchal regressions and MMRs. This means that for any two observations the residual terms should be uncorrelated.
2. Both regression types assume that there is less than complete multicollinearity. Multicollinearity is a perfect relationship between two or more predictors, which is problematic as it makes it difficult to ascertain the true importance of each predictor (Field, 2013).
3. Hierarchal regressions and MMR require homoscedasticity. However, MMRs have the additional assumption of homogeneity of error variance. Essentially, both assumptions are related to the same requirement that residuals have a constant distribution around a regression line (Aguinis, 2004). More specifically, homoscedasticity refers to a constant distribution for individual scores, while homogeneity of error variance refers to whether the distribution of residuals is constant across moderator subgroups. Therefore, the homogeneity of error variance assumption specifies that the variance in Y that is unaccounted for by X is the same across moderator-based subgroups (Aguinis & Pierce, 1998).
4. Hierarchal regressions and MMRs require that the relationship being modeled be linear.

In other words, the mean values of the outcome variable for each increment of the predictor lie along a straight line (Field, 2013).

5. It is also assumed that the residuals for both hierarchal regression and MMRs are random, normally distributed variables with a mean of zero (Aguinis, 2004). Therefore, the differences between the model and the observed data should most frequently be zero.
6. Finally, all predictors in the MMR analyses were mean centered prior for creation of the product terms in order to assist with the interpretation of the MMR results. This allows for the creation of a meaningful zero point, which is the mean of the predictor variable in the sample (Dalal & Zickar, 2012). Also, mean centering guarantees that the coefficients for the two variables defining the product term will be interpretable within the range of the data (Hayes, 2013).

For the hierarchal regressions, the data was reviewed for the presence of outliers and influential cases as outlined by Field (2013) via case diagnostics. Cases that had standardized residuals less than -2 or greater than 2 were identified before checking their Cook's distance and Mahalanobis distance. Cook's distance measures a case's overall influence on the regression model. Values greater than 1 may indicate an overly influential case. On the other hand, Mahalanobis distance measures the distance of cases from the means of the predictor variables. In smaller samples (n = 100) and with three predictors, values greater than 15 are problematic (Field, 2013). None of the cases identified through this process had problematic values on either of these two measures. Two cases in the appearance self-esteem regression had standardized residuals greater than 3. However, given that the Cook's distance and Mahalanobis distance values were both well within the accepted range, they were retained in the regression.

Various steps were taken to ensure that the hierarchal regression analyses met all assumptions. To check whether the assumption of independent errors was tenable, the Durbin-Watson was performed. This measure can vary between 0 and 4, with values below 1 and above 3 indicating possible violation of this assumption (Field, 2013). The Durbin-Watson values for the regression analyses all fell within the acceptable range. To ensure that there was no multicollinearity, the VIF statistics was examined. VIF factors greater than 10 as well as an average VIF substantially greater than 1 are indicative of possible violations of this assumption. Examinations of this statistics for the hierarchal regression analyses did not indicate violation of this assumption.

To visually inspect the validity of some regression assumptions, plots of residual values were examined. More specifically, the standardized residuals (difference between the observed data and the values the model predicts) were plotted along the Y axis against the standardized predicted values of the dependent variable on the X axis. This plot helps to determine whether the assumptions of random errors and homoscedasticity are met. In addition, the studentized residuals (the unstandardized residual divided by an estimate of its standard deviation) were plotted along the Y axis against the standardized predicted values of the dependent variable on the X axis. This plot is helpful in identifying any heteroscedasticity that may exist. Furthermore, scatterplots of the partial plots were used to check the assumption of linearity. Finally, histograms of the standardized residuals and normal probability plots were used to check whether the residuals in the models were normally distributed. No obvious violations of normality, linearity, or homoscedasticity were noted in the data.

While the MMR analyses were done using the PROCESS macro, the equations were also entered into SPSS via forced entry in order to check whether assumptions had been met. The same methods used for the hierarchal regression were utilized with the MMR models, including performing case diagnostics. For the moderated moderation model there was one individual that had a Mahalanobis distance that approached the cut-off of 15. However, the removal of this individual did not significantly change the model's prediction and, consequently, this case was retained in the analysis.

One assumption that appeared to be violated for the MMR equations was that of multicollinearity. However, as Shieh (2010) notes, there are two types of multicollinearity; essential and nonessential. Essential multicollinearity occurs when an actual relationship exists between predictor variables. Nonessential multicollinearity can arise due to the scaling of the predictor variables. This can often be remedied via centering of the predictors. It should be noted that the centering of the variables does not affect the detection of interaction effects (Shieh, 2010). In the present study, once the predictors were centered, the problem with multicollinearity was eliminated.

For MMRs that have a dichotomous moderator, the assumption of error variance needs to be evaluated. Aguinis, Petersen, and Pierce (1999) developed the program ALTMMR as a tool to test this assumption. The main statistic that the program produces is Bartlett's *M*, which assesses whether the null hypothesis of homogeneity of error variance is met. The program also provides DeShon and Alexander's heuristic which states that the F statistic used in MMR starts to be adversely affected when the error variance of one subgroup is approximately 1.5 times larger than another subgroup (Aguinis, 2004). Aguinis recommends the use of both Bartlett's *M* and the DeShon and Alexander heuristic when determining whether this assumption is met. In the event the assumption is not met, or when there is a discrepancy between both procedures, the program provides James' *J* statistic and Alexander's *A* statistic to verify whether any moderation is present. These two statistics are alternatives to the MMR *F* test that can be used to test a moderator hypothesis when heterogeneous error variance exists (Aguinis, 2004). If the *J* and *A* statistics are consistent with the MMR results, the moderation can be considered valid even though the assumption of error variance is violated. The results of the ALTMMR program will be reviewed below when appropriate.

Whenever evidence of moderation of X's effect on Y is present, the results are typically probed via the pick-a-point approach. This procedure selects values representing "low", "moderate", and "high" on the moderator (M) by taking values -1 standard deviation below the mean, the mean, and 1 standard deviation above the mean. For the moderated moderation model a variant of the pick-a-point approach was used that looked at whether M moderated X's effect on Y at low, moderate, and high levels of W. Another method that has recently been used more frequently to probe interactions is the Johnson-Neyman technique (see Hayes & Matthes, 2009), which identifies the values(s) along *M* at which the effect of *X* on *Y* becomes statistically significant. This has been termed the "region of significance". One of the benefits of the Johnson-Neyman approach is that it eliminates the need for the identification of arbitrary values representing low, moderate, or high levels of *M*. The moderated moderation model uses an alternate form of the Johnson-Neyman technique that identifies where the conditional interaction between X and M transitions from being significant to not significant along the continuum of W.

The present analysis probed any interactions using a combination of the two techniques outlined above. The pick-a-point technique was used in order to visually represent the effect at different levels of the moderator. In addition, the Johnson-Neyman approach was used to identify regions of significance.

Data Preparation

All data was entered into SPSS v.21 and examined for missing values. The missing data points accounted for less than 1% of the total data. For the measures completed prior to coming to the laboratory, five individuals were missing single items on the SSES, and one individual was missing all of the SSES. For the measures completed post-social comparison challenge, eight were missing single items on the SSES. Missing data was replaced with prorated scores for the items within individuals on the scale or subscales in question. The individual missing the SSES pre-social comparison had her subsequent score carried backwards.

Data were also examined for outliers defined as $z > \pm 3.29$. The analysis revealed a single outlier for the pre-social comparison negative mood variable. The outlier was replaced using the next highest nonoutlier score, plus 0.1 (Field, 2013).

Psychometric Variables

Descriptive information and reliability coefficients of the psychometric variables are presented in Table 1. The negative mood variable was significantly skewed both pre- and post-social comparison, with skewness exceeding the convention of 1.96 consistent with $p < .05$ (Field, 2013). The square root transformation produced $z_{\text{Skewness}} < 1.96$ for both pre- and post-social comparison negative mood. The StressEraser® score distribution was also significantly skewed; however, this was also remedied via a square root transformation. The HRV metric RMSSD was significantly skewed and was therefore transformed via a natural log transformation (ln RMSSD) as is customary in this field of research. Finally, the social comparison variable was significantly negatively skewed; therefore, it was first reflected prior to being subjected to a square root transformation. Once the transformation was performed, the variable was again reflected so that the interpretation of the results would not be reversed.

Manipulation Check

In order to ascertain the internal validity of the BF experimental manipulation, three dependent variables were examined: StressEraser® score, ln RMSSD and RR, all of which should be sensitive to the effects of the manipulation. It was predicted that relative to the low-HRV BF condition, participants in the high-HRV BF condition would evidence higher StressEraser®

Table 1

Reliability Coefficients and Descriptive Statistics of the Psychometric Variables Pre- and Post-Social Comparison Challenge

	Pre				Post			
Variables	*M*	*SD*	α	$Z_{Skewness}$	*M*	*SD*	α	$Z_{Skewness}$
EDEQ								
Shape/Weight Concerns	1.85	1.08	.90	1.77				
SSES								
Appearance	18.30	4.83	.86	- 0.57	17.58	5.20	.88	- 0.16
Tiggemann VASs								
Negative mood	26.02	11.13	.61	3.87	35.65	18.05	.84	3.26
Square root transformed	5.01	1.03		2.22	5.77	1.53		0.15
Body dissatisfaction	47.89	19.07	.73	0.51	55.90	21.62	.85	- 1.23
Feature Processing					41.74	21.84	.76	1.05
Social comparison processing					64.79	23.40	.92	- 2.39
Square root transformed					5.37	2.13		1.23

Note. SSES = State Self-Esteem Scale; EDEQ = Eating Disorder Examination Questionnaire; VAS = Visual Analogue Scales; α = Cronbach's alpha internal consistency.

scores and ln RMSSD as well as lower RR. The no-BF condition was predicted to be between the two BF conditions on the three variables.

StressEraser® score. A 3 × 2 (condition: low-HRV BF vs. no-BF vs. high-HRV BF; EDEQ group: low vs. high) between-participants ANOVA was used to examine whether StressEraser® scores differed as a function of condition and EDEQ group. As previously noted, the scores were significantly skewed and therefore were subjected to a square root transformation. The analysis of the transformed data revealed a significant condition main effect, $F(2, 108) = 74.83$, $p < .001$, $\eta^2 = .581$ (see Figure 5 in original raw units), but no significant EDEQ group main effect, $F(1, 108) = 0.43$, $p = .511$, $\eta^2 = .004$, or Condition × EDEQ Group interaction, $F(2, 108) = 0.07$, $p = .933$, $\eta^2 = .001$. As predicted, the first of two planned contrasts revealed that the high-HRV BF condition attained higher StressEraser® scores than the other two conditions combined, $t(112) = 12.09$, $p < .001$, $r = .75$. The second contrast between the low-HRV BF condition and no-BF condition was not significant, $t(76) = -1.77$, $p = .138$, $r = .20$.

Respiration rate. A Kolmogorov-Smirnov test revealed that the RR for the low-HRV BF, $D(38) = 0.17$, $p = .005$ and the high-HRV BF, $D(36) = 0.16$, $p = .015$, were both significantly non-normal, wherein significant positive skew was detected in both of these group distributions. Box and whisker plots of the data are presented in Figure 6. Successive application of a variety of data transformation algorithms (square root, log, reciprocal) failed to remedy the significant skew within these distributions, thereby rendering inappropriate the use of ANOVA to test for differences between group means. Alternatively, a Kruskal-Wallis test for differences between group medians was conducted to test whether condition resulted in different RRs during the BF phase. The omnibus test proved to be statistically significant, $H(2) = 83.32$, $p < .001$. This was followed up by three post hoc Mann-Whitney tests for each of the 3 two-group comparisons of the median RRs. Family-wise Type I error rate of $\alpha = .05$ was maintained by setting Bonferroni adjusted per-comparison error rate to $\alpha/3 = .0167$. The high-HRV BF condition had significantly lower RR than both the no-BF, $U = 36.50$, $r = -.82$, and low-HRV BF conditions, $U = 17.50$, $r = -.84$; *Mdn*s = 8, 17.4, and 28, respectively. The RR was higher in the low-HRV BF versus no-BF condition, $U = 193.00$, $r = -.64$. These results are consistent with the intended manipulation of RR.

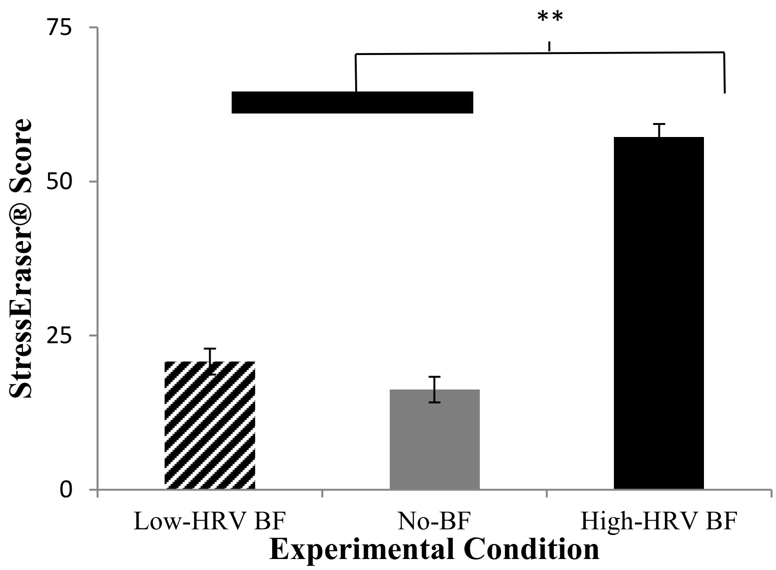


Figure 5. Mean StressEraser® score (±1 *SE*) plotted as a function of BF condition. ** $p < .001$, where the high-HRV BF condition attained higher scores than the other two conditions combined.

ln RMSSD. A 4 × 3 × 2 (phase: baseline vs. BF vs. social comparison vs. recovery; condition: low-HRV BF vs. no-BF vs. high-HRV BF; EDEQ group: low vs. high) mixed model ANOVA was used to examine changes in ln RMSSD over phases of the experiment as a function of condition and EDEQ group. A significant main effect was found for phase, Wilks' $\Lambda = .637$, $F(3, 106) = 20.14$, $p < .001$, $\eta^2 = .363$. This was qualified by a significant Condition × Phase interaction, Wilks' $\Lambda = .823$, $F(6, 212) = 3.62$, $p = .002$, $\eta^2 = .093$. Figure 7 depicts ln RMSSD for each of the BF conditions across the phases of the experiment. To determine the source of the interaction, a series of ANCOVAs was conducted for each phase with baseline ln RMSSD serving as the covariate and condition serving as the independent variable. Per-comparison error rate was set to $\alpha/3 = .0167$. The simple effect of condition at the BF phase proved to be significant, $F(2, 110) = 14.76$, $p < .001$, $\eta^2 = .212$. A planned contrast revealed that the high-HRV BF condition had higher ln RMSSD than the other two conditions combined, $t(112) = 5.17$, $p < .001$, $r = .44$. The second contrast revealed that the low-HRV condition did not differ from the no-BF condition, $t(76) = 1.72$, $p = .091$, $r = .19$. The simple effect of condition was not significant at the social comparison phase, $F(2, 110) = 3.53$, $p = .033$, $\eta^2 = .060$, or the recovery phase, $F(2, 111) = 1.47$, $p = .235$, $\eta^2 = .026$, of the experiment.

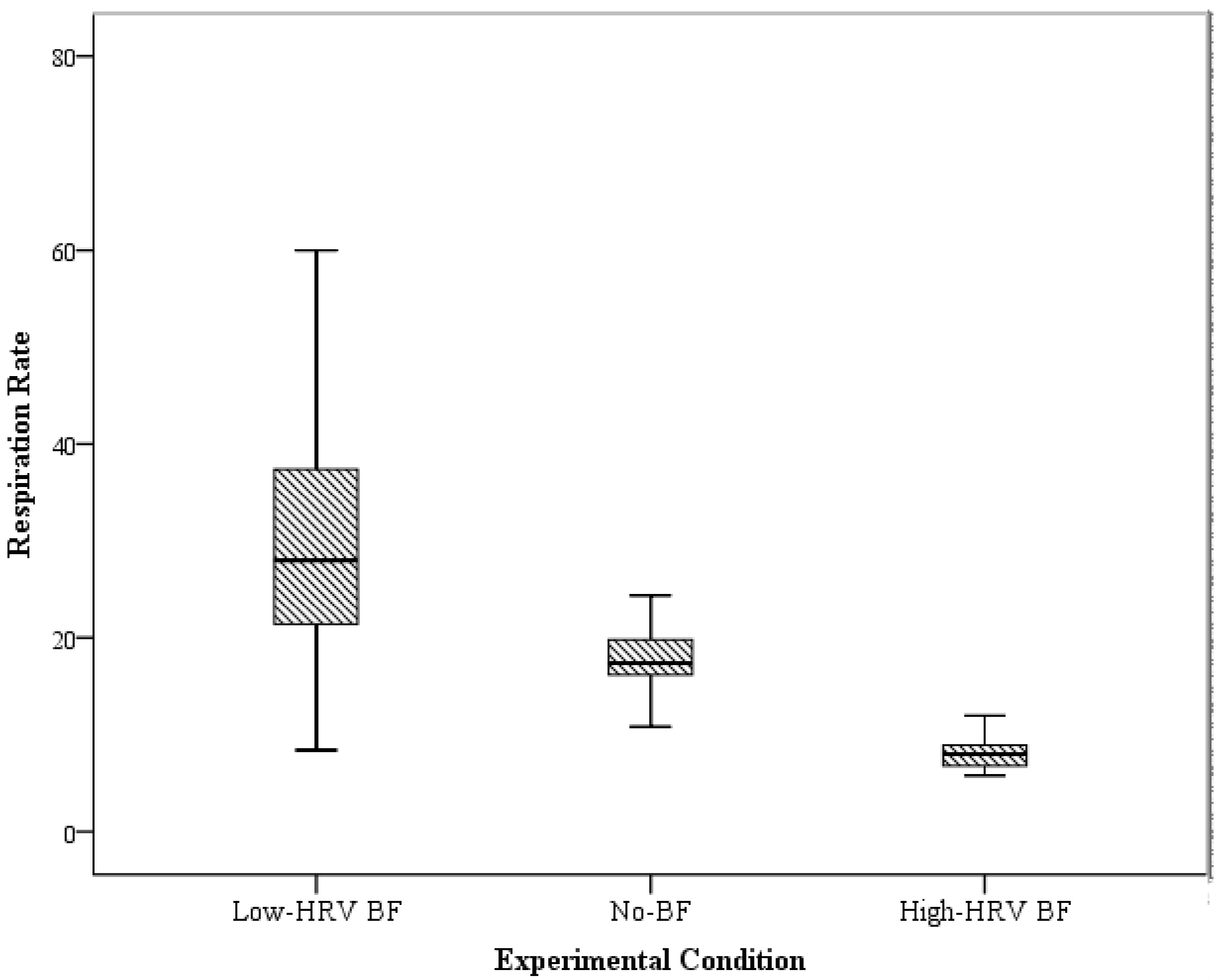


Figure 6. Respiration rate plotted as a function of BF condition.

To summarize, results indicate that the experimental manipulation of condition was indeed effective in raising ln RMSSD among high-HRV BF participants during the BF phase; however, this effect did not persist throughout the rest of the experimental phases. Table 2 displays ln RMSSD values for each condition across the phases of the experiment.

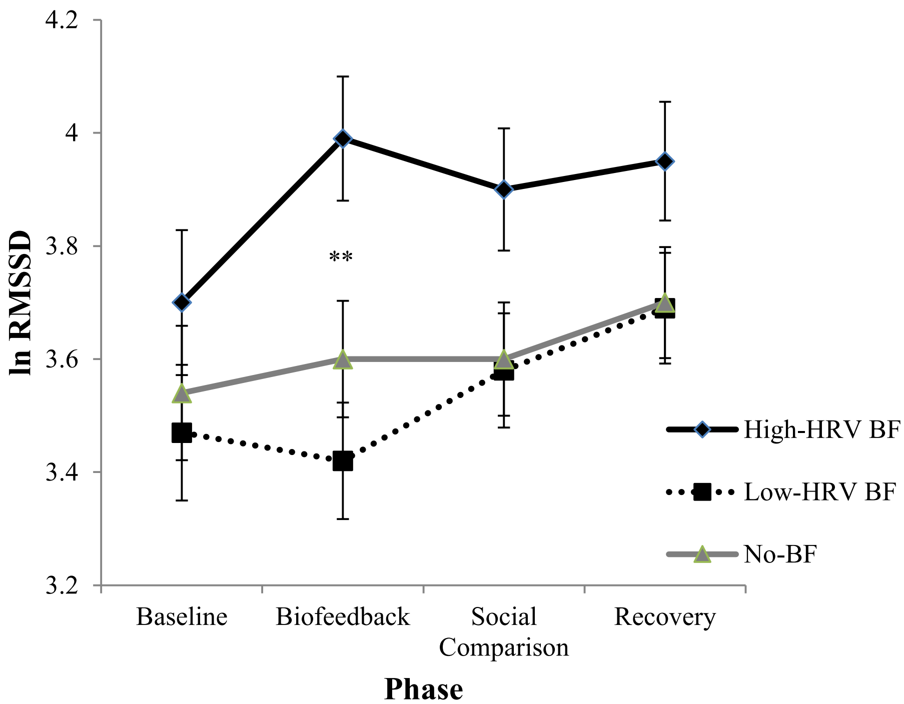


Figure 7. ln RMSSD (±1 *SE*) plotted as a function of phase and BF condition. ** $p < .001$, which represents a significant difference between high-HRV BF and the other two conditions combined.

Hypothesis 1

It was predicted that individuals in the high-HRV BF condition would experience attenuated negative responses to the social comparison challenge when compared to those in the low-HRV BF and no-BF conditions. Furthermore, regardless of condition assignment, individuals with higher dispositional body concerns were predicted to experience greater negative mood and body dissatisfaction and decreases in appearance self-esteem as the result of the social comparison challenge. To test the hypotheses that the BF manipulation and dispositional body concerns would separately and/or interactively affect psychological responses to the social comparison, three separate 2× 3 × 2 (EDEQ group: low vs. high; BF condition: low-HRV vs. no-BF vs. high-HRV; time: pre- vs. post-social comparison) ANOVAs were conducted, one for each of the following dependent variables; negative mood, body dissatisfaction, and appearance self-esteem. Family-wise Type I error rate of $\alpha = .05$ was maintained by setting Bonferroni adjusted per-comparison error rate to $\alpha/3 = .0167$.

Table 2.

Descriptive Statistics for ln RMSSD Over the Phases of the Experiment for Each Condition

	Phase							
	Baseline		BF		Social Comparison		Recovery	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Low-HRV BF	3.47	0.71	3.42	0.57	3.58	0.58	3.69	0.56
No-BF	3.57	0.70	3.62	0.69	3.62	0.65	3.73	0.60
High-HRV BF	3.67	0.80	3.96	0.65	3.86	0.65	3.92	0.66

Negative mood. A main effect of time was found, $F(1, 108) = 60.49$, $p < .001$, $\eta^2 = .359$, whereby the sample as a whole reported an increase in negative mood over the course of the social comparison. However, contrary to predictions, this was not moderated by BF condition. Specifically, neither the main effect for BF condition, $F(2, 108) = 0.57$, $p = .566$, $\eta^2 = .010$, nor the BF condition × Time interaction was significant, $F(2, 108) = 0.15$, $p = .865$, $\eta^2 = .003$. Thus, high-HRV BF failed to attenuate the observed effects of social comparison on negative mood.

Consistent with hypothesis 1, a significant main effect for EDEQ group did emerge, $F(1, 108) = 21.69$, $p < .001$, $\eta^2 = .167$, that, importantly, was qualified by its interaction with time, $F(1, 108) = 21.78$, $p < .001$, $\eta^2 = .168$ (see Figure 8). Two post-hoc tests of the simple effects of time were conducted, with per-comparison error rate set to $\alpha/2 = .025$. Using this criterion, the main effect of time was not significant in the low-EDEQ group, $F(1, 55) = 5.26$, $p = .026$, $\eta^2 = .087$. However, the high-EDEQ group was the source of the interaction as the simple effect of time was significant in this condition, $F(1, 57) = 71.32$, $p < .001$, $\eta^2 = .556$, with a resultant large effect size (Cohen, 1988). The mood of participants with high dispositional body concerns was uniquely and negatively influenced by the social comparison.

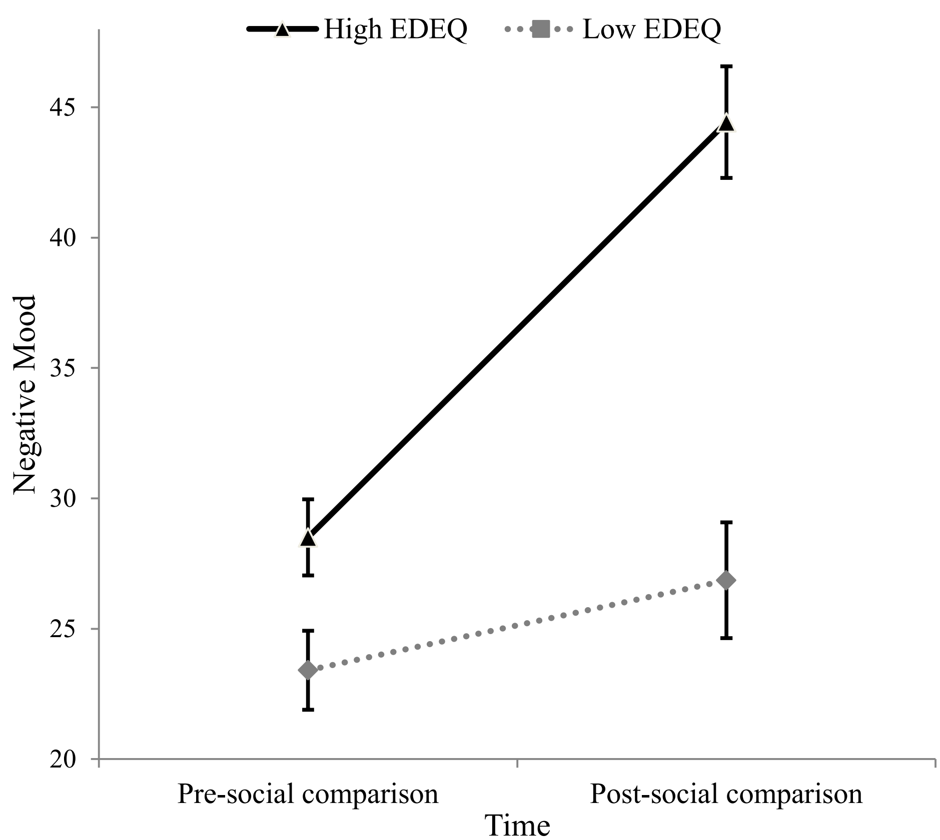


Figure 8. Negative mood (±1 *SE*) plotted as a function of dispositional body concerns, pre- and post-social comparison challenge.

Body dissatisfaction. The results revealed a significant EDEQ group main effect, $F(1, 108) = 86.28$, $p < .001$, $\eta^2 = .444$, with means (*SD*) for the low- and high-EDEQ groups of 38.36

(15.41) and 64.87 (15.08), respectively. The time main effect was also significant, $F(1, 108) = 57.99$, $p < .001$, $\eta^2 = .349$, where body dissatisfaction increased from pre- $M = 47.55$ (15.16) to post-social comparison $M = 55.69$ (17.30). No other main or interaction effects attained significance.

Appearance self-esteem. Once again, the results produced a significant EDEQ group main effect on the dependent variable SSES: Appearance, $F(1, 108) = 77.70$, $p < .001$, $\eta^2 = .418$, with means (*SD*) = 21.06 (5.34) versus 14.94 (5.14) for the low- and high-EDEQ groups, respectively.

Collectively, these results indicate that, contrary to hypothesis 1, in no case did BF moderate psychological reactivity to the social comparison challenge. On the other hand, the social comparison task produced an increase in negative mood particularly among individuals predisposed to dispositional body concerns, which is consistent with predictions. The social comparison challenge led to a comparatively smaller increase in body dissatisfaction in the sample as whole. The results also indicated that individuals with higher dispositional body concerns experienced greater body dissatisfaction and lower appearance self-esteem overall.

Hypothesis 2

Hypothesis 2 concerns the differential prediction of psychological response to the social comparison challenge as a function of the type and intensity of processing that the participants engaged in during that challenge. Specifically, it was hypothesized that individuals' pervasiveness of comparison of self to the models regarding appearance, weight, and shape would predict increases on the criterion variables of negative mood and body dissatisfaction, and decreases on the third criterion variable of appearance self-esteem over the course of the social comparison challenge. However, pervasiveness of feature processing was not anticipated to predict psychological response. Table 3 shows the intercorrelations between the form of processing and the three criterion variables. The table shows that engaging in one type of processing is relatively statistically independent of the other, $r = -.17$, $p = .07$.

To test the above model, separate hierarchal regression analyses were conducted for each of the three criterion variables. In Step 1 of each analysis, baseline values of the relevant criterion variable were entered. This was followed in step two by the inclusion of the two forms of processing; feature and social comparison. These processing variables accounted for significant additional variance over and above the pre-comparison values for negative mood, $\Delta R^2 = .113$, $\Delta F(2, 110) = 13.43$, $p < .001$, body dissatisfaction, $\Delta R^2 = .026$, $\Delta F(2, 110) = 6.00$, $p = .003$, and appearance self-esteem, $\Delta R^2 = .104$, $\Delta F(2, 110) = 16.40$, $p < .001$. Table 4 displays the resulting regression coefficients[1]. The results indicate that social comparison processing was related to higher negative mood and body dissatisfaction, and to lower appearance self-esteem, after viewing the images depicting the thin idealized images. On the other hand, feature processing was not related to any of the outcome variables.

Exploratory Analyses

Three exploratory MMR analyses were conducted to further investigate the above observation regarding negative mood. In particular, the analyses examined whether participants' negative mood reactivity could be predicted, where reactivity was defined as post- minus pre-social comparison. The first model explored the finding that higher dispositional body concerns (EDEQ-WS) was associated with greater negative mood following the social comparison challenge (see Figure 8). Specifically, this analysis examined whether this relationship was moderated by resting ln RMSSD and condition. The second and third models investigated the

[1] One multivariate outlier was detected, however, its exclusion from analyses did not appreciably change the results reported herein with it included.

relationship between social comparison processing and subsequent negative mood. The models assessed whether this relationship was moderated by resting ln RMSSD and EDEQ-WS, respectively. Table 5 displays the descriptive information for the variables included in the MMR analyses.

Table 3.
Intercorrelations Between Forms of Processing and Negative Mood, Body Dissatisfaction, and SSES: Appearance for the Whole Sample (N = 114)

	SoCo	*NM pre*	*NM post*	*BD pre*	*BD post*	*App pre*	*App post*
Feature Processing	-.17	.05	-.15	-.10	-.16	.10	.22
Social Comparison (SoCo)	–	.16	.43	.34	.46	-.25	-.50
Negative Mood (NM)-pre		–	.62	.40	.40	-.36	-.44
Negative Mood (NM)-post			–	.64	.71	-.59	-.72
Body Dissatisfaction (BD)-pre				–	.85	-.69	-.82
Body Dissatisfaction (BD)-post					–	-.62	-.86
SSES: Appearance (App)-pre						–	.71
SSES: Appearance (App)-post							–

Note. SSES = State Self-Esteem Scale. Correlations > .21 are significant at $p < .05$

Table 4.
Summary of Hierarchal Regression Analyses for the Prediction of Negative Mood, Body Dissatisfaction and SSES: Appearance

	Negative Mood			*Body Dissatisfaction*			*SSES: Appearance*		
	B	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Step 1									
Constant	1.21	0.51		9.37	2.84		3.00	1.29	
Pre-measure	0.92	0.10	.65 **	0.97	0.06	.86 **	0.80	0.07	.74 **
Step 2									
Constant	0.66	0.53		6.57	4.04		8.41	1.67	
Pre-measure	0.85	0.09	.61 **	0.90	0.06	.80 **	0.69	0.06	.64 **
Feature Processing	-0.01	0.01	-.11	-0.06	0.05	-.06	0.02	0.01	.08
Social Comparison	0.22	0.05	.31 **	1.58	0.51	.16 *	-0.78	0.14	-.32 **

Note. SSES = State Self-Esteem Scale. For negative mood R^2= .43 for Step 1 ($p < .001$); ΔR^2 = .11 for Step 2 ($p < .001$). For body dissatisfaction R^2 = .73 for Step 1 ($p < .001$); ΔR^2 = .03 for Step 2 (p = .003). For SSES: Appearance R^2 = .55 for Step 1 ($p < .001$); ΔR^2 = .10 for Step 2 ($p < .001$).
* $p < .01$. ** $p < .001$.

EDEQ-WS, condition, and ln RMSSD. To review, the primary analysis reported above found no evidence that BF served to mitigate the negative consequences of a social comparison challenge. However, the original hypothesis was predicated on the assumption that all individuals would respond similarly to the BF induction. In other words, the analysis did not take into account any individual differences in how participants would respond to the HRV manipulation. A closer inspection of the individuals in the high-HRV BF condition revealed a significant negative relationship between resting ln RMSSD and subsequent HRV change as a results of the BF phase, $r = -.59$, $p < .001$. Hence, participants with lower resting ln RMSSD experienced the greatest change (i.e., increase) in HRV as a result of the BF phase when compared to their counterparts with higher resting ln RMSSD, as can be seen in the scatterplot of Figure 9.

Table 5.

Descriptive Statistics for the Variables Included in the MMR Analyses

			Condition					
	Overall Sample (*N* = 114)		Low-HRV BF (n = 38)		No-BF (*n* = 40)		High-HRV BF (*n* = 36)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Negative mood reactivity	0.79	1.16	0.87	1.42	0.70	0.98	0.81	1.08
Social comparison processing	5.37	2.13	5.45	2.00	5.26	2.36	5.40	2.05
EDEQ-WS	1.85	1.08	1.85	1.18	1.71	1.11	2.00	0.94
ln RMSSD	3.57	0.73	3.47	0.71	3.57	0.70	3.67	0.80

Note. Negative mood reactivity and social comparison processing are expressed in units of square root transformation. EDEQ-WS = Eating Disorder Examination Questionnaire weight and shape concerns scale. ln RMSSD = natural log of Root Mean Square of the Successive Differences.

Therefore, an MMR analysis was conducted to investigate whether resting HRV played a role in how effective the BF manipulation was in mitigating the negative consequences of the social comparison challenge. Specifically, the possibility that the established relationship between higher dispositional body concerns and negative mood could be moderated by resting HRV was explored. The analysis compared whether this relationship was different for participants in the high-HRV BF condition versus those in the no-BF condition who did not undergo any HRV manipulation. Pre-social comparison negative mood score was used as a covariate.

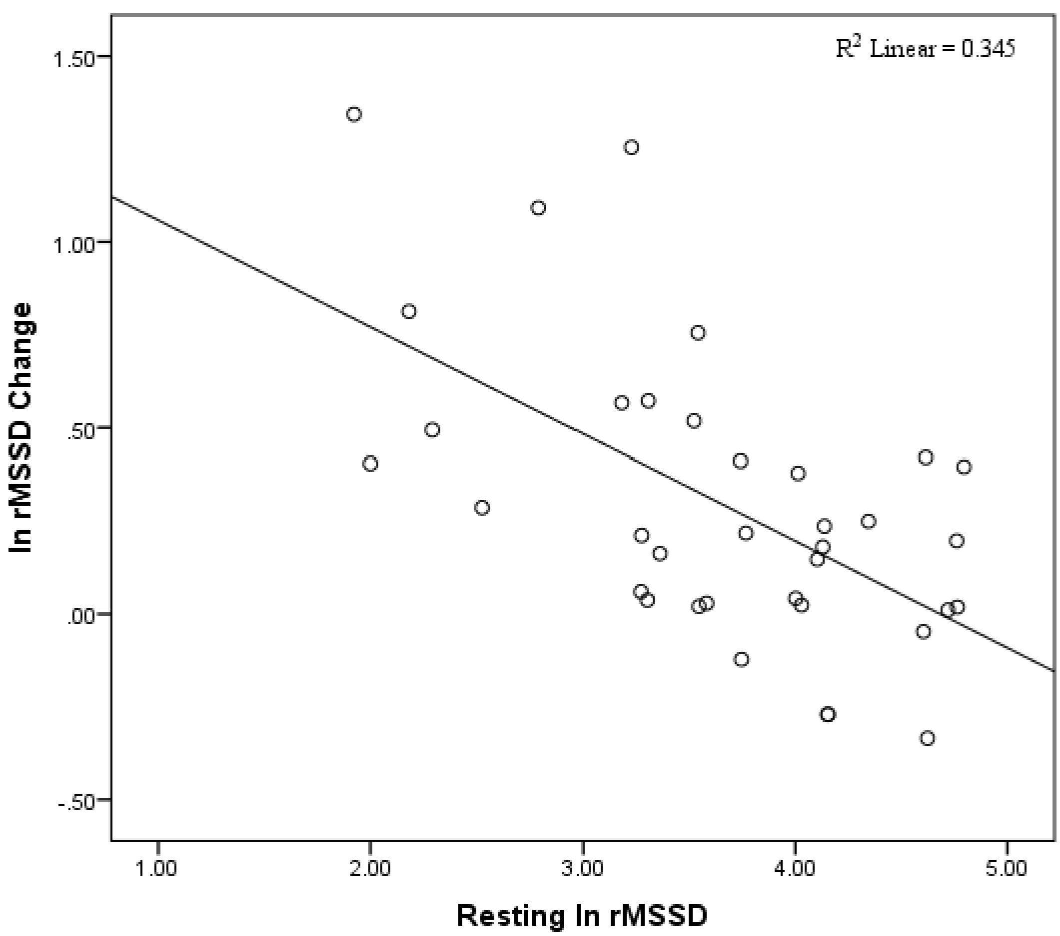


Figure 9. Scatterplot of change in ln RMSSD due to the BF phase as a function of resting ln RMSSD.

The results indicated a significant three-way interaction of EDEQ-WS × Condition × ln RMSSD, $B = 0.84$, $t(67) = 2.74$, $p = .008$. Testing of the error variance assumption for this model revealed that Bartlett's *M* indicated homogenous error variance (3.62, $p = .057$); however, the DeShon and Alexander heuristic was violated. The results of the James' *J* statistic (1.33, *U*crit = 4.01, p > .05) and Alexander's *A* statistic (1.30, $p = .299$) did not indicate moderation. Aguinis (2004) states that when the results of these statistics differ from the MMR *F* test, definite conclusions can only be made after further replication of the findings.

Despite the inability to make generalizations from the current results, the three-way interaction was probed using variations of the pick-a-point and Johnson-Neyman techniques. In the pick-a-point variation, the moderation of the relationship between EDEQ-WS and negative mood reactivity by condition was tested at low, moderate, and high resting ln RMSSD values. The results indicated that only for individuals with low resting ln RMSSD did the experimental condition moderate the relationship between EDEQ-WS and negative mood reactivity, $B = -0.86$, $t(67) = -2.37$, $p = .021$. The simple effect of condition upon reactivity revealed that EDEQ-WS predicted negative mood reactivity only for those in the no-BF condition, $B = 0.71$, t(67) = 3.89, p < .001. For those in the high-HRV BF condition with low resting ln RMSSD, EDEQ-WS did not predict negative mood reactivity, $B = -0.14$, t(67) = -0.46, p = .649. The results of the pick-a-point technique are displayed in Figure 10. As can be seen in the middle and bottom panels of Figure 10, higher EDEQ-WS predicts greater negative mood reactivity regardless of condition assignment for individuals with moderate to high resting ln RMSSD. However, this relationship is not present in those with lower resting ln RMSSD who were assigned to the high-HRV BF condition as seen in the top panel.

The Johnson-Neyman technique was used to identify where the interaction between EDEQ-WS and condition transitioned between statistically significant and not significant along the continuum of ln RMSSD. The results identified the region of significance as being below a value of 3.25 on resting ln RMSSD. Thus, only within this region did condition moderate the relationship between EDEQ-WS and negative mood reactivity. Therefore, while EDWQ-WS predicted negative mood reactivity for individuals with resting ln RMSSD values below 3.25 in the no-BF condition, this was not the case for those with similar resting ln RMSSD in the high-HRV BF condition.

Overall, these results indicate that HRV BF did serve to mitigate the negative consequences of the social comparison in a select group of participants. In particular, HRV BF was only effective in decreasing the negative mood reactivity for those with lower resting ln RMSSD, the same group who maximally responded to the biofeedback with large increases in HRV.

Social comparison processing and 1n RMSSD. The second exploratory MMR analysis examined whether the observed effect of social comparison processing upon negative mood reactivity was moderated by resting ln RMSSD. The model was conducted separately for each of the three experimental conditions. Table 6 displays the series of regressions conducted using resting ln RMSSD as a moderator in the prediction of negative mood reactivity from social comparison processing (top-panel).

Low-HRV BF condition. The analysis indicated that ln RMSSD did not moderate the relationship between social comparison processing and negative mood reactivity, B = -0.34, t(33) = 1.73, p = .093. The analysis was rerun with the interaction term removed from the model as recommended by Hayes (2013). The reanalysis that excluded this nonsignificant interaction term revealed that both social comparison processing, B = 0.25, t(34) = 1.72, p = .094, and ln RMSSD B = 0.10, t(34) = 0.31, p = .758 did not significantly predict negative mood reactivity in this condition.

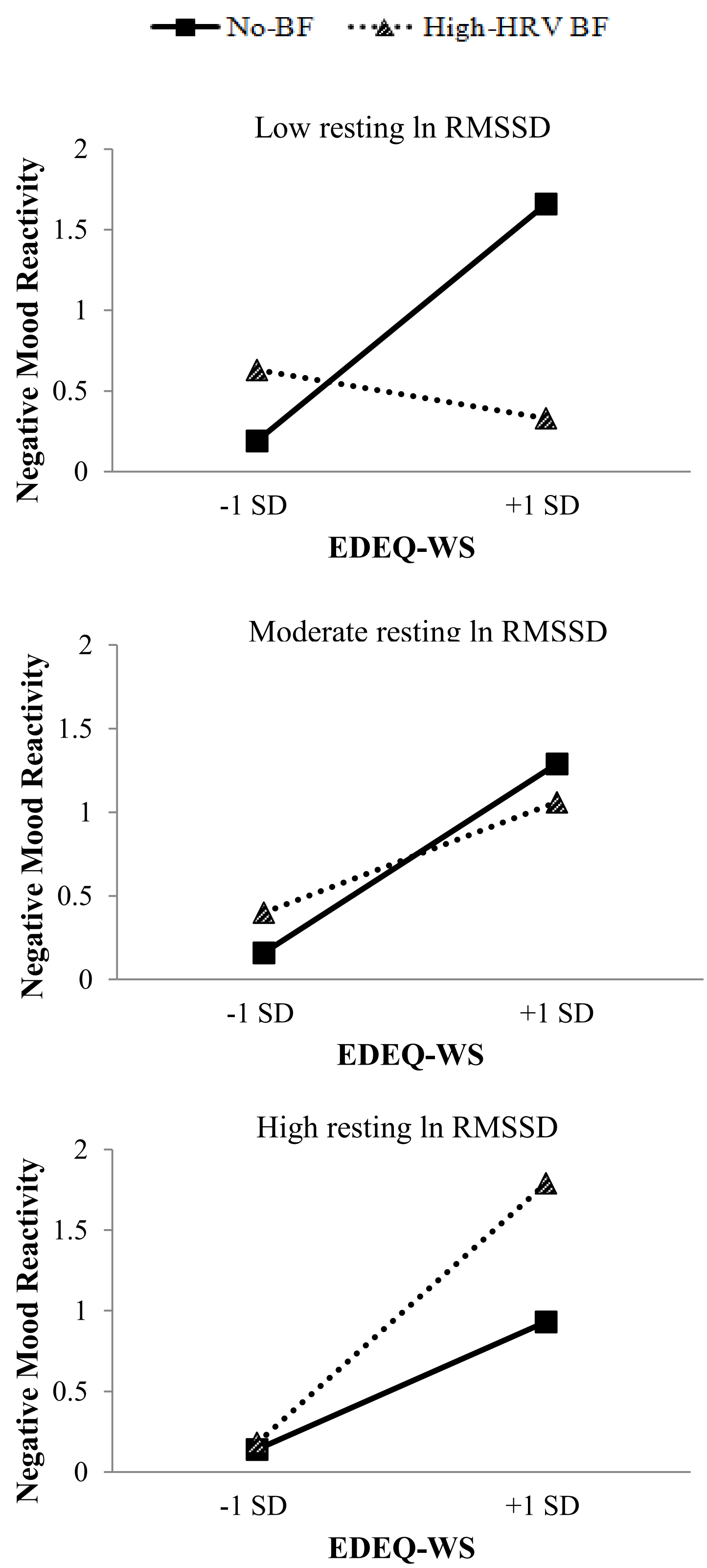


Figure 10. Negative mood reactivity post-social comparison challenge plotted as a function of EDEQ-WS and condition for individuals with low, moderate, and high resting ln RMSSD.

No-BF condition. Significant moderation was also not present in this condition, *B* = - 0.05, *t*(35) = - 0.57, *p* = .571. However the reanalysis excluding the interaction term indicated that social comparison processing significantly predicted negative mood reactivity, *B* = 0.29, *t*(36) = 4.03, *p* < .001. Therefore, more time spent engaged in social comparison processing predicted greater negative mood reactivity. ln RMSSD once again did not significantly predict negative mood reactivity, *B* = -0.02, *t*(36) = - 0.11, *p* = .915.

High-HRV BF condition. Moderation was again not found in this condition, *B* = 0.16, *t*(31) = 1.79, *p* = .084. The reanalysis revealed that neither social comparison processing, *B* = 0.09, *t*(32) = 1.18, *p* = .245, nor ln RMSSD, *B* = 0.34, *t*(32) = 1.41, *p* = .169, significantly predicted negative mood reactivity.

Overall, the results of this exploratory MMR analysis indicated that only in the no-BF condition did social comparison processing significantly predict negative mood reactivity. Furthermore, in no experimental condition did resting ln RMSSD moderate the relationship between social comparison processing and negative mood reactivity.

Social comparison processing and EDEQ-WS. The final MMR analyses explored whether the relationship between social comparison processing and negative mood reactivity was dependent on EDEQ-WS. Table 6 (bottom panel) displays the series of regressions conducted using EDEQ-WS as a moderator in the prediction of negative mood reactivity from social comparison processing.

Low-HRV BF condition. EDEQ-WS did not moderate the relationship between social comparison processing and negative mood reactivity, *B* = 0.02, *t*(33) = 0.24, *p* = .815. Subsequent analysis revealed that EDEQ-WS significantly predicted negative mood reactivity, *B* = 0.37, *t*(34) = 2.11, *p* = .043, while social comparison processing did not, *B* = 0.17, *t*(34) =

1.19, $p = .241$. Therefore, higher EDEQ-WS was related to more negative mood reactivity experienced by the participants, irrespective of the amount of time engaged in social comparison processing.

Table 6.

Moderated Multiple Regression Results of the Regression Coefficients B (SE) Predicting Negative Mood Reactivity from Social Comparison Processing with ln RMSSD (top panel) and EDEQ-WS (bottom panel) as Moderators

	Condition								
	Low-HRV BF			No-BF			High-HRV BF		
Variable	*B (SE)*	*t*	*p*	*B (SE)*	*t*	*p*	*B (SE)*	*t*	*p*
Constant	1.93 (1.37)	1.41	.169	1.18 (0.67)	1.78	.084	1.53 (1.11)	1.38	.178
Covariate	-0.23 (0.26)	-0.86	.396	-0.10 (0.12)	-0.86	.396	-0.15 (0.20)	-0.72	.475
X	0.39 (0.14)	2.89	**.007****	0.28 (0.08)	3.66	**.001***	0.11 (0.08)	1.37	.182
M^a	-0.23 (0.33)	-0.71	.485	-0.01 (0.22)	-0.07	.947	0.45 (0.22)	2.09	**.045***
$X \times M^a$	0.39 (0.23)	1.73	.093	-0.05 (0.09)	-0.57	.571	0.16 (0.09)	1.79	.084
Constant	2.48 (1.26)	1.97	.058	1.44 (0.65)	2.21	**.034***	2.31 (1.09)	2.11	**.043***
Covariate	-0.33 (0.24)	-1.37	.180	-0.17 (0.12)	-1.38	.177	-0.30 (0.20)	-1.50	.145
X	0.16 (0.15)	1.11	.276	0.20 (0.06)	3.29	**.004***	0.04 (0.07)	0.57	.573
M^b	0.38 (0.18)	2.08	**.046***	-0.22 (0.18)	-1.23	**.002****	0.35 (0.24)	1.45	.158
$X \times M^b$	0.02 (0.08)	0.24	.815	0.09 (0.04)	2.01	.053	0.06 (0.09)	0.69	.494

Note. Covariate = Negative mood at baseline. X = Social comparison processing; M^a = *ln RMSSD;* M^b = *EDEQ-WS.* For top panel: low-HRV BF $R^2 = .24$ ($p = .063$); no-BF $R^2 = .45$ ($p = .004$); high-HRV BF $R^2 = .17$ ($p = .012$). For bottom panel: low-HRV BF $R^2 = .23$ ($p = .042$); no-BF $R^2 = .62$ ($p < .001$); high-HRV BF $R^2 = .17$ ($p = .117$)
* $p < .05$. ** $p < .01$. §§ $p = .001$

No-BF condition. Moderation was again not significant in this condition, $B = 0.09$, $t(35) = 2.01$, $p = .053$. Reanalysis revealed that both EDEQ-WS, $B = 0.39$, $t(36) = 2.78$, $p = .009$, and social comparison processing, $B = 0.21$, $t(36) = 3.13$, $p = .004$, predicted negative mood reactivity. Therefore, more time spent engaged in social comparison processing and higher EDEQ-WS each significantly predicted greater negative mood reactivity.

High-HRV BF condition. EDEQ-WS did not moderate the relationship between social comparison processing and negative mood reactivity in this condition, $B = 0.06$, $t(31)$ 0.69, $p = .494$. The reanalysis indicated that neither EDEQ-WS, $B = 0.39$, $t(32) = 1.90$, $p = .066$, nor social comparison processing, $B = 0.06$, $t(32) = 0.88$, $p = .384$, significantly predicted negative mood reactivity.

These results indicate that EDEQ-WS did not moderate the relationship between social comparison processing and negative mood reactivity in any of the experimental conditions. However, in the low-HRV BF condition higher EDEQ-WS predicted greater negative mood reactivity. In addition, in the no-BF condition both EDEQ-WS and social comparison processing predicted negative mood reactivity. Finally, in the high-HRV BF condition neither EDEQ-WS nor social comparison processing predicted negative mood reactivity.

Overall, the results of the above two exploratory MMR analyses revealed that social comparison processing did not predict negative mood reactivity in either of the BF conditions; however, when participants experienced the social comparison challenge without any instructions manipulating their breathing rates, social comparison processing was related to negative mood reactivity. In addition, higher EDEQ-WS predicted greater negative mood in both the low-HRV BF and no-BF conditions. However, the relationship between EDEQ-WS and negative mood was disrupted in the high-HRV BF condition.

Discussion

The primary purpose of the present study was to consider the question, “Can HRV BF mitigate the negative consequences of a social comparison challenge?” The answer proves to be more complex than first anticipated. The first response is a conservative ‘no’; that is, HRV BF did not alleviate the negative responses to thin idealized images for the average female. The second answer is a qualified ‘yes’; BF diminished negative mood reactivity, but only for females who had intrinsically low resting HRV. We will first explore possible reasons why HRV BF was not effective for the average female before examining the role that intrinsic HRV played in determining the success of the intervention.

HRV BF: Not Effective for the Average Participant

The present study was originally conceived with the assumption that HRV BF would be equally beneficial for all individuals in the high-HRV BF condition. Thus, it was assumed that if we were able to significantly increase the HRV of the participants in this condition, this would translate into physiological and psychological benefits. This assumption was grounded in the proposal of Martens et al. (2008) who theorized that increasing an individual’s vagal tone would serve to buffer stress reactivity. However, contrary to predictions, the elevated HRV during the BF phase did not lead to diminished negative psychological responses during the social comparison challenge. It also did not result in a muted physiological stress response.

There are several possible reasons` why the HRV BF induction did not help to alleviate the negative responses to the challenge. First, while the breathing induction was successful in increasing HRV during the BF phase for the high-HRV BF condition, the change in HRV was short-lived. During the subsequent social comparison phase, participants in the high-HRV BF continued to have higher HRV than those in the two other conditions, although the difference was no longer statistically significant with the application of the Bonferroni correction. These results differ from other studies that have found that the increased vagal tone achieved during HRV BF persists through to the period following the BF (Hassett et al., 2007; Karavidas et al., 2007; Lehrer et al., 2003). However, a more recent study by Prinsloo, Derman et al. (2013b) found that a single HRV BF induction resulted in a nonsignificant increase in HRV during the intervention, followed by vagal withdrawal and drop in HRV during a subsequent phase of the experiment. Participants in the present study also experienced a similar drop in HRV during the phase immediately following the BF induction. Therefore, it is possible that the changes in HRV in response to the BF induction were not prolonged enough to translate into any actual threat buffering capacity.

The second possible reason why the HRV BF did not translate into the predicted psychological buffering effect pertains to the quality of HRV BF achieved by participants during the brief 15-min session. It is possible that participants needed more training to master the breathing technique in order to maximize the effects of the BF. Most of the studies examining HRV BF have used longer BF training modules, rather than the one brief session used in the present study. Studies have implemented modules ranging from 4 (Rene, 2008) to 11 weeks (Nolan et al., 2005). Some studies had participants engage in daily BF sessions (Zucker et al., 2009), while others involved up to 12 individual sessions (Meule, Freund, Skirde, Vögele, & Kubler, 2012).

The present study was attempting to replicate the brief induction used in the Sherlin et al. (2009) study. They found both their HRV BF and control conditions resulted in decreased state anxiety in response to a cognitive stressor; however, the BF group also experienced decreased HR reactivity. The only physiological measure they reported on was HR; thus, it is impossible to say what may have occurred to any HRV measure in their study. However, Prinsloo, Rauch et al. (2013) recently examined the effects of a single session of HRV BF and found no significant increase in RMSSD during their BF phase, the same HRV metric used in the present study. Thus, it is possible that RMSSD may not be the best measure of HRV to utilize in brief BF intervention studies such as the present one.

In addition, the quality of the HRV BF session may have been compromised by the general instructions given to the participants. As previously indicated, research has found that HRV amplitude is typically maximized at 0.1 Hz which can be achieved by breathing at a rate of 6 breaths/min (Lehrer et al, 2000). However, it is important to note that this resonant frequency differs from individual to individual with findings indicating maximal HRV amplitudes ranging from rates of 4 to 7 breaths/min (Muench, 2008; Song & Lehrer, 2003). Therefore, while the current study encouraged participants to breathe somewhere in the range of 6 breaths/min, this may not have been the ideal rate for every individual. Moreover, a review of the respiration rate indicated that, on average, individuals in the high-HRV BF condition achieved a rate of 8 breaths/min. Of the participants in this condition, only 30% achieved rates between 5 and 7 breaths/min. Furthermore, 27% of the individuals in the high-HRV BF condition scored lower on the StressEraser® than the highest scoring person in the low-HRV BF condition. Recall that participants in the low-HRV BF condition had received instructions intended to minimize their efficiency in using the BF device. These results are consistent with the findings of Sherlin and colleagues (2009) who found that 30% of participants in their BF condition had trouble using the StressEraser® efficiently and achieved limited points during the intervention period. These results suggest that a portion of the participants in the high-HRV BF condition would have benefitted from further training on the proper use of the StressEraser®. To this end, future studies may want to incorporate the paced breathing techniques previously used to determine individual resonant frequencies (Lehrer et al., 2000) in order to maximize the benefits of the BF induction.

The HRV BF failed to diminish the physiological stress response participants experienced after viewing the media images. However, it is important to note that that the social comparison challenge failed to elicit a physiological stress response in the first instance. Therefore, there was no physiological stress response to mitigate. Although this was unexpected, the reality is that there has been little research into physiological responses to social comparison (Green & Ohrt, 2013), with existing findings being quite mixed (Haynos & Fruzzetti, 2011). Indeed, while the negative psychological responses are well documented, some researchers have proposed that media images are experienced as physiologically favourable stimuli. For example, Tamez (2008) found that females experienced inhibited startle reflex responses to images depicting thin models, suggestive of a positive affective reaction. Tamez proposed this was due to the participants evaluating the images as desirable and consistent with how beauty is defined in society. However, a subsequent study by Tamez (2010) found that participants experienced greater startle reflex responses when viewing images of thin models, suggesting that participants processed the images as being unpleasant. Yet another study using a clinical sample of individuals with anorexia nervosa found no difference in startle response to pictures of slim bodies when compared to controls (Friederich et al., 2006). Recently, Green and Ohrt (2013) found decreased HR in females viewing thin ideal pictures. The authors postulated that this response was indicative of an orienting reaction which would signify that the stimuli were emotionally salient.

Overall, these studies underscore how inconsistent the findings have been with respect to physiological responses to thin images. It is an area that has received very little attention in the literature and that has been studied using different physiological measures. It is likely that the variation in findings is due to the differing methodological approaches used. In addition, findings have indicated that at the group level, patterns of sympathetic activation and vagal suppression have been noted in response to standard laboratory stressors (Berntson & Cacioppo, 2004). However, Berntson and Cacioppo noted that daily life stressors have been shown to produce a wide array of autonomic responses, with some individuals displaying significant sympathetic activation, while others show mostly vagal withdrawal, and yet others a combination of both. Thus, there appears to exist an "individual response uniqueness" (p.58) in reaction to some stressors that may not be captured when examining responses across the whole sample of participants.

In summary, HRV BF did not result in diminished negative responses to viewing the thin idealized images for the average participant. This was true even though the BF induction lead to increased HRV for those in the high-HRV BF condition. At the outset of this study we hypothesized that an increase in HRV would lead to more adaptive responses to the thin images across the group as a whole. This was not the case. These results indicate that Martens and colleagues' (2008) proposed relationship between increased vagal tone and improved stress reactivity is not as clear as first thought. To explore this further, we turned our attention to the participants within the high-HRV BF condition to see whether any individual differences influenced the effectiveness of the intervention that could not be detected at the group level of statistical analysis.

HRV BF: The Role of Resting HRV

An examination of those in the high-HRV BF group indicated that not all individuals benefitted equally from the intervention. Specifically, the analysis revealed that those with lower resting HRV were the ones whose HRV increased most during the BF induction. As outlined previously, having lower resting HRV suggests that one is more susceptible to stressors and less able to appropriately regulate emotions. Sim and Zeman (2006) proposed that difficulties regulating emotions may serve to differentiate typical body image concerns from clinically significant levels. Therefore, individuals with lower resting HRV would theoretically be the most vulnerable to the social comparison challenge. However, it was precisely these individuals who experienced the least negative mood reactivity. This finding is particularly noteworthy given that this effect served to disrupt the observed association between dispositional body concerns and resultant negative mood reactivity. Comparing participants in the high-HRV BF condition with those in the no-BF condition helps illustrate the significance of this finding. Within the no-BF condition, the results were consistent with expectations based on the literature: Individuals with higher body concerns experienced the most negative mood reactivity. However, in the high-HRV BF condition, it was the individuals with elevated body concerns and low intrinsic HRV who showed reduced negative mood reactivity. These results raise a very intriguing notion; that is, the effectiveness of HRV BF is dependent on resting HRV. While the current results require replication, they suggest that HRV BF may be especially beneficial for individuals who have lower resting HRV in the first place. These findings are noteworthy given that lower tonic HRV implies a less flexible autonomic system. As previously mentioned, the dangers of psychological inflexibility and, by extension, physiological rigidity, are numerous (i.e., allostatic load). More specifically, the less adaptive an individual is, the more likelihood he or she will respond to threats inappropriately or have difficulty habituating to stressors (Juster et al., 2011). This rigidity has been linked to a variety of disorders including anorexia nervosa (Merwin et al., 2011). Thus, training individuals to increase their HRV may help to offset some of the problems associated with intrinsically reduced autonomic variation.

Recent findings by Kogan, Gruber, Shallcross, Ford, and Mauss (2013) may help to make sense of the present finding that those with lower resting HRV were the ones that benefitted from the HRV BF. Kogan et al. posited that both too little *and* too much vagal tone may be maladaptive. They proposed that individuals with moderate levels of tonic vagal tone experience the greatest well-being. The notion that there may be a point at which increased vagal tone is no longer beneficial is a new finding. The authors hypothesized that this may be due to the association between vagal tone and social engagement. Specifically, they postulated that when an individual has elevated vagal tone, it can lead to excessive social interactions which can result in negative outcomes. Therefore, moderate vagal tone allows for more appropriate behaviour. Thus, it is possible that those in the present study with lower resting HRV benefitted from the intervention because their resultant vagal tone temporarily elevated into the more adaptive range. If this were the case, one of the more important implications of the present study is that HRV BF may be a potential option in helping to reduce the negative psychological effects of social comparison for people with intrinsically low resting HRV. Future HRV BF studies should therefore specifically target such individuals for this intervention.

It is important to note that there are several reasons why this finding requires replication. First, as indicated previously, the moderated multiple regression did not conclusively meet the homogeneity of error variance assumption. Aguinis (2004) notes that while there is no need to ignore findings that do not meet this assumption, he does suggest that replication is needed before confirming that statistical moderation was present. Second, there were only 8 individuals who were below the critical HRV value identified through the Johnson-Neyman technique as previously outlined. While this does represent over 20% of the individuals who received the HRV BF, the small sample size merits replication with a larger sample. Third, current results were detected via exploratory analysis not grounded in a priori hypothesis testing. For all these reasons, the results identify a potentially significant phenomenon in need of further examination.

The Effect of Social Comparison

Before discussing findings relevant to the two remaining hypotheses, it is necessary to review the general findings regarding the effect of the social comparison challenge. Viewing the thin ideal images proved to be a psychological stressor for the participants. Consistent with meta-analytic findings (Grabe et al., 2008; Groesz et al., 2002; Hausenblas et al., 2013; Want, 2009), exposure to magazine images depicting thin models led to negative psychological reactions. More specifically, there were significant increases in negative mood and body dissatisfaction as a result of the social comparison challenge for the average participant.

However, contrary to predictions, appearance self-esteem was not significantly impacted by viewing the images. This lack of effect is not unprecedented in the literature. Martin and Kennedy (1993) found that viewing media images had no effect on how individuals judged their own attractiveness. Similarly, Jung and Lennon (2003) found that viewing attractive images of thin models did not have any effect on self-esteem. Others have found positive effects on self-esteem (e.g., Joshi, Herman, & Polivy, 2004; Mills, Polivy, Herman, & Tiggemann, 2002). Several explanations for the lack of negative response or even the enhancement of self-esteem have been proposed. One factor that has been shown to impact how females respond to thin images is whether they are restrained eaters or not. Restrained eaters are often motivated to fit the thin ideal and so may find the images inspiring (Mills et al., 2002). Others have proposed that what motivates females to compare themselves to the models dictates how they feel in response. For example, female participants can use the thin models in the advertisements as a symbol for self-improvement or enhancement, which does not lead to negative consequences (Halliwell & Dittmar, 2005). Future studies may want to explore participants' motivations for engaging in actual social comparison processes.

While viewing media images depicting thin models had a negative psychological impact, it did not elicit a physiological response. The lack of physiological reactivity to the social comparison challenge is most evident in the HRV experienced by participants in the no-BF condition. To review, participants in the no-BF condition viewed the advertisements under the most natural of circumstances, as they were not given any instructions to alter their breathing rates. As can be seen in Figure 7, which depicts HRV for each condition across the phases of the experiment, participants in the no-BF condition had relatively stable HRV throughout. Uusitalo et al. (2011) found that the particular HRV measure used in the present study, RMSSD, decreased when faced with an acute stressor. In contrast, the present findings did not reveal such a drop in RMSSD as a result of the social comparison phase, thereby indicating no stress response as indexed by this chosen metric of HRV.

The fact that participants did not experience a physiological response and yet demonstrated psychological reactions is not completely surprising. Previous research has found that females tend to report experiencing more negative emotions to stressful stimuli than men; however, their physiological responses do not necessarily parallel these psychological reactions (Kelly, Forsyth, & Karekla, 2006; Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004). The demonstrated psychological response is consistent with the automatic evaluation proposed to occur during a social comparison scenario (Stapel & Blanton, 2004; Watts, Cranney, & Gleitzman, 2008). In other words, some individuals may have overlearned through repeated exposure and reinforcement what is desirable and what is undesirable such that they experience immediate emotional responses to particular stimuli, especially if they find themselves lacking on the particular dimension used as a basis for comparison (Watts et al., 2008; Want, 2009). Exposure to thin ideal models is such a common and everyday experience that females may experience these emotions in a “well-rehearsed” manner (Watts et al., 2008, p.362), even if they place minimal attention to the actual images. This notion of the images being routine may have also contributed to the lack of physiological reactions, as the advertisements could have been judged to be unremarkable by the participants. Tiggemann, Verri, and Scaravaggi (2005) have previously suggested habituation as a possible reason why some individuals have reduced reactions to media images.

The Effects of Dispositional Body Concerns and Social Comparison Processing

In addition to exploring the effects of HRV BF, the present study investigated the impact of dispositional body concerns and social comparison processing on participants’ reactions to the media images. Two predictions were made. First, it was hypothesized that individuals with greater body concerns would experience more negative reactions to the images, regardless of BF condition. Second, it was predicted that the more individuals reported engaging in direct comparisons to the models on appearance factors, the worse they would feel following exposure to the images.

With regard to the issue of dispositional body concerns, the results were consistent with predictions as individuals with higher dispositional body concerns experienced a greater increase in negative mood as a result of the social comparison when compared to those with lower degrees of body concerns. These results serve to build on previous findings showing that preexisting body concerns moderate the effect of social comparison (e.g., Want, 2009). Furthermore, the results of the exploratory analyses revealed an interesting finding with regard to the role of dispositional body concerns in predicting negative reactions. The MMR analyses showed that dispositional body concerns did not significantly predict negative mood reactivity in the high-HRV BF condition. Therefore, increasing participants' HRV by having them take slow, smooth breaths disrupted the association between dispositional body concerns and negative mood reactivity.

One possible reason for this finding is that the use of the StressEraser® may have resulted in benefits that were not captured by the measures used in the present study. As previously outlined, the StressEraser® is designed to assist with relaxation training and stress management and has been found to be effective with a variety of problems. Prinsloo, Derman, and colleagues (2013a) found that a single use of the StressEraser® caused increased positive feelings in their participants. The authors hypothesized that these changes were due to activation of structures within the central autonomic network. In addition, Prinsloo, Rauch et al. (2013) found that individuals in their BF group displayed changes in electroencephalogram suggestive of states of increased attention and relaxation. These findings were noted after a single BF session and despite the intervention failing to cause any significant changes in HRV. In the present study, HRV was higher in the high-HRV BF group during the intervention phase. While the elevation in HRV was no longer statistically significant during the social comparison phase, the change in HRV may have been sufficient to cause similar results as those of the Prinsloo studies (Prinsloo, Derman, et al., 2013a; Prinsloo, Rauch, et al., 2013). Therefore, these findings suggest that participants in the high-HRV BF condition may have experienced physiological changes that helped to disrupt this association between preexisting body concerns and negative mood reactivity. Future studies may need to expand the measures used in order to capture the full benefits of this intervention.

With respect to the second hypothesis, the current findings are in line with those of Tiggemann and Polivy (2010), who found that the pervasiveness of social comparison processing predicted higher body dissatisfaction and lower mood. Specifically, the more time participants spent comparing themselves to the models on appearance factors, the worse off they felt. Overall, these findings support the notion that the way women process media images has direct consequences for their well-being. Unexpectedly, another interesting finding of the exploratory analyses was that social comparison processing did not predict negative mood reactivity in the two BF conditions. In his meta-analysis, Want (2009) speculated that females make spontaneous appearance-based social comparisons when viewing media images and, as a result, experience adverse effects. However, in order to protect their self-image, Want proposes that females "who are otherwise not cognitively occupied" (p.266), engage in active defensive responses in order to minimize the adverse effects. Consequently, Want proposes that having participants engaged, or distracted, should prevent these defensive responses that help to mitigate the negative consequences of the social comparison challenge. Conversely, our results are not consistent with this notion. Only in the condition that was not cognitively occupied prior to viewing the media images did engagement in social comparison processing predict negative mood. On the other hand, the two BF conditions that had been given particular instructions did not evidence an association between social comparison processing and subsequent negative mood reactivity. It is important to note that the instructional sets were given prior to the social comparison challenge, although it is plausible that individuals in the two BF conditions were more engaged cognitively during the subsequent phase when compared to those in the no-BF condition. Thus, contrary to Want's assertion, the results suggest that those who were cognitively engaged experienced diminished effects of social comparison processing.

This raises the possibility that simply having individuals focus on their breathing, regardless of the specific instructions, can help to interrupt the adverse effects of exposure to idealized media images. Sherlin and colleagues (2009) found that the two types of biofeedback exercises in their study both diminished reactivity to a stressor. One group in the study practiced HRV BF, while the other performed a passive biofeedback exercise. In the passive condition individuals were instructed to watch the wave on a handheld device and "let go" of troublesome thoughts. The authors speculated that the lack of significant differences between their conditions was due to a type of "concentrative relaxation". Therefore, it is possible that having participants engage in some form of mental activity requiring focused concentration may have served a beneficial purpose when compared to those who were not engaged in any activity. Previous findings have noted that providing an opportunity to focus one's attention has been found to be one of the most common ways of relaxing (Van Dixhoorn, 2007). Thus, engaging individuals prior to viewing the images may have served to interrupt the effect of social comparison processing on negative mood reactivity.

Implications for Future Research

The present study has several implications for future research. Chief among these concerns the use of HRV BF and the need to consider resting HRV prior to the implementation of the intervention. The current results suggest that a blanket application of this intervention would not maximize the positive effects of this approach. Rather, individual differences in intrinsic HRV should be taken into account. As noted, HRV BF is designed to increase variability, therefore it would make sense that those who are low in variability would be the ones to benefit. This suggests a potential application for this intervention, especially given that some have proposed that low HRV is a marker for psychopathology (Thayer & Lane, 2000, 2009). Melzig, Weike, Hamm, and Thayer (2009) argued that individual differences in resting HRV should be considered when designing a study; however, they made this suggestion regarding investigations into startle reflex responses. To our knowledge, other HRV BF studies have not taken resting HRV into consideration prior to implementing the BF.

It is possible that taking resting HRV into account may be more pressing when examining the acute effects of HRV BF. While this has not been examined, it is plausible that a single use of the StressEraser® has immediate effects on those whose HRV is lower as they are the ones who stand to benefit in the short-term. Perhaps more prolonged exposure would be needed to see the same change in those with higher HRV. It should be noted that while the studies that have looked at a single use of the StressEraser® have found benefits, the gains have not been exceedingly better than comparison groups (e.g., Prinsloo, Derman, et al., 2013; Sherlin et al., 2009). It is quite possible that not taking resting HRV into account limited the effectiveness of the interventions in those studies as well.

Another notable finding of the present study is the evidence showing that HRV can be manipulated. The present study attempted to manipulate participants' HRV through the use of specific BF instructional sets. We were unable to decrease individuals' HRV levels via instructions to take short, shallow breaths. This is useful to note, as the higher respiration rate did not result in lowered HRV, which differs from the findings of Song and Lehrer (2003). It is likely that the reason it did not lead to lowered HRV was the fact that even though the respiration rate in the low-HRV BF group was higher, they were no more inefficient in using the

StressEraser® than those in the no-BF condition. On the other hand, the high-HRV BF instructional set was effective in increasing vagal tone during the BF phase, as participants in this condition had higher HRV when compared to participants in the other two conditions. This indicates that having participants engage in slow, deliberate breathing successfully manipulated participants' HRV as intended. Another main contribution of the present study is the exploration into the effects of media images on HRV. We had hypothesized that viewing the thin images would lead to a distinguishable physiological stress reaction. While the current results failed to show an HRV response, there are other metrics that should be examined in future studies. To our knowledge, this is the first study to look at HRV responses to thin images.

The findings also served to bolster the existing literature on the effects of social comparison to thin images. It should be noted that while the majority of studies point to the detrimental impact of media images on how females view themselves, there are some who contend that this effect is negligible or only influences those with preexisting body image concerns (e.g., Ferguson, 2013). However, the present study found a large effect size with regard to the resultant negative mood experienced by participants with dispositional body concerns. In addition, body dissatisfaction increased across the sample as a result of the social comparison challenge. In other words, these findings show that the negative impact of the thin images was not isolated to only those with preexisting body concerns, nor was it negligible. Furthermore, the images were taken from relatively common fashion magazines that are available at most retail locations. Consequently, it is possible that some females are viewing similar images on a regular basis. While the current study explicitly instructed the participants to compare themselves to the models, previous findings have noted that such comparisons can occur automatically (e.g., Want, 2009). If viewing these images results in similar negative responses outside of the laboratory this can lead to serious consequences. As previously mentioned, elevated negative mood has been linked to problematic eating behaviours (e.g., Pike et al., 2008; Smyth et al., 2007). Therefore, these results suggest a continued need to target the discontent the average female experiences about her body. This is especially true of those whose degree of discontent is more serious. Also, media sources should continue to be cognizant of how their presentation of the ideal female form can negatively impact some of their consumers.

The results of the current study also help to provide some information on a particular question within the social comparison literature. Specifically, there has been some debate as to what type of instructions cause participants to engage in social comparison processing when viewing idealized media images. While some studies have found support for the notion that explicit instructions to compare themselves to the models is more effective (Cattarin et al., 2000; Tiggemann & McGill, 2004; Tiggemann et al., 2009), others have proposed that social comparison occurs in a more automatic, non-deliberate manner (Want, 2009). Want found a counter-intuitive pattern such that effect sizes were larger when participants focused on nonappearance features (i.e. originality) of the idealized images. However, the current results found that explicit instructions to compare oneself to the models based on appearance factors results in a large effect size, particularly for participants with high dispositional body concerns. While the present study did not compare the effects of different instructional sets on subsequent social comparison processing, participants were asked to quantify how well they followed the instructions. The results indicated that the amount of time spent focusing on appearance factors was related to greater negative mood and body dissatisfaction and lower appearance self-esteem. These results lend support to the notion that explicit instructions to compare oneself to idealized images are effective in eliciting a social comparison response.

Limitations

The present study has limitations that affect the interpretations of the findings. First, the premise going into the study was that the social comparison challenge would produce a stress related physiological response. Therefore, by having participants engage in a behaviour that promoted greater autonomic balance, the belief was that stress reactivity would be diminished. However, since the exposure to the media images failed to produce a physiological stress reaction, there was no physiological reactivity to reduce. While this finding was unexpected, it is notable that, to our knowledge, this was the first study that examined HRV reactivity to a social comparison challenge. Future studies may want to incorporate other physiological measures in order to see whether any reactions can be detected.

As previously mentioned, the present study did not ensure that participants actually mastered the HRV BF techniques or breathe at their individual resonant frequency. Therefore, the effects of the HRV BF may not have been optimized under the current design. We were interested in examining whether a brief training and intervention period would be beneficial. The potential benefit of keeping the training and intervention brief is increased motivation and adherence by participants (Sherlin et al., 2009). However, other studies have found that more prolonged HRV BF modules have resulted in long-term HRV changes (Kennedy & Pretorius, 2008; Reiner, 2008; Zucker et al., 2009). It is possible that a more individualized training format that maximizes efficiency may be better suited for situations where body image and body satisfaction are concerned. This may be especially important given the ingrained and automatic reaction many individuals experience with these types of stimuli.

Finally, the timing of the measures may have cued some participant responses. For example, participants were asked to report how much time they spent comparing themselves to the models after reporting negative mood and body dissatisfaction. Therefore, it is possible that participants who experienced increases on these dimensions may have felt they had spent more time comparing themselves to the models, or they could have reported higher scores as a way to explain how they were feeling. In future, it may be better to have participants report how much they engaged in social comparison processing prior to assessing their psychological responses.

Conclusion

Our results showed that not all individuals benefitted from HRV BF. Rather, individual differences in intrinsic HRV moderated the overall effectiveness of the intervention. Specifically, HRV BF was beneficial in mitigating negative mood reactivity for individuals with low resting HRV. This finding has significant implications for future HRV BF studies, as it will be important to take resting HRV into account before implementing the intervention. Consistent with the existing literature, the social comparison challenge proved to be a psychological stressor, particularly for those with higher dispositional body concerns. However, the present results indicate that exposure to advertisements depicting thin ideal models was not experienced as a physiological stressor as indexed by HRV. In addition, the results suggest that engaging in HRV BF may serve to disrupt the documented link between higher dispositional body concerns and greater negative responses to a social comparison challenge. Moreover, the results bolster the existing literature indicating that engaging in active social comparison processing is related to greater negative responses after viewing thin ideal images. However, this effect may be disrupted by having participants engage in breathing exercises. Future studies may want to investigate whether this impact is due specifically to breathing patterns or whether any activity that engages participants' attention has similar effects.

References

Abell, T.L., Malagelada, J.R., Lucas, A.R., Brown, M.L., Cammaleri, M., Go, V.L.W., ...Huse, D.M. (1987). Gastric electromechanical and neurohormonal function in anorexia nervosa. *Gastroenterology, 93,* 958–65.

Acharya, U. R., Joseph, K. P., Kannathal, N., Lim, C. M., & Suri, J. S. (2006). Heart rate variability: A review. *Medical and Biological Engineering and Computing*, *44*(12), 1031-1051.

Ackard, D. M., Kearney-Cooke, A., & Peterson, C. B. (2000). Effect of body image and self-image on women's sexual behaviors. *International Journal of Eating Disorders*, *28*(4), 422-429.

Adam, T. C., & Epel, E. S. (2007). Stress, eating and the reward system. *Physiology & Behavior*, *91*(4), 449-458.

Aguinis, H. (2004). *Regression analysis for categorical moderators.* New York: The Guilford Press.

Aguinis, H., Petersen, S. A., & Pierce, C. A. (1999). Appraisal of the homogeneity of error variance assumption and alternatives to multiple regression for estimating moderating effects of categorical variables. *Organizational Research Methods*, *2*(4), 315-339.

Aguinis, H., & Pierce, C. A. (1998). Testing moderator variable hypotheses meta-analytically. *Journal of Management*, *24*(5), 577-592.

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review*, *30*(2), 217-237.

Allen, J.J.B., Chambers, A.S., & Towers, D.N. (2007). The many metrics of cardiac chronotropy: A pragmatic primer and a brief comparison of metrics. *Biological Psychology, 74*, 243-262.

doi:10.1016/j.biopsycho.2006.08.005

Allen, J.J.B., Chambers, A.S., & Towers, D.N. (2011). A pragmatic manual for getting started with QRStool: Reducing EKG data and obtaining many metrics with CMetX. Retrieved from: http://jallen.faculty.arizona.edu/resources_and_downloads

Annus, A. M., Smith, G. T., Fischer, S., Hendricks, M., & Williams, S. F. (2007). Associations among family-of-origin food-related experiences, expectancies, and disordered eating. *International Journal of Eating Disorders*,*40*(2), 179-186.

Anschutz, D. J., Spruijt-Metz, D., Van Strien, T., & Engels, R. C. (2011). The direct effect of thin ideal focused adult television on young girls' ideal body figure. *Body Image, 8*(1), 26-33.

Anton, S. D., Perri, M. G., & Riley, J. R. (2000). Discrepancy between actual and ideal body images: Impact on eating and exercise behaviors. *Eating Behaviors*, *1*(2), 153-160.

Appelhans, B. M., & Luecken, L. J. (2006). Heart rate variability as an index of regulated emotional responding. *Review of General Psychology, 10*(3), 229-240. doi:10.1037/1089-2680.10.3.229

Bailer UF, Kaye WH (2003). A review of neuropeptide and neuroendocrine dysregulation in anorexia and bulimia nervosa. *Current Drug Targets - CNS & Neurological Disorders*, 2: 53–59. Retrieved from http://eatingdisorders.ucsd.edu/research/imaging/PDFs/2003/bailer2003 review.pdf

Ball, K., & Lee, C. (2000). Relationships between psychological stress, coping and disordered eating: A review. *Psychology & Health*, *14*(6), 1007-1035.

Bauer, K. W., Bucchianeri, M. M., & Neumark-Sztainer, D. (2013). Mother-reported parental weight talk and adolescent girls' emotional health, weight control attempts, and disordered eating behaviors. *Journal of Eating Disorders*, 1:45.

Baumeister, R. F., & Heatherton, T. F. (1996). Self-regulation failure: An overview. *Psychological Inquiry*, *7*(1), 1-15.

Beauchaine, T. P. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology, 13*(2), 183-214. doi:10.1017/S0954579401002012

Benas, J. S., Uhrlass, D. J., & Gibb, B. E. (2010). Body dissatisfaction and weight-related teasing: A model of cognitive vulnerability to depression among women. *Journal of Behavior Therapy and Experimental Psychiatry*, *41*(4), 352-356. doi:10.1016/j.jbtep.2010.03.006

Berg, K. C., Frazier, P., & Sherr, L. (2009). Change in eating disorder attitudes and behavior in college women: Prevalence and predictors. *Eating Behaviors*,*10*(3), 137-142.

Berking, M., & Wupperman, P. (2012). Emotion regulation and mental health: recent findings, current challenges, and future directions. *Current Opinion in Psychiatry*, *25*(2), 128-134.

Berntson, G.G., Bigger Jr., J.T., Eckberg, D.L., Grossman, P., Kaufmann, P.G., Malik, M.,…Van Der Molan, M.W. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology* 34 (6), 623–648.

Berntson, G. G., & Cacioppo, J. T. (2004). Heart rate variability: Stress and psychiatric conditions. In M. Malik & A. J. Camm (Eds.), *Dynamic electrocardiography* (pp. 57– 64). New York, NY: Blackwell/Futura. doi:10.1002/9780470987483.ch7

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology, 30*(2), 183-196. doi:10.1111/j.1469-8986.1993.tb01731.x

Berntson, G. G., Lozano, D. L., & Chen, Y. J. (2005). Filter properties of root mean square successive difference (RMSSD) for heart rate. *Psychophysiology*, *42*(2), 246-252.

Bessenoff, G. R. (2006). Can the media affect us? Social comparison, self-discrepancy, and the thin ideal. *Psychology of Women Quarterly*, *30*(3), 239-251.

Bizik, G., Picard, M., Nijjar, R., Tourjman, V., McEwen, B. S., Lupien, S. J., & Juster, R. P. (2013). Allostatic load as a tool for monitoring physiological dysregulations and comorbidities in patients with severe mental illnesses. *Harvard Review of Psychiatry*, *21*(6), 296-313.

Bohon, C., & Stice, E. (2012). Negative affect and neural response to palatable food intake in bulimia nervosa. *Appetite*, *58*(3), 964-970.

Borkovec, T. D., Ray, W. J., & Stöber, J. (1998). Worry: A cognitive phenomenon intimately linked to affective, physiological, and interpersonal behavioral processes. *Cognitive Therapy and Research, 22(*6), 561-576. doi: 10.1023/A:1018790003416

Botta, R. A. (2003). For your health? The relationship between magazine reading and adolescents' body image and eating disturbances. *Sex Roles, 48*(9-10), 389-399. doi:10.1023/A:1023570326812

Brown, A., & Dittmar, H. (2005). Think “thin” and feel bad: The role of appearance schema activation, attention level, and thin–ideal internalization for young women’s responses to ultra–thin media ideals. *Journal of Social and Clinical Psychology*, *24*(8), 1088-1113.

Bydlowski, S., Corcos, M., Jeammet, P., Paterniti, S., Berthoz, S., Laurier, C., ... & Consoli, S. M. (2005). Emotion-processing deficits in eating disorders. *International Journal of Eating Disorders*, *37*(4), 321-329.

Cahill, S., & Mussap, A. J. (2007). Emotional reactions following exposure to idealized bodies predict unhealthy body change attitudes and behaviors in women and men. *Journal of Psychosomatic Research*, *62*(6), 631-639.

Carrasco, MJ Gaitán, R. González, O. Yánez, S. (2001). Correlation among Poincare plot indexes and time and frequency domain measures of heart rate variability. *Journal of Medical Engineering & Technology*, *25*(6), 240-248.

Cash, T. F. (2004). Body image: Past, present, and future. *Body Image*, *1*(1), 1-5.

Cash, T. F., & Brown, T. A. (1987). Body image in anorexia nervosa and bulimia nervosa: A review of the literature. *Behavior Modification, 11*, 487–521.

Cash, T. F., Morrow, J. A., Hrabosky, J. I., & Perry, A. A. (2004). How has body image changed? A cross-sectional investigation of college women and men from 1983 to 2001. *Journal of Consulting and Clinical Psychology, 72*(6), 1081-1089. doi:10.1037/0022-006X.72.6.1081

Cash, T. F., & Pruzinsky, T. (2002). *Body image: A handbook of theory, research, and clinical practice.* New York: Guilford Press.

Cattanach, L., Malley, R., & Rodin, J. (1988). Psychologic and physiologic reactivity to stressors in eating disordered individuals. *Psychosomatic Medicine, 50*(6), 591-599.

Cattarin, J. A., Thompson, J. K., Thomas, C., & Williams, R. (2000). Body image, mood, and televised images of attractiveness: The role of social comparison. *Journal of Social and Clinical Psychology*, *19*(2), 220-239.

Chambers, A. S., & Allen, J. J. (2002). Vagal tone as an indicator of treatment response in major depression. *Psychophysiology*, *39*(6), 861-864.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cohen, H., Benjamin, J., Geva, A. B., Matar, M. A., Kaplan, Z., & Kotler, M. (2000). Autonomic dysregulation in panic disorder and in post-traumatic stress disorder: application of power spectrum analysis of heart rate variability at rest and in response to recollection of trauma or panic attacks. *Psychiatry Research*, *96*(1), 1-13.

Cohen, H., Kotler, M., Matar, M. A., Kaplan, Z., Miodownik, H., & Cassuto, Y. (1997). Power spectral analysis of heart rate variability in posttraumatic stress disorder patients. *Biological Psychiatry*, *41*(5), 627-629.

Cooper, M. J., Wells, A., & Todd, G. (2004). A cognitive model of bulimia nervosa. *British Journal of Clinical Psychology*, *43*(1), 1-16.

Corning, A. F. (2002). Self-esteem as a moderator between perceived discrimination and psychological distress among women. *Journal of Counseling Psychology*, *49*(1), 117-126. doi:10.1037/0022-0167.49.1.117

Corstorphine, E. (2006). Cognitive–emotional–behavioural therapy for the eating disorders: Working with beliefs about emotions. *European Eating Disorders Review*, *14*(6), 448-461.

Corstorphine, E., Mountford, V., Tomlinson, S., Waller, G., & Meyer, C. (2007). Distress tolerance in the eating disorders. *Eating Behaviors*, *8*(1), 91-97.

Dakanalis, A., & Riva, G. (2013). Current considerations for eating and body-related disorders among men. In L. B. Sams, & J. A. Keels (Eds.), *Handbook on body image: Gender differences, sociocultural influences and health implications* (pp. 195–216). New York: Nova Science Publishers.

Dalal, D. K., & Zickar, M. J. (2012). Some common myths about centering predictor variables in moderated multiple regression and polynomial regression. *Organizational Research Methods*, *15*(3), 339-362.

Dallman, M., Pecoraro, N., Akana, S., la Fleur, S., Gomez, F., Houshyar, H.,...Manalo, S. (2003). Chronic stress and obesity: A new view of "comfort food". *Proceedings of the National Academy of Sciences*, *100*(20), 11696-11701.

Davis, R., & Jamieson, J. (2005). Assessing the functional nature of binge eating in the eating disorders. *Eating Behaviors, 6*(4), 345-354. doi:10.1016/j.eatbeh.2005.02.001

Del Pozo, J.,M. (2002). *Biofeedback treatment increases heart rate variability in patients with known coronary artery disease.* (Order No. 3045863, Alliant International University, San Diego). *ProQuest Dissertations and Theses,* , 88-88 p. Retrieved from http://ezproxy.lakeheadu.ca/login?url=http://search.proquest.com/docview/305453260?accountid=11956. (305453260).

DeLongis, A., Folkman, S., & Lazarus, R. S. (1988). The impact of daily stress on health and mood: Psychological and social resources as mediators. *Journal of Personality and Social Psychology, 54*(3), 486-495.

Demaree, H. A., Robinson, D. L., Everhart, D. E., & Schmeichel, B. J. (2004). Resting RSA is associated with natural and self-regulated responses to negative emotional stimuli. *Brain and Cognition, 56*, 14–23.

Denson, T. F., Grisham, J. R., & Moulds, M. L. (2011). Cognitive reappraisal increases heart rate variability in response to an anger provocation. *Motivation and Emotion*, *35*(1), 14-22.

Eisenberg, D., Nicklett, E. J., Roeder, K., & Kirz, N. E. (2011). Eating disorder symptoms among college students: Prevalence, persistence, correlates, and treatment-seeking. *Journal of American College Health*, *59*(8), 700-707.

El-Sheikh, M., & Erath, S. A. (2011). Family conflict, autonomic nervous system functioning, and child adaptation: State of the science and future directions. *Development and*

Psychopathology, *23*(02), 703-721.

El-Sheikh, M., Kouros, C. D., Erath, S., Cummings, E. M., Keller, P., & Staton, L. (2009). Marital conflict and children's externalizing behavior: Pathways involving interactions between parasympathetic and sympathetic nervous system activity. *Monographs of the Society for Research in Child Development*,*74*(1), vii.

Eldredge, K. L., & Agras, W. S. (1996). Weight and shape overconcern and emotional eating in binge eating disorder. *International Journal of Eating Disorders, 19*(1), 73-82. doi:10.1002/(SICI)1098-108X(199601)19:1<73::AID-EAT9>3.0.CO;2-T

Elliot, A. J., Payen, V., Brisswalter, J., Cury, F., & Thayer, J. F. (2011). A subtle threat cue, heart rate variability, and cognitive performance. *Psychophysiology*, *48*(10), 1340-1345.

Epel, E., Lapidus, R., McEwen, B., & Brownell, K. (2001). Stress may add bite to appetite in women: A laboratory study of stress-induced cortisol and eating behavior. *Psychoneuroendocrinology*, *26*(1), 37-49.

Evers, C., Stok, F. M., & de Ridder, D. T. (2010). Feeding your feelings: Emotion regulation strategies and emotional eating. *Personality and Social Psychology Bulletin*, *36*, 792-804.

Fairburn, C. G., & Bèglin, S. J. (1994). Assessment of eating disorders: Interview or self-report questionnaire? *International Journal of Eating Disorders, 16*(4), 363-370.

Fairburn, C. G., Cooper, Z., & Shafran, R. (2003). Cognitive behaviour therapy for eating disorders: A "transdiagnostic" theory and treatment. *Behaviour Research and Therapy, 41*(5), 509-528. doi:10.1016/S0005-7967(02)00088-8

Favaro, A., & Santonastaso, P. (1997). Suicidality in eating disorders: Clinical and psychological correlates. *Acta Psychiatrica Scandinavica, 95*(6), 508-514. doi:10.1111/j.1600-0447.1997.tb10139.x

Feingold, A., & Mazzella, R. (1998). Gender differences in body image are increasing. *Psychological Science, 9*(3), 190-195. doi:10.1111/1467-9280.00036

Ferguson, C. J. (2013). In the eye of the beholder: Thin-ideal media affects some, but not most, viewers in a meta-analytic review of body dissatisfaction in women and men. *Psychology of Popular Media Culture*, *2*(1), 20-37. doi: 10.1037/a0030766

Festinger, L. (1954). A theory of social comparison processes. *Human Relations, 7*, 117-140. doi:10.1177/001872675400700202

Field, A. (2013*). Discovering statistics using SPSS* (4th ed.). London: Sage Publications Ltd.

Flegal, K. M., Carroll, M. D., Kit, B. K., & Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *Journal of the Americam Medical Association, 307*(5), 491-497.

Fouts, G., & Burggraf, K. (1999). Television situation comedies: Female body images and verbal reinforcements. *Sex Roles*, *40*(5-6), 473-481.

Fouts, G., & Burggraf, K. (2000). Television situation comedies: Female weight, male negative comments, and audience reactions. *Sex Roles*, *42*(9-10), 925-932.

Fox, J. R., & Harrison, A. (2008). The relation of anger to disgust: The potential role of coupled emotions within eating pathology. *Clinical Psychology & Psychotherapy*, *15*(2), 86-95.

Fox, J. R., & Power, M. J. (2009). Eating disorders and multi-level models of emotion: An integrated model. *Clinical Psychology & Psychotherapy*, *16*(4), 240-267.

Friederich, H. C., Brooks, S., Uher, R., Campbell, I. C., Giampietro, V., Brammer, M., ... & Treasure, J. (2010). Neural correlates of body dissatisfaction in anorexia nervosa. *Neuropsychologia*, *48*(10), 2878-2885.

Friederich, H. C., Kumari, V., Uher, R., Riga, M., Schmidt, U., Campbell, I. C., ... & Treasure, J.

(2006). Differential motivational responses to food and pleasurable cues in anorexia and bulimia nervosa: A startle reflex paradigm. *Psychological Medicine*, *36*(09), 1327-1335.

Friedman, B. H. (2007). An autonomic flexibility–neurovisceral integration model of anxiety and cardiac vagal tone. *Biological Psychology*, *74*(2), 185-199.

Gaebler, M., Daniels, J. K., Lamke, J. P., Fydrich, T., & Walter, H. (2013). Heart rate variability and its neural correlates during emotional face processing in social anxiety disorder. *Biological Psychology*, *94*(2), 319-330.

Gilboa-Schechtman, E., Avnon, L., Zubery, E., & Jeczmien, P. (2006). Emotional processing in eating disorders: Specific impairment or general distress related deficiency? *Depression and Anxiety*, *23*(6), 331-339.

Ginty, A. T., Phillips, A. C., Higgs, S., Heaney, J. L., & Carroll, D. (2012). Disordered eating behaviour is associated with blunted cortisol and cardiovascular reactions to acute psychological stress. *Psychoneuroendocrinology*, *37*(5), 715-724.

Gluck, M. E. (2006). Stress response and binge eating disorder. *Appetite, 46*(1), 26-30. doi:10.1016/j.appet.2005.05.004

Gluck, M. E., Geliebter, A., Hung, J., & Yahav, E. (2004). Cortisol, hunger, and desire to binge eat following a cold stress test in obese women with binge eating disorder. *Psychosomatic Medicine*, *66*(6), 876-881.

Gluck, M. E., Geliebter, A., & Lorence, M. (2004). Cortisol stress response is positively correlated with central obesity in obese women with binge eating disorder (BED) before and after cognitive-behavioral treatment. *Annals of the New York Academy of Sciences*, *1032*(1), 202-207.

Grabe, S., Ward, L. M., & Hyde, J. S. (2008). The role of the media in body image concerns among women: A meta-analysis of experimental and correlational studies. *Psychological Bulletin, 134*(3), 460-476. doi:10.1037/0033-2909.134.3.460

Green, M. A., & Ohrt, T. K. (2013). Psychophysiological reactions to objectified weight-classified stimuli. *Psychology of Popular Media Culture*, *2*(1), 61-71.

Greenberg, J., Solomon, S., Pyszczynski, T., Rosenblatt, A., Burling, J., Lyon, D., ... Pinel, E. (1992). Why do people need self-esteem? Converging evidence that self-esteem serves an anxiety-buffering function. *Journal of Personality and Social Psychology, 63*(6), 913-922. doi:10.1037/0022-3514.63.6.913

Grippo, A. J., & Johnson, A. K. (2002). Biological mechanisms in the relationship between depression and heart disease. *Neuroscience & Biobehavioral Reviews*, *26*(8), 941-962.

Groesz, L. M., Levine, M. P., & Murnen, S. K. (2002). The effect of experimental presentation of thin media images on body satisfaction: A meta-analytic review. *International Journal of Eating Disorders, 31*(1), 1-16. doi:10.1002/eat.10005

Groesz, L. M., McCoy, S., Carl, J., Saslow, L., Stewart, J., Adler, N., ... & Epel, E. (2012). What is eating you? Stress and the drive to eat. *Appetite*, *58*(2), 717-721.

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology, 2*(3), 271-299. doi:10.1037/1089-2680.2.3.271

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology*, *39*(3), 281-291. doi: 10.1017/S0048577201393198

Gross, J. J., & Munoz, R. F. (1995). Emotion regulation and mental health. *Clinical Psychology: Science and Practice*, *2*(2), 151-164. doi: 10.1111/j.1468-2850.1995.tb00036.x

Guzik, P., Piskorski, J., Krauze, T., Schneider, R., Wesseling, K. H., Wykretowicz, A., & Wysocki, H. (2007). Correlations between the Poincaré plot and conventional heart rate variability parameters assessed during paced breathing. *The Journal of Physiological Sciences*, *57*(1), 63-71.

Hagan, M. M., Wauford, P. K., Chandler, P. C., Jarrett, L. A., Rybak, R. J., & Blackburn, K. (2002). A new animal model of binge eating: Key synergistic role of past caloric restriction and stress. *Physiology & Behavior*, *77*(1), 45-54.

Halliwell, E., & Dittmar, H. (2004). Does size matter? The impact of model's body size on women's body-focused anxiety and advertising effectiveness. *Journal of Social and Clinical Psychology*, *23*(1), 104-122.

Halliwell, E., & Dittmar, H. (2005). The role of self-improvement and self-evaluation motives in social comparisons with idealised female bodies in the media. *Body Image*, *2*(3), 249-261.

Halliwell, E., & Dittmar, H. (2006). Associations between appearance-related self-discrepancies and young women's and men's affect, body satisfaction, and emotional eating: A comparison of fixed-item and participant-generated self-discrepancies. *Personality and Social Psychology Bulletin, 32*(4), 447-458. doi:10.1177/0146167205284005

Halmi, K. A. (2009). Perplexities and provocations of eating disorders. *Journal of Child Psychology and Psychiatry*, *50*(1-2), 163-169.

Hansen, A. L., Johnsen, B. H., & Thayer, J. F. (2003). Vagal influence on working memory and attention. *International Journal of Psychophysiology*,*48*(3), 263-274.

Harper, B., & Tiggemann, M. (2008). The effect of thin ideal media images on women's self-objectification, mood, and body image. *Sex Roles, 58*(9-10), 649-657. doi:10.1007/s11199-007-9379-x

Harrison, K., & Cantor, J. (1997). The relationship between media consumption and eating disorders. *Journal of Communication, 47*(1), 40-67. doi:10.1111/j.1460-

2466.1997.tb02692.x

Harrison, A., Sullivan, S., Tchanturia, K., & Treasure, J. (2009). Emotion recognition and regulation in anorexia nervosa. *Clinical Psychology & Psychotherapy*, *16*(4), 348-356.

Harrison, A., Sullivan, S., Tchanturia, K., & Treasure, J. (2010). Emotional functioning in eating disorders: Attentional bias, emotion recognition and emotion regulation. *Psychological Medicine*, *40*(11), 1887-1897.

Hassett, A. L., Radvanski, D. C., Vaschillo, E. G., Vaschillo, B., Sigal, L. H., Karavidas, M. K., ... Lehrer, P. M. (2007). A pilot study of the efficacy of heart rate variability (HRV) biofeedback in patients with fibromyalgia. *Applied Psychophysiology and Biofeedback, 32*(1), 1-10. doi:10.1007/s10484-006-9028-0

Hausenblas, H. A., Campbell, A., Menzel, J. E., Doughty, J., Levine, M., & Thompson, J. K. (2013). Media effects of experimental presentation of the ideal physique on eating disorder symptoms: A meta-analysis of laboratory studies. *Clinical Psychology Review*, *33*(1), 168-181.

Hawkins, N., Richards, P. S., Granley, H. M., & Stein, D. M. (2004). The impact of exposure to the thin-ideal media image on women. *Eating Disorders: The Journal of Treatment & Prevention, 12*(1), 35-50. doi:10.1080/10640260490267751

Hay, P., & Williams, S. E. (2013). Exploring relationships over time between psychological distress, perceived stress, life events and immature defense style on disordered eating pathology. *BMC Psychology*, *1*(1), 27. doi:10.1186/2050-7283-1-27

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: Guilford Press.

Hayes, A. F., & Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behavior Research Methods*, *41*(3), 924-936.

Hayes, S. C., Luoma, J. B., Bond, F. W., Masuda, A., & Lillis, J. (2006). Acceptance and commitment therapy: Model, processes and outcomes. *Behaviour Research and Therapy*, *44*(1), 1-25.

Haynos, A. F., & Fruzzetti, A. E. (2011). Anorexia nervosa as a disorder of emotion dysregulation: Evidence and treatment implications. *Clinical Psychology: Science and Practice*, *18*(3), 183-202.

Heatherton, T. F., & Baumeister, R. F. (1991). Binge eating as escape from self-awareness. *Psychological Bulletin*, *110*(1), 86-108.

Heatherton, T. F., Mahamedi, F., Striepe, M., Field, A. E., & Keel, P. (1997). A 10-year longitudinal study of body weight, dieting, and eating disorder symptoms. *Journal of Abnormal Psychology, 106*(1), 117-125.

Heatherton, T. F., & Polivy, J. (1991). Development and validation of a scale for measuring state self-esteem. *Journal of Personality and Social Psychology, 60*, 895-910, doi:10.1037/0022-3514.60.6.895

Heilman, K. J., Handelman, M., Lewis, G., & Porges, S. W. (2008). Accuracy of the StressEraser® in the detection of cardiac rhythms. *Applied Psychophysiology and Biofeedback*, *33*(2), 83-89.

Heinberg, L. J. (1996). Theories of body image: Perceptual, developmental, and sociocultural factors. In J. K. Thompson (Ed.), *Body image, eating disorders, and obesity: An integrative guide for assessment and treatment* (pp. 27–48). Washington DC: American Psychological Association.

Heinberg, L. J., & Thompson, J. K. (1995). Body image and televised images of thinness and attractiveness: A controlled laboratory investigation. *Journal of Social and Clinical Psychology, 14*(4), 325-338.

Helfert, S., & Warschburger, P. (2011). A prospective study on the impact of peer and parental pressure on body dissatisfaction in adolescent girls and boys. *Body Image, 8*(2), 101-109.

Helfert, S., & Warschburger, P. (2013). The face of appearance-related social pressure: Gender, age and body mass variations in peer and parental pressure during adolescence. *Child and Adolescent Psychiatry and Mental Health*, *7*(1), 16.

Helicor. (2006) *The StressEraser owner's manual.* New York, NY: Helicor Inc.

Heron, K. E., & Smyth, J. M. (2013). Body image discrepancy and negative affect in women's everyday lives: An ecological momentary assessment evaluation of self-discrepancy theory. *Journal of Social and Clinical Psychology, 32*(3), 276-295.

Holliday, J., Uher, R., Landau, S., Collier, D., & Treasure, J. (2006). Personality pathology among individuals with a lifetime history of anorexia nervosa. *Journal of Personality Disorders*, *20*(4), 417-430.

Horacek, T. M., White, A., Betts, N. M., Hoerr, S., Georgiou, C., Nitzke, S., & Greene, G. (2002). Self-efficacy, perceived benefits, and weight satisfaction discriminate among stages of change for fruit and vegetable intakes for young men and women. *Journal of the American Dietetic Association*, *102*(10), 1466-1470.

Ip, K., & Jarry, J. L. (2008). Investment in body image for self-definition results in greater vulnerability to the thin media than does investment in appearance management. *Body Image*, *5*(1), 59-69.

Jackson, L.A. (1992). *Physical appearance and gender: Sociobiological and sociocultural* *perspectives*. New York, NY: State University of New York Press.

Jacobi, C., Hayward, C., de Zwaan, M., Kraemer, H. C., & Agras, W. S. (2004). Coming to terms with risk factors for eating disorders: Application of risk terminology and suggestions for a general taxonomy. *Psychological Bulletin*, *130*(1), 19-65.

Jeffers, A., Benotsch, E. G., & Koester, S. (2013). Misuse of prescription stimulants for weight loss, psychosocial variables, and eating disordered behaviors. *Appetite*, *65*, 8-13.

Johnson, J. G., Cohen, P., Kasen, S., & Brook, J. S. (2002). Eating disorders during adolescence and the risk for physical and mental disorders during early adulthood. *Archives of General Psychiatry, 59*(6), 545-552. doi:10.1001/archpsyc.59.6.545

Joshi, R., Herman, C. P., & Polivy, J. (2004). Self-enhancing effects of exposure to thin-body images. *International Journal of Eating Disorders*, *35*(3), 333-341.

Jung, J., & Lennon, S. J. (2003). Body image, appearance self-schema, and media images. *Family and Consumer Sciences Research Journal*, *32*(1), 27-51.

Juster, R. P., Bizik, G., Picard, M., Arsenault-Lapierre, G., Sindi, S., Trepanier, L., ... & Lupien, S. J. (2011). A transdisciplinary perspective of chronic stress in relation to psychopathology throughout life span development. *Development and Psychopathology*, *23*(03), 725-776.

Karavidas, M. K., Lehrer, P. M., Vaschillo, E., Vaschillo, B., Marin, H., Buyske, S., ... & Hassett, A. (2007). Preliminary results of an open label study of heart rate variability biofeedback for the treatment of major depression. *Applied Psychophysiology and Biofeedback*, *32*(1), 19-30.

Karazsia, B. T., van Dulmen, M. H., Wong, K., & Crowther, J. H. (2013). Thinking meta-theoretically about the role of internalization in the development of body dissatisfaction and body change behaviors. *Body Image*, *10*(4), 433-441. doi: 10.1016/j.bodyim.2013.06.005

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review*, *30*(7), 865-878.

Kaye, W. H., Wierenga, C. E., Bailer, U. F., Simmons, A. N., & Bischoff-Grethe, A. (2013). Nothing tastes as good as skinny feels: the neurobiology of anorexia nervosa. *Trends in Neurosciences*, *36*(2), 110-120.

Keery, H., van den Berg, P., & Thompson, J. K. (2004). An evaluation of the tripartite influence model of body dissatisfaction and eating disturbance with adolescent girls. *Body Image*, *1*(3), 237-251.

Kelly, M. M., Forsyth, J. P., & Karekla, M. (2006). Sex differences in response to a panicogenic challenge procedure: An experimental evaluation of panic vulnerability in a non-clinical sample. *Behaviour Research and Therapy*, *44*(10), 1421-1430.

Kennedy, J. J., & Pretorius, M. (2008). Integrating a portable biofeedback device into call centre environments to reduce employee stress: Results from two pilot studies. *Journal of Workplace Behavioral Health*, *23*(3), 295-307.

Koenig, L. J., & Wasserman, E. L. (1995). Body image and dieting failure in college men and women: Examining links between depression and eating problems. *Sex Roles, 32*(3-4), 225-249. doi:10.1007/BF01544790

Kogan, A., Gruber, J., Shallcross, A. J., Ford, B. Q., & Mauss, I. B. (2013). Too much of a good thing? Cardiac vagal tone's nonlinear relationship with well-being. *Emotion, 13*(4), 599-604.

Koo-Loeb, J. H., Costello, N., Light, K. C., & Girdler, S. S. (2000). Women with eating disorder tendencies display altered cardiovascular, neuroendocrine, and psychosocial profiles. *Psychosomatic Medicine*, *62*(4), 539-548.

Koo-Loeb, J. H., Pedersen, C., & Girdler, S. S. (1998). Blunted cardiovascular and catecholamine stress reactivity in women with bulimia nervosa. *Psychiatry Research*, *80*(1), 13-27.

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological Psychology*, *84*(3), 394-421. doi:10.1016/j.biopsycho.2010.03.010

Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H., & Kirschbaum, C. (2004). HPA axis responses to laboratory psychosocial stress in healthy elderly adults, younger adults, and children: Impact of age and gender. *Psychoneuroendocrinology*, *29*(1), 83-98.

Lagos, L., Vaschillo, E., Vaschillo, B., Lehrer, P., Bates, M., & Padina, R. (2008) Heart rate variability biofeedback as a strategy for dealing with competitive anxiety: A case study. *Biofeedback,* 36, 109-115. Retrieved from http://www.aapb.org/tl_files /AAPB/files/biof_heart_rate.pdf

Lampard, A. M., MacLehose, R. F., Eisenberg, M. E., Neumark-Sztainer, D., & Davison, K. K. (2014). Weight-related teasing in the school environment: Associations with psychosocial health and weight control practices among adolescent boys and girls. *Journal of Youth and Adolescence*, 1-11. doi:http://dx.doi.org/10.1007/s10964-013-0086-3

Langlois, J. H., Kalakanis, L., Rubenstein, A. J., Larson, A., Hallam, M., & Smoot, M. (2000). Maxims or myths of beauty? A meta-analytic and theoretical review. *Psychological Bulletin*, *126*(3), 390-423. doi: 10.1037/0033-2909.126.3.390

Lattimore, P., & Caswell, N. (2004). Differential effects of active and passive stress on food intake in restrained and unrestrained eaters. *Appetite*, *42*(2), 167-173.

Lehrer, P., Carr, R. E., Smetankine, A., Vaschillo, E., Peper, E., Porges, S... Hochron, S. (1997). Respiratory sinus arrhythmia versus neck/trapezius EMG and incentive inspirometry biofeedback for asthma: A pilot study. *Applied Psychophysiology and Biofeedback, 22*(2), 95-109. doi:10.1023/A:1026224211993

Lehrer, P. M., Vaschillo, E., & Vaschillo, B. (2000). Resonant frequency biofeedback training to increase cardiac variability: Rationale and manual for training. *Applied Psychophysiology and Biofeedback, 25*(3), 177-191.

Lehrer, P. M., Vaschillo, E., Vaschillo, B., Lu, S., Eckberg, D. L., Edelberg, R., ... Hamer, R. M. (2003). Heart rate variability biofeedback increases baroreflex gain and peak expiratory flow. *Psychosomatic Medicine, 65*(5), 796-805. doi:10.1097/01.PSY.0000089200.81962.19

Levine, M. P., & Chapman, K. (2011). Media influences on body image. In T. Cash & L. Smolak (Eds.), *Body image: A handbook of science, practice, and prevention* (2nd ed., pp. 101-109). New York, NY: The Guilford Press.

Levine, M. D., & Marcus, M. D. (1997). Eating behavior following stress in women with and without bulimic symptoms. *Annals of Behavioral Medicine, 19*(2), 132-138. doi:10.1007/BF02883330

Levine, M. P., & Murnen, S. K. (2009). "Everybody knows that mass media are/are not [pick one] a cause of eating disorders": A critical review of evidence for a causal link between media, negative body image, and disordered eating in females. *Journal of Social and Clinical Psychology*, *28*(1), 9-42.

Lewis-Beck M. S., Bryman A. & Liao T. F. (2004*) The sage encyclopedia of social science research methods*. Thousand Oaks, CA: Sage Publications, Inc.

Lopez-Guimera, G., Levine, M. P., Sanchez-Carracedo, D., & Fauquet, J. (2010). Influence of mass media on body image and eating disordered attitudes and behaviors in females: A review of effects and processes. *Media Psychology, 13*(4), 387-416.

Lovallo, W. R. (2005). *Stress and health: Biological and psychological interactions*. Thousand

Oaks, CA: Sage Publications, Inc.

Luce, K. H., & Crowther, J. H. (1999). The reliability of the eating disorder Examination—Self-report questionnaire version (EDE-Q). *International Journal of Eating Disorders, 25*(3), 349-351. doi:10.1002/(SICI)1098-108X(199904)25:3<349::AID-EAT15>3.0.CO;2-M

Marcotte, D., Fortin, L., Potvin, P., & Papillon, M. (2002). Gender differences in depressive symptoms during adolescence role of gender-typed characteristics, self-esteem, body image, stressful life events, and pubertal status. *Journal of Emotional and Behavioral Disorders*, *10*(1), 29-42.

Martens, A., Allen, J. J. B., Greenberg, J., & Johns, M. (2006). *The autonomic physiology of terror management: Investigating the effects of self-esteem on vagal tone*. Unpublished manuscript, Tucson, Arizona.

Martens, A., Greenberg, J., & Allen, J. J. B. (2008). Self-esteem and autonomic physiology: Parallels between self-esteem and cardiac vagal tone as buffers of threat. *Personality and Social Psychology Review, 12*(4), 370-389. doi:10.1177/1088868308323224

Martens, A., Greenberg, J., Allen, J. J. B., Hayes, J., Schimel, J., & Johns, M. (2010). Self-esteem and autonomic physiology: Self-esteem levels predict cardiac vagal tone. *Journal of Research in Personality*, *44*(5), 573-584.

Martin, M. C., & Kennedy, P. F. (1993). Advertising and social comparison: Consequences for female preadolescents and adolescents. *Psychology & Marketing. Special Issue: The Pursuit of Beauty, 10*(6), 513-530. doi:10.1002/mar.4220100605

Masuda, A., Hill, M. L., & Tone, E. B. (2012). The role of mindfulness and disordered eating cognitions in psychological distress among college females with elevated disordered eating. *Mindfulness*, *3*(2), 132-138.

McCormack, H. M., Horne, D. J., & Sheather, S. (1988). Clinical applications of visual analogue scales: A critical review. *Psychological Medicine: A Journal of Research in Psychiatry and the Allied Sciences, 18*(4), 1007-1019. doi:10.1017/S0033291700009934

McCraty, R., Atkinson, M., & Tomasino, D. (2003). Impact of a workplace stress reduction program on blood pressure and emotional health in hypertensive employees. *The Journal of Alternative & Complementary Medicine*, *9*(3), 355-369.

McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York Academy of Sciences*, *840*(1), 33-44.

McEwen, B. S. (2007). Physiology and neurobiology of stress and adaptation: Central role of the brain. *Physiological Reviews*, *87*(3), 873-904. doi:10.1152/physrev.00041.2006

McEwen, B. S., & Stellar, E. (1993). Stress and the individual: mechanisms leading to disease. *Archives of Internal Medicine*, *153*(18), 2093-2101.

McLay, R. N., & Spira, J. L. (2009). Use of a portable biofeedback device to improve insomnia in a combat zone, a case report. *Applied Psychophysiology and Biofeedback, 34*(4), 319-321. doi:10.1007/s10484-009-9104-3

Melzig, C. A., Weike, A. I., Hamm, A. O., & Thayer, J. F. (2009). Individual differences in fear-potentiated startle as a function of resting heart rate variability: Implications for panic disorder. *International Journal of Psychophysiology*, *71*(2), 109-117.

Menzel, J. E., Schaefer, L. M., Burke, N. L., Mayhew, L. L., Brannick, M. T., & Thompson, J. K. (2010). Appearance-related teasing, body dissatisfaction, and disordered eating: A meta-analysis. *Body Image*, *7*(4), 261-270.

Merwin, R. M., Moskovich, A. A., Wagner, H. R., Ritschel, L. A., Craighead, L. W., & Zucker, N. L. (2013). Emotion regulation difficulties in anorexia nervosa: Relationship to self-perceived sensory sensitivity. *Cognition & Emotion*, *27*(3), 441-452.

Merwin, R. M., Rosenthal, M. Z., & Coffey, K. A. (2009). Experiential avoidance mediates the relationship between sexual victimization and psychological symptoms: Replicating findings with an ethnically diverse sample. *Cognitive Therapy and Research*, *33*(5), 537-542.

Merwin, R. M., Timko, C. A., Moskovich, A. A., Konrad, K., Zucker, N. L., & Bulik, C. (2011). Psychological flexibility and symptom expression in anorexia nervosa. *Eating Disorders: Journal of Treatment and Prevention, 19*(1), 62–82

Merwin, R. M., Zucker, N. L., Lacy, J. L., & Elliott, C. A. (2010). Interoceptive awareness in eating disorders: Distinguishing lack of clarity from non-acceptance of internal experience. *Cognition and Emotion*, *24*(5), 892-902.

Meule, A., Freund, R., Skirde, A. K., Vögele, C., & Kübler, A. (2012). Heart rate variability biofeedback reduces food cravings in high food cravers. *Applied Psychophysiology and Biofeedback*, *37*(4), 241-251.

Mezzacappa, E., Tremblay, R. E., Kindlon, D., Saul, J. P., Arseneault, L., Seguin, J., ... & Earls, F. (1997). Anxiety, antisocial behavior, and heart rate regulation in adolescent males. *Journal of Child Psychology and Psychiatry*,*38*(4), 457-469. doi: 10.1111/j.1469-7610.1997.tb01531.x

Michael, S. L., Wentzel, K., Elliott, M. N., Dittus, P. J., Kanouse, D. E., Wallander, J. L., ... & Schuster, M. A. (2014). Parental and peer factors associated with body image discrepancy among fifth-grade boys and girls. *Journal of Youth and Adolescence*, *43*(1), 15-29.

Mills, J. S., Polivy, J., Herman, C. P., & Tiggemann, M. (2002). Effects of exposure to thin media images: Evidence of self-enhancement among restrained eaters. *Personality and Social Psychology Bulletin*, *28*(12), 1687-1699.

Mond, J. M., Hay, P. J., Rodgers, B., Owen, C., & Beumont, P. J. V. (2004). Temporal stability of the eating disorder examination questionnaire. *International Journal of Eating Disorders, 36*(2), 195-203. doi:10.1002/eat.20017

Monteath, S. A., & McCabe, M. P. (1997). The influence of societal factors on female body image. *The Journal of Social Psychology, 137*(6), 708-727. doi:10.1080/00224549709595493

Morrison, T. G., Kalin, R., & Morrison, M. A. (2004). Body-image evaluation and body-image investment among adolescents: A test of sociocultural and social comparison theories. *Adolescence, 39*(155), 571-572.

Muench, F. (2008). HRV: The manufacturers and vendors speak. *The Portable StressEraser Heart Rate Variability Biofeedback Device: Background and Research*, 35-39.

Myers, T. A., & Crowther, J. H. (2009). Social comparison as a predictor of body dissatisfaction: A meta-analytic review. *Journal of Abnormal Psychology, 118*(4), 683-698. doi:10.1037/a0016763

Nichter, M., & Vuckovic, N. (1994). Fat talk: Body image among adolescent girls. In N. Sault (Ed.), *Many mirrors: Body image and social relations* (pp. 109-131). New Brunswick, NJ: Rutgers University Press.

Nolan, R. P., Kamath, M. V., Floras, J. S., Stanley, J., Pang, C., Picton, P., & Young, Q. R. (2005). Heart rate variability biofeedback as a behavioral neurocardiac intervention to enhance vagal heart rate control. *American Heart Journal*, *149*(6), 1137.e1–1137.e7.

Norman, G.R., Streiner, D.L. (2008). *Biostatistics: The bare essentials* (3rd ed). Hamilton, Ontario: BC Decker Inc,.

Nugent, A. C., Bain, E. E., Thayer, J. F., Sollers III, J. J., & Drevets, W. C. (2011). Heart rate variability during motor and cognitive tasks in females with major depressive disorder. *Psychiatry Research: Neuroimaging*, *191*(1), 1-8. doi:10.1016/j.pscychresns.2010.08.013

Penttilä, J., Helminen, A., Jartti, T., Kuusela, T., Huikuri, H. V., Tulppo, M. P., ... & Scheinin, H. (2001). Time domain, geometrical and frequency domain analysis of cardiac vagal outflow: Effects of various respiratory patterns. *Clinical Physiology*, *21*(3), 365-376.

Phares, V., Steinberg, A. R., & Thompson, J. K. (2004). Gender differences in peer and parental influences: Body image disturbance, self-worth, and psychological functioning in preadolescent children. *Journal of Youth and Adolescence, 33*(5), 421-429. doi:http://dx.doi.org/10.1023/B:JOYO.0000037634.18749.20

Pike, K. M., Hilbert, A., Wilfley, D. E., Fairbum, C. G., Dohm, F. A., Walsh, B. T., & Striegel-Moore. (2008). Toward an understanding of risk factors for anorexia nervosa: A case-control study. *Psychological Medicine, 38,* 1443-1453. doi:10.1017/S0033291707002310

Pike, K. M., Wilfley, D., Hilbert, A., Fairburn, C. G., Dohm, F. A., & Striegel-Moore, R. H. (2006). Antecedent life events of binge-eating disorder. *Psychiatry Research*, *142*(1), 19-29.

Pinaquy, S., Chabrol, H., Simon, C., Louvet, J. P., & Barbe, P. (2003). Emotional eating, alexithymia, and binge-eating disorder in obese women. *Obesity Research*, *11*(2), 195-201.

Polivy, J., & Herman, C. P. (2002). Causes of eating disorders. *Annual Review of Psychology*, *53*(1), 187-213.

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. *Psychophysiology*, *32*(4), 301-318.

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*(2), 116-143. doi: 10.1016/j.biopsycho.2006.06.009

Porges, S. W., Doussard-Roosevelt, J. A., & Maiti, A. K. (1994). Vagal tone and the physiological regulation of emotion. *Monographs of the Society for Research in Child Development*, *59*(2-3), 167-186.

Posavac, H. D., Posavac, S. S., & Posavac, E. J. (1998). Exposure to media images of female attractiveness and concern with body weight among young women. *Sex Roles, 38*, 187–201.

Prinsloo, G. E., Derman, W. E., Lambert, M. I., & Rauch, H. L. (2013a). The effect of a single episode of short duration heart rate variability biofeedback on measures of anxiety and relaxation states. *International Journal of Stress Management*, *20*(4), 391-411.

Prinsloo, G. E., Derman, W. E., Lambert, M. I., & Rauch, H. L. (2013b). The effect of a single session of short duration biofeedback-induced deep breathing on measures of heart rate variability during laboratory-induced cognitive stress: A pilot study. *Applied Psychophysiology and Biofeedback*, *38*(2), 81-90.

Prinsloo, G. E., Rauch, H. L., Karpul, D., & Derman, W. E. (2013). The effect of a single session of short duration heart rate variability biofeedback on EEG: a pilot study. *Applied Psychophysiology and Biofeedback*, *38*(1), 45-56.

Prinsloo, G. E., Rauch, H. L., Lambert, M. I., Muench, F., Noakes, T. D., & Derman, W. E. (2011). The effect of short duration heart rate variability (HRV) biofeedback on cognitive performance during laboratory induced cognitive stress. *Applied Cognitive Psychology*, *25*(5), 792-801.

Pu, J., Schmeichel, B. J., & Demaree, H. A. (2009). Cardiac vagal control predicts spontaneous regulation of negative emotional expression and subsequent cognitive performance. *Biological Psychology, 82*(2), 186-195. doi:10.1016/j.biopsycho.2009.07.006

Puhl, R., & Brownell, K. D. (2001). Bias, discrimination, and obesity. *Obesity Research*, *9*(12), 788-805.

Pyszczynski, T., Solomon, S., Greenberg, J., & Stewart-Fouts, M. (1995). The liberating and constraining aspects of self: Why the freed bird finds a new cage. In A. Oosterwegel & R. A. Wicklund (Eds.), *The self in European and North American culture: Development and processes* (pp. 357-373). Amsterdam: Kluwer Academic.

Rector, N. A., & Roger, D. (1997). The stress buffering effects of self-esteem. *Personality and Individual Differences, 23*(5), 799-808. doi:10.1016/S0191-8869(97)00095-0

Reiner, R. (2008). Integrating a portable biofeedback device into clinical practice for patients with anxiety disorders: Results of a pilot study. *Applied Psychophysiology and Biofeedback*, *33*(1), 55-61.

Rene, R. (2008). *The efficacy of a portable HRV feedback device in conjunction with mental health treatment of clients with major depressive disorder enrolled in a county welfare-to-work program.* (Order No. 3305746, Alliant International University, San Diego). *ProQuest Dissertations and Theses*, 150. Retrieved from http://ezproxy.lakeheadu.ca/login?url =http://search. proquest.com/docview/304833256? accountid=11956. (304833256).

Ricciardelli, L. A., & McCabe, M. P. (2001). Self-esteem and negative affect as moderators of sociocultural influences on body dissatisfaction, strategies to decrease weight, and strategies to increase muscles among adolescent boys and girls. *Sex Roles, 44*(3-4), 189-207. doi:10.1023/A:1010955120359

Rierdan, J., & Koff, E. (1997). Weight, weight-related aspects of body image, and depression in early adolescent girls. *Adolescence, 32*(127), 615-624.

Rodin, J., Silberstein, L., & Striegel-Moore, R. (1984). Women and weight: A normative discontent. *Nebraska Symposium on Motivation, 32*, 267-307.

Roldan, O. E. (2008). *Body dissatisfaction and affect: The effects of mode of mind induction and three dimensional body shape exposure*. Unpublished master's thesis, Lakehead University, Thunder Bay, Ontario, Canada.

Rosenberg, N., Bloch, M., Ben Avi, I., Rouach, V., Schreiber, S., Stern, N., & Greenman, Y. (2013). Cortisol response and desire to binge following psychological stress: Comparison between obese subjects with and without binge eating disorder. *Psychiatry Research*, *208*(2), 156-161. doi:10.1016/j.psychres.2012.09.050

Rudiger, J. A., & Winstead, B. A. (2013). Body talk and body-related co-rumination: Associations with body image, eating attitudes, and psychological adjustment. *Body Image*, *10*(4), 462-471.

Salk, R. H., & Engeln-Maddox, R. (2011). "If you're fat, then I'm humongous!" Frequency, content, and impact of fat talk among college women. *Psychology of Women Quarterly*, *35*(1), 18-28. doi: 10.1177/0361684310384107

Sassaroli, S., & Ruggiero, G. M. (2005). The role of stress in the association between low self-esteem, perfectionism, and worry, and eating disorders. *International Journal of Eating Disorders, 37*(2), 135-141. doi:10.1002/eat.20079

Schmidt, U., & Treasure, J. (2006). Anorexia nervosa: Valued and visible. A cognitive-interpersonal maintenance model and its implications for research and practice. *British Journal of Clinical Psychology*, *45*(3), 343-366.

Schneiderman, I., Zilberstein-Kra, Y., Leckman, J. F., & Feldman, R. (2011). Love alters autonomic reactivity to emotions. *Emotion*, *11*(6), 1314-1321.

Sherlin, L., Gevirtz, R., Wyckoff, S., & Muench, F. (2009). Effects of respiratory sinus arrhythmia biofeedback versus passive biofeedback control. *International Journal of Stress Management, 16*(3), 233-248. doi:10.1037/a0016047

Sherlin, L., Muench, F., & Wyckoff, S. (2010). Respiratory sinus arrhythmia feedback in a stressed population exposed to a brief stressor demonstrated by quantitative EEG and sLORETA. *Applied Psychophysiology and Biofeedback*,*35*(3), 219-228.

Shieh, G. (2010). On the misconception of multicollinearity in detection of moderating effects: Multicollinearity is not always detrimental. *Multivariate Behavioral Research*, *45*(3), 483-507.

Shorter, L., Brown, S. L., Quinton, S. J., & Hinton, L. (2008). Relationships between body-shape discrepancies with favored celebrities and disordered eating in young women. *Journal of Applied Social Psychology*, *38*(5), 1364-1377.

Shroff, H., & Thompson, J. K. (2006). Peer influences, body-image dissatisfaction, eating dysfunction and self-esteem in adolescent girls. *Journal of Health Psychology, 11*(4), 533-551. doi:10.1177/1359105306065015

Siepmann, M., Aykac, V., Unterdörfer, J., Petrowski, K., & Mueck-Weymann, M. (2008). A pilot study on the effects of heart rate variability biofeedback in patients with depression and in healthy subjects. *Applied Psychophysiology and Biofeedback, 33*(4), 195-201. doi:10.1007/s10484-008-9064-z

Sim, L., & Zeman, J. (2006). The contribution of emotion regulation to body dissatisfaction and disordered eating in early adolescent girls. *Journal of Youth and Adolescence*, *35*(2), 207-216. doi:10.1007/s10964-005-9003-8

Slade, P. D. (1982). Towards a functional analysis of anorexia nervosa and bulimia nervosa. *British Journal of Clinical Psychology, 21*, 167-179. doi:10.1111/j.2044-

8260.1982.tb00549.x

Slade, P. D. (1988). Body image in anorexia nervosa. *British Journal of Psychiatry, 153*(Suppl 2), 20-22.

Smolak, L., Levine, M. P., & Schermer, F. (1999). Parental input and weight concerns among elementary school children. *International Journal of Eating Disorders*, *25*(3), 263-271.

Smyth, J. M., Wonderlich, S. A., Heron, K. E., Sliwinski, M. J., Crosby, R. D., Mitchell, J. E., & Engel, S. G. (2007). Daily and momentary mood and stress are associated with binge eating and vomiting in bulimia nervosa patients in the natural environment. *Journal of Consulting and Clinical Psychology*, *75*(4), 629-638.

Sohn, S. H. (2010). Sex differences in social comparison and comparison motives in body image process. *North American Journal of Psychology*, *12*, 481-500.

Song, H., & Lehrer, P. M. (2003). The effects of specific respiratory rates on heart rate and heart rate variability. *Applied Psychophysiology and Biofeedback, 28*(1), 13-23. doi:10.1023/A:1022312815649

Spitzer, B. L., Henderson, K. A., & Zivian, M. T. (1999). Gender differences in population versus media body sizes: A comparison over four decades. *Sex Roles, 40*(7-8), 545-565. doi:10.1023/A:1018836029738

Stapel, D. A., & Blanton, H. (2004). From seeing to being: Subliminal social comparisons affect implicit and explicit self-evaluations. *Journal of Personality and Social Psychology*, *87*(4), 468.

Startup, H., Lavender, A., Oldershaw, A., Stott, R., Tchanturia, K., Treasure, J., & Schmidt, U. (2013). Worry and rumination in anorexia nervosa. *Behavioural and Cognitive Psychotherapy*, *41*(03), 301-316.

Steele, C. M. (1988). The psychology of self-affirmation: Sustaining the integrity of the self. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 21, pp. 261-302). New York: Academic Press.

Steinglass, J. E., Sysko, R., Mayer, L., Berner, L. A., Schebendach, J., Wang, Y., ... & Walsh, B. T. (2010). Pre-meal anxiety and food intake in anorexia nervosa. *Appetite*, *55*(2), 214-218.

Stice, E. (1994). Review of the evidence for a sociocultural model of bulimia nervosa and an exploration of the mechanisms of action. *Clinical Psychology Review*, *14*(7), 633-661. doi: 10.1016/0272-7358(94)90002-7

Stice, E., & Bearman, S. K. (2001). Body-image and eating disturbances prospectively predict increases in depressive symptoms in adolescent girls: A growth curve analysis. *Developmental Psychology, 37*(5, pp. 597-607), September. doi:10.1037/0012-1649.37.5.597

Stice, E., Cameron, R. P., Killen, J. D., Hayward, C., & Taylor, C. B. (1999). Naturalistic weight-reduction efforts prospectively predict growth in relative weight and onset of obesity among female adolescents. *Journal of Consulting and Clinical Psychology, 67*(6), 967-974. doi:10.1037/0022-006X.67.6.967

Stice, E., Ng, J., & Shaw, H. (2010). Risk factors and prodromal eating pathology. *Journal of Child Psychology and Psychiatry, 51*(4), 518-525. doi:10.1111/j.1469-7610.2010.02212.x

Stice, E., & Shaw, H. E. (1994). Adverse effects of the media portrayed thin-ideal on women and linkages to bulimic symptomatology. *Journal of Social and Clinical Psychology, 13*(3), 288-308.

Stokes, R., & Frederick-Recascino, C. (2003). Women's perceived body image: relations with personal happiness. *Journal of Women & Aging*, *15*(1), 17-29.

Strack, B. W. (2003). *Effect of heart rate variability (HRV) biofeedback on batting performance in baseball*. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 64* (Electronic; Print). (2003-95018-090)

Strahan, E. J., Wilson, A. E., Cressman, K. E., & Buote, V. M. (2006). Comparing to perfection: How cultural norms for appearance affect social comparisons and self-image. *Body Image*, *3*(3), 211-227.

Strauman, T. J., Vookles, J., Berenstein, V., Chaiken, S., & Higgins, E. T. (1991). Self-discrepancies and vulnerability to body dissatisfaction and disordered eating. *Journal of Personality and Social Psychology*, *61*(6), 946-956.

Sypeck, M. F., Gray, J. J., & Ahrens, A. H. (2004). No longer just a pretty face: Fashion magazines' depictions of ideal female beauty from 1959 to 1999. *International Journal of Eating Disorders*, *36*(3), 342-347.

Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA: Pearson.

Tamez, J.P. (2008). *Social comparison using women's subjective and physiological reactivity to thin and average size models (Master's thesis).* Retrieved from http://repository.tamu.edu/bitstream/handle/1969.1/ETD-TAMU-2826/TAMEZ-THESIS.pdf?sequence=1

Tamez, J. P. (2010). *Psychophysiological reactivity to self and model images in an upward social comparison manipulation.* (Order No. 3446575, Texas A&M University). *ProQuest Dissertations and Theses*, 64. Retrieved from http://ezproxy.lakeheadu.ca/login?url=http://search.proquest.com/docview/856359323?accountid=11956. (856359323).

Tantleff-Dunn, S., Barnes, R. D., & Larose, J. G. (2011). It's not just a “woman thing:” The current state of normative discontent. *Eating Disorders*, *19*(5), 392-402.

Teegarden, S. L., & Bale, T. L. (2008). Effects of stress on dietary preference and intake are dependent on access and stress sensitivity. *Physiology & Behavior*, *93*(4), 713-723.

Telch, C. F., & Agras, W. S. (1996). Do emotional states influence binge eating in the obese? *International Journal of Eating Disorders, 20*(3), 271-279. doi:10.1002/(SICI)1098-108X(199611)20:3<271::AID-EAT6>3.0.CO;2-L

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers III, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews*, *36*(2), 747-756.

Thayer, J. F., & Brosschot, J. F. (2005). Psychosomatics and psychopathology: Looking up and down from the brain. *Psychoneuroendocrinology. Special Issue: Stress, Sensitisation and Somatisation: A Special Issue in Honour of Holger Ursin, 30*(10), 1050-1058. doi:10.1016/j.psyneuen.2005.04.014

Thayer, J. F., Friedman, B. H., & Borkovec, T. D. (1996). Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry*,*39*(4), 255-266.

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders*, *61*(3), 201-216.

Thayer, J. F., & Lane, R. D. (2009). Claude Bernard and the heart–brain connection: Further elaboration of a model of neurovisceral integration. *Neuroscience & Biobehavioral Reviews*, *33*(2), 81-88.

Thayer, J. F., & Ruiz-Padial, E. (2006). Neurovisceral integration, emotions and health: An update. *International Congress Series, 1287,* 122-127.

Thompson, J. K., & Heinberg, L. J. (1999). The media's influence on body image disturbance and eating disorders: We've reviled them, now can we rehabilitate them? *Journal of Social Issues, 55*(2), 339-353. doi:10.1111/0022-4537.00119

Thompson, J.K., Heinberg, L.J., Altabe, M., & Tantleff-Dunn, S. (1999). Sociocultural theory: The media and society. In J.K. Thompson & L.J. Heinberg et al (Eds.), *Exacting beauty: Theory, assessment, and treatment of body image disturbance*. (pp. 85-124). Washington, D.C.: American Psychological Association.

Thompson, J. K., & Stice, E. (2001). Thin-ideal internalization: Mounting evidence for a new risk factor for body-image disturbance and eating pathology. *Current Directions in Psychological Science, 10*(5), 181-183. doi:10.1111/1467-8721.00144

Tiggemann, M. (2004). Body image across the adult life span: Stability and change. *Body Image*, *1*(1), 29-41. doi: 10.1016/S1740-1445(03)00002-0

Tiggemann, M. (2005). The state of body image research in clinical and social psychology. *Journal of Social and Clinical Psychology.Special Issue: Body Image and Eating Disorders: Sociocultural Pressures and Perceptions, 24*(8), 1202-1210. doi: 10.1521/jscp.2005.24.8.1202

Tiggemann, M. (2011). Sociocultural perspectives on human appearance and body image. In T. Cash & L. Smolak (Eds.), *Body image: A handbook of science, practice, and prevention* (2nd ed., pp. 12-19). New York, NY: The Guilford Press.

Tiggemann, M., & McGill, B. (2004). The role of social comparison in the effect of magazine advertisements on women's mood and body dissatisfaction. *Journal of Social and Clinical Psychology.Special Issue: Body Image and Eating Disorders, 23*(1), 23-44. doi:10.1521/jscp.23.1.23.26991

Tiggemann, M., & Polivy, J. (2010). Upward and downward: Social comparison processing of thin idealized media images. *Psychology of Women Quarterly, 34*(3), 356-364. doi:10.1111/j.1471-6402.2010.01581.x

Tiggemann, M., Polivy, J., & Hargreaves, D. (2009). The processing of thin ideals in fashion magazines: A source of social comparison or fantasy? *Journal of Social and Clinical Psychology, 28*(1), 73-93. doi:10.1521/jscp.2009.28.1.73

Tiggemann, M., & Slater, A. (2004). Thin ideals in music television: A source of social comparison and body dissatisfaction. *International Journal of Eating Disorders*, *35*(1), 48-58. doi:10.1002/eat.10214

Tiggemann, M., Slater, A., Bury, B., Hawkins, K., & Firth, B. (2013). Disclaimer labels on fashion magazine advertisements: Effects on social comparison and body dissatisfaction. *Body Image*, *10*(1), 45-53. doi: 10.1016/j.bodyim.2012.08.001

Tiggemann, M., Verri, A., & Scaravaggi, S. (2005). Body dissatisfaction, disordered eating, fashion magazines, and clothes: A cross-cultural comparison between Australian and Italian young women. *International Journal of Psychology*, *40*(5), 293-302. **doi:** 10.1080/00207590444000311

Torres, S. J., & Nowson, C. A. (2007). Relationship between stress, eating behavior, and obesity. *Nutrition*, *23*(11), 887-894.

Tozzi, F., Sullivan, P. F., Fear, J. L., McKenzie, J., & Bulik, C. M. (2003). Causes and recovery in anorexia nervosa: The patient's perspective. *International Journal of Eating Disorders*, *33*(2), 143-154.

Tuschen-Caffier, B., & Vögele, C. (1999). Psychological and physiological reactivity to stress: An experimental study on bulimic patients, restrained eaters and controls. *Psychotherapy* *and Psychosomatics, 68*(6), 333-340. doi:10.1159/000012352

Tyrka, A. R., Waldron, I., Graber, J. A., & Brooks-Gunn, J. (2002). Prospective predictors of the onset of anorexic and bulimic syndromes. *International Journal of Eating Disorders*, *32*(3), 282-290.

Uijtdehaage, S. H., & Thayer, J. F. (2000). Accentuated antagonism in the control of human heart rate. *Clinical Autonomic Research*, *10*(3), 107-110.

Uusitalo, A., Mets, T., Martinmäki, K., Mauno, S., Kinnunen, U., & Rusko, H. (2011). Heart rate variability related to effort at work. *Applied Ergonomics*, *42*(6), 830-838.

Van Dixhoorn, J. (2007). Whole-body breathing, a systems perspective on respiratory retraining. In P. Lehrer, R. Woolfolk, & W. Sime (Eds.), *Principles and practice of stress management* (pp. 291–332). New York: Guilford.

Vanasse, A., Demers, M., Hemiari, A., & Courteau, J. (2006). Obesity in Canada: Where and how many? *International Journal of Obesity, 30*(4), 677-683. doi:10.1038/sj.ijo.0803168

Vartanian, L. R., & Dey, S. (2013). Self-concept clarity, thin-ideal internalization, and appearance-related social comparison as predictors of body dissatisfaction. *Body Image, 10*(4), 495-500. doi: 10.1016/j.bodyim.2013.05.004

Vaschillo, E. G., Vaschillo, B., & Lehrer, P. M. (2006). Characteristics of resonance in heart rate variability stimulated by biofeedback. *Applied Psychophysiology and Biofeedback, 31*(2), 129-142. doi:10.1007/s10484-006-9009-3

Vella, E. J., & Friedman, B. H. (2007). Autonomic characteristics of defensive hostility: Reactivity and recovery to active and passive stressors. *International Journal of Psychophysiology*, *66*(2), 95-101.

Volokhov, R. N., & Demaree, H. A. (2010). Spontaneous emotion regulation to positive and negative stimuli. *Brain and Cognition*, *73*(1), 1-6.

Waller, G., Babbs, M., Milligan, R., Meyer, C., Ohanian, V., & Leung, N. (2003). Anger and core beliefs in the eating disorders. *International Journal of Eating Disorders*, *34*(1), 118-124.

Wang, M., & Saudino, K. J. (2011). Emotion regulation and stress. *Journal of Adult Development*, *18*(2), 95-103. doi: 10.1007/s10804-010-9114-7

Want, S. C. (2009). Meta-analytic moderators of experimental exposure to media portrayals of women on female appearance satisfaction: Social comparisons as automatic processes. *Body Image, 6*(4), 257-269. doi:10.1016/j.bodyim.2009.07.008

Watts, K., Cranney, J., & Gleitzman, M. (2008). Automatic evaluation of body-related images. *Body Image*, *5*(4), 352-364.

Wendell, J. W., Masuda, A., & Le, J. K. (2012). The role of body image flexibility in the relationship between disordered eating cognitions and disordered eating symptoms among non-clinical college students. *Eating Behaviors*, *13*(3), 240-245.

Wertheim, E. H., Martin, G., Prior, M., Sanson, A., & Smart, D. (2002). Parental influences in the transmission of eating and weight related values and behaviors. *Eating Disorders: The Journal of Treatment and Prevention, 10*, 321 – 334.

Wheat, A. L., & Larkin, K. T. (2010). Biofeedback of heart rate variability and related physiology: A critical review. *Applied Psychophysiology and Biofeedback*, *35*(3), 229-242.

Wildes, J. E., Ringham, R. M., & Marcus, M. D. (2010). Emotion avoidance in patients with anorexia nervosa: Initial test of a functional model. *International Journal of Eating Disorders*, *43*(5), 398-404.

Yamamiya, Y., Cash, T. F., Melnyk, S. E., Posavac, H. D., & Posavac, S. S. (2005). Women's exposure to thin-and-beautiful media images: Body image effects of media-ideal internalization and impact-reduction interventions. *Body Image, 2*(1), 74-80. doi:10.1016/j.bodyim.2004.11.001

Yamamiya, Y., Shroff, H., & Thompson, J. K. (2008). The tripartite influence model of body image and eating disturbance: A replication with a Japanese sample. *International Journal of Eating Disorders*, *41*(1), 88-91.

Zucker, T. L., Samuelson, K. W., Muench, F., Greenberg, M. A., & Gevirtz, R. N. (2009). The effects of respiratory sinus arrhythmia biofeedback on heart rate variability and posttraumatic stress disorder symptoms: A pilot study. *Applied Psychophysiology and Biofeedback, 34*(2), 135-143. doi:10.1007/s10484-009-9085-2

Appendix A

Recruitment E-mail

Dear Potential Participant,

I am a graduate student in Clinical Psychology here at Lakehead University and I am conducting a study under the supervision of Dr. Ron Davis in the Department of Psychology. The purpose of this study is to examine how advertisements impact people's physiological responses. For this study, you will first be asked to go to http://www.surveymonkey.com to fill out some demographic information and respond to a few questionnaires pertaining to things like eating attitudes and behaviours. This will take no more than 15 minutes of your time. After completing the questionnaires you will be directed to an internet site to sign up for the second part of the study. Participation in this part of the study would require one hour of your time. For this part of the study you would be asked to come in to our laboratory, answer some questionnaires, and practice some specific breathing techniques before viewing some advertisements selling such female products as clothes, purses, shoes and perfume. While completing this part of the study you will be attached to a heart rate monitoring system. In total, participation will result in 2 bonus marks in your Introductory Psychology class.

This study will be occurring in specific time slots; therefore it is important that you complete the first part of the study as soon as possible in order to reserve a spot. If you have any questions please respond to this e-mail.

Sincerely,

Eduardo Roldan, M.A.
Ph.D. Candidate (Clinical Psychology)
Department of Psychology, Lakehead University
E-Mail: oeroldan@lakeheadu.ca
Phone: 622-5620

Appendix B

Participant Information and Consent Forms

PARTICIPANT INFORMATION FORM

Dear Potential Participant,

Thank you for your interest in participating in our study on responses to media advertisements. This research is being conducted by Jenny Morgan and Eduardo Roldan under the supervision of Dr. Ron Davis in the Department of Psychology at Lakehead University.

The purpose of this study is to examine how viewing advertisements, following an opportunity to do some breathing exercises while monitoring your own heart rate, impacts physiological responses in females. For this study, you will first be asked to fill out a confidential survey that asks you questions about different aspects of your emotions, eating attitudes and personality. This online survey will take 25-30 minutes of your time.

At the end of the survey you will then be asked to sign up for the second part of the study. Participation in this part of the study would require 1 hour of your time. For this part of the study you would be asked to come in to our laboratory where you would:

1. listen to portions of a podcast of the CBC show Age of Persuasion
2. wear some sensors to continuously record your heart rate and your respiration,
3. learn about a specific breathing exercise and use a handheld device to monitor your heart rate
4. practice the specific breathing exercise
5. watch some media advertisements on a big screen

If you agree to participate in this study, you can earn 2 bonus marks in qualifying Lakehead Psychology courses.

This study will be occurring in specific time slots. Therefore, it is important that you complete the first part of the study as soon as possible in order to reserve a spot in this study. If you have any questions please respond to this e-mail.

Your participation in this study is completely voluntary and you may withdraw from it at any time without penalty. All information that you provide will be kept completely confidential. Only Dr. Ron Davis, Eduardo Roldan and Jenny Morgan will be permitted to view your information. All of the information that you provide will be assigned a code and will be securely stored at Lakehead University for 5 years, as per University regulations. In addition, your identifying information will be kept completely confidential in reports of results and publications.

There are no known physical or psychological risks associated with participation in this study. In rare instances, such things like drowsiness or lightheadedness may be experienced during the breathing exercise. In this event, you will be instructed to stop the session. You are free to not answer any questions posed to you on the online confidential survey. Similarly, you are free to withdraw from the study at any time without penalty or consequence.

The Research Ethics Board (REB), which is located in the Office of Research at Lakehead

University, has approved this study. If you have any questions regarding this research, feel free to contact the REB at (807) 343-8283.

Thank you for considering participation in this study.

Sincerely,

Eduardo Roldan, M.A.
Lakehead University, Thunder Bay, ON. Email: oeroldan@lakeheadu.ca

Jenny Morgan,
Lakehead University, Thunder Bay, ON. Email: jmorgan1@lakeheadu.ca

Dr. Ron Davis, Associate Professor of Psychology. Lakehead University, Thunder Bay, ON,
Email: ron.davis@lakeheadu.ca, Phone: (807) 343-8646

PARTICIPANT CONSENT FORM

By providing my name and student number below, I indicate that I have read the “Participant Information Form” and that I have had the opportunity to receive satisfactory answers from the researchers concerning any questions that I might have about my participation. I understand and agree to the following:

1. I understand all of the information on the “Participant Information Sheet”.

2. I agree to participate in this study.

3. I am a volunteer and can withdraw at any time from this study without penalty or consequence.

4. I may choose not to answer any question asked in the online survey without penalty or consequence.

5. I understand there is the small possibility of experiencing minor discomfort, such as things like sleepiness and lightheadedness. Should I experience any personal distress or discomfort, I will be instructed to stop the session immediately.

6. My data will remain confidential and will be securely stored in the Department of Psychology at Lakehead University for 5 years.

7. My information will remain anonymous should any publications or public presentations come out of this study.

8. I may receive a summary of this research upon completion of this study.

9. I give my permission to be contacted by telephone and/or E-mail for the purpose of participation in this study.

[ ] By checking this box I acknowledge that I am FEMALE and that I have read the above information and understand the information that has been provided to me. In addition, by checking this box I consent to participate in the study.

Before continuing with this survey, please provide your name, student number, and the Psychology course that you are enrolled in to ensure you receive the bonus points for participation in the Media Study. Please note that your name and student number will be kept confidential and separate from your responses on this survey. Also, the information you provide here will NEVER be used for any purpose other than the bonus.

Full Name: ______________________
Lakehead University Student Number: ______________________
Professor`s Name and Course Number and Section_______________________________

***Please Note:*
In order to protect your privacy your responses will not be saved on this computer. It is important that you complete the entire survey in order for your responses to be received. You will be notified when the survey is completed and it is safe to close the window.
Thank you again for your participation. Please click "next"

Appendix C

Demographic Questionnaire

Demographics

1. How old are you?

2. Marital Status:

Married/Common law

Divorce/Separated

Single

Widowed

3. What is your ethnicity?

Caucasian/White

Aboriginal/First Nation

South Asian

Hispanic

African-Canadian/Black

East Asian

Middle Eastern

If none of these adequately describes your ethnicity, how best would you identify yourself:

4. School Enrollment

Full-Time

Part-Time

○ Other

5. What academic program(s) are you in?

[ ]

6. What is your current height?

	Feet	**Inches**
Height		

7. What is your current weight in pounds? Guess if you do not know. Do not include "lbs" or any other letters with your answer.

[ ]

8. How often do you consume caffeinated beverages?

○ 1 beverage per day

○ 2 per day

○ 3 per day

○ 4+ per day

○ I do not consume caffeinated beverages

9. Do you regularly smoke cigarettes?

○ Yes

○ No

Appendix D

Eating Disorder Examination Questionnaire (EDEQ)

EDE-Q

Instructions
The following questions are concerned with the **PAST FOUR WEEKS ONLY** (**28 DAYS**). Please read each question carefully and circle the number on the right. Please answer ALL the questions.

EXAMPLES:

ON HOW MANY DAYS OUT OF THE PAST 28 DAYS…….	No days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	Every day
…Have you tried to eat vegetables?	0	1	2	(3)	4	5	6
…How many times have you walked to school?	0	1	(2)	3	4	5	6

ON HOW MANY DAYS OUT OF THE PAST 28 DAYS…..	No days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	Every day
1. …Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight?	0	1	2	3	4	5	6
2. …Have you gone for long periods of time (8 hrs or more) without eating anything in order to influence your shape or weight?	0	1	2	3	4	5	6
3. …Have you tried to avoid eating any foods which you like in order to influence your shape or weight?	0	1	2	3	4	5	6
4. …Have you ever tried to follow definite rules regarding your eating in order to influence your shape or weight; for example, a calorie limit, a set amount of food, or rules about what or when you should eat?	0	1	2	3	4	5	6
5. …Have you wanted your stomach to be empty?	0	1	2	3	4	5	6

6. …Has thinking about food or its calorie content made it much more difficult to concentrate on things you are interested in; for example, read, watch TV, or follow a conversation?	0	1	2	3	4	5	6
7. …Have you been afraid of losing control over your eating?	0	1	2	3	4	5	6
8. …Have you had episodes of binge eating?	0	1	2	3	4	5	6

ON HOW MANY DAYS OUT OF THE PAST 28 DAYS…..	No days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	Every Day
9. …Have you eaten in secret? (Do not count binges.)	0	1	2	3	4	5	6
10. …Have you definitely wanted your stomach to be flat?	0	1	2	3	4	5	6
11. …Has thinking about shape or weight made it more difficult to concentrate on things you are interested in; for example, read, watch TV, or follow a conversation?	0	1	2	3	4	5	6
12. …Have you had a definite fear that you might gain weight or become fat?	0	1	2	3	4	5	6
13. …Have you felt fat?	0	1	2	3	4	5	6
14. …Have you had a strong desire to lose weight?	0	1	2	3	4	5	6

OVER THE PAST FOUR WEEKS (28 DAYS)…….

15. …On what proportion of times that you have eaten have you felt guilty because the effect on your shape or weight? (Do not count binges.) (Circle the number which applies.)	0. None of the times 1. A few of the times 2. Less than half the times 3. Half the times 4. More than half the times 5. Most of the times 6. Every time
16. … Over the past four weeks (28 days), have there been any times when you have eaten what other people would regard as an unusually large amount of food given the circumstances? (Please circle appropriate number).	**0- NO** **1- YES**
17. …How many such episodes have you had over the past four weeks? (Please write the appropriate number.)	________
18. ….During how many of these episodes of overeating did you have a sense of having lost control?	________
19. ….Have you had other episodes of eating in which you have had a sense of having lost control and eaten too much, but have not eaten an unusually large amount of food given the circumstances?	**0- NO** **1- YES**
20. … How many such episodes have you had over the past four weeks?	________
21. ….Over the past four weeks have you made yourself sick (vomit) as a means of controlling your shape or weight?	**0---NO** **1--- YES**
22. ….How many times have you done this over the past four weeks?	________
23. ….Have you taken laxatives as a means of controlling your shape or weight?	**0 ---NO** **1 ---YES**
24. ….How many times have you done this over the past four weeks?	________
25. ….Have you taken diuretics (water tablets) as a means of controlling your shape or weight?	**0 ---NO** **1 ---YES**
26. ….How many times have you done this over the past four weeks?	________
27. ….Have you exercised hard as a means of controlling your shape or weight?	**0 ---NO** **1 ---YES**
28. ….How many times have you done this over the past four weeks?	________

OVER THE PAST FOUR WEEKS (28 DAYS)...........

(Please circle the number which best describes your behaviour)

	NOT AT ALL	**SLIGHTLY**	**MODERATELY**	**MARKEDLY**
29. ....Has your weight influenced how you think about (judge) yourself as a person?	0	1	2	3
30. ....Has your shape influenced how you think about (judge) yourself as a person?	0	1	2	3
31. ....How much would it upset you if you had to weigh yourself once a week for the next four weeks?	0	1	2	3
32. ....How dissatisfied have you felt about your weight?	0	1	2	3
33. ....How dissatisfied have you felt about your shape?	0	1	2	3
34. ….How concerned have you been about other people seeing you eat?	0	1	2	3

OVER THE PAST FOUR WEEKS (28 DAYS)...........

(Please circle the number which best describes your behaviour)

	NOT AT ALL	SLIGHTLY	MODERATELY	MARKEDLY
35 ....How uncomfortable have you felt seeing your body; for example, in the mirror, in shop window reflections, while undressing or taking a bath or shower?	0	1	2	3
36....How uncomfortable have you felt about others seeing your body; for example, in shared changing rooms, when swimming or wearing tight clothes?	0	1	2	3

Appendix E

Visual Analogue Scales (VASs)

VASs

Mark a slash on each of the lines below to indicate your answer:

1) At **this moment** in time how **anxious** do you feel?

Not at all ________________________________ **Very Much**

2) At **this moment** in time how **depressed** do you feel?

Not at all ________________________________ **Very Much**

3) At **this moment** in time how **happy** do you feel?

Not at all ________________________________ **Very Much**

4) At **this moment** in time how **angry** do you feel?

Not at all ________________________________ **Very Much**

5) At **this moment** in time how **confident** do you feel?

Not at all ________________________________ **Very Much**

6) At **this moment** in time how **fat** do you feel?

Not at all ____ **Very Much**

7) At **this moment** in time how **physically attractive** do you feel?

Not at all ____ **Very Much**

8) At **this moment** in time how **satisfied with your body size and shape** do you feel?

Not at all ____ **Very Much**

Processing VAS

Mark a slash on each of the lines below to indicate your answer:

1) While you were viewing the advertisements how much thought did **you give to how interesting the ads were?**

No thought ______________________________ **A lot of thought**

2) While you were viewing the advertisements how much thought did **you give to the layout of the ads?**

No thought ______________________________ **A lot of thought**

3) While you were viewing the advertisements how much thought did **you give to how well the ads promoted the products?**

No thought ______________________________ **A lot of thought**

4) In general, to what extent did you **compare yourself to the women in the ads?**

No comparison ______________________________ **A lot of comparison**

5) In general, to what extent did you **compare yourself to the women in the ads based on appearance?**

No comparison ______________________________ **A lot of comparison**

6) In general, to what extent did you **compare yourself to the women in the ads based on body shape?**

No comparison ______________________________ **A lot of comparison**

7) In general, to what extent did you **compare yourself to the women in the ads based on body weight?**

No comparison ______________________________ **A lot of comparison**

Appendix F

State Self-Esteem Scale (SSES)

Current Thoughts

This is a questionnaire designed to measure what you are thinking at this moment. There is, of course, no right answer for any statement. The best answer is what you feel is true of yourself at this moment. Be sure to answer all of the items even if you are not sure of the best answer. Again, answer these questions as they are true for you **RIGHT NOW**.

1= Not at all
2= A little bit
3= Somewhat
4=Very much
5=Extremely

1. I feel confident about my abilities.	1	2	3	4	5
2. I am worried about whether I am regarded as a success or failure.	1	2	3	4	5
3. I feel satisfied about the way my body looks right now.	1	2	3	4	5
4. I feel frustrated or rattled about my performance.	1	2	3	4	5
5. I feel that I am having trouble understanding things that I read.	1	2	3	4	5
6. I feel that others respect and admire me.	1	2	3	4	5
7. I am dissatisfied with my weight.	1	2	3	4	5
8. I feel self-conscious.	1	2	3	4	5
9. I feel as smart as others.	1	2	3	4	5
10. I feel displeased with myself.	1	2	3	4	5
11. I feel good about myself.	1	2	3	4	5
12. I am pleased with my appearance right now.	1	2	3	4	5
13. I am worried about what other people think of me.	1	2	3	4	5
14. I feel confident that I understand things.	1	2	3	4	5
15. I feel inferior to others at this moment.	1	2	3	4	5
16. I feel unattractive.	1	2	3	4	5

Appendix G

Pilot study results

The purpose of the present study was to examine the possible beneficial effects of HRV biofeedback through the use of slow, gentle breaths. However, in order to achieve this, we were interested in having a comparison group that was as different as possible from the intervention condition. This would increase the chances of seeing the beneficial effects of the HRV biofeedback. We were unsure how best to design a comparison group that provided a significant contrast to our intervention condition; therefore, we sought to examine two different approaches to see which differed the most from the biofeedback condition. One of the instructional sets we were interested in asked participants to increase their respiration rate, as research findings have noted this decreases HRV. The second condition did not receive any instructions regarding their breathing. However, we wanted to ensure that participants' attention was equally engaged, so they were instructed to focus on the wave of the handheld device throughout the session. We were also interested in how participants felt after using the different instructional sets after 15 minute sessions. Hence, a pilot study was conducted to examine these questions. To summarize, the pilot study's purpose was twofold: to determine which instructional set maximized the difference with the actual HRV biofeedback condition; and, to ensure that participants did not experience any adverse effects to the different instructional sets.

The study had 30 graduate students assigned to one of three conditions: active biofeedback, attention, and no-instruction. The active biofeedback condition was instructed to monitor their breathing while using the StressEraser® in a way that allowed them to maximize their HRV by finding their resonant frequency. The instructions were based on the procedure followed by Sherlin and colleagues (2009) in combination with the directions provided by the StressEraser® owner's manual (Helicor, 2006). Specifically, participants in the active condition were instructed to produce slow and gentle breaths by following the features on the device, which inform individuals when to inhale and exhale. Furthermore, participants in this condition were told that the purpose of the exercise was to maximize the points they accumulated on the StressEraser®.

Participants in the attention condition were directed to take short, shallow breaths while focusing on the wave. The instructions were designed to produce a higher respiration rate which Song and Lehrer (2003) previously showed led to decreased HRV. In addition, these individuals were told to minimize the points they accumulated on the device , and were not informed about the features on the device that are designed to provide feedback to help maximize HRV. Finally, the no-instruction condition did not receive any instructions on how to use the StressEraser®; rather, participants were asked to sit as still as possible and focus on the wave throughout the exercise. The two instructional conditions were given 15 min tutorials outlining their respective instructional sets prior to partaking in a 15 min session implementing their assigned task. The no-instruction condition did not have a tutorial and instead completed only the 15 min session.

The three conditions were then compared on StressEraser® scores, as well as how they impacted participants' affective or somatic experience. For affective and somatic responses, all participants were asked to complete the eight VASs used by Heinberg and Thompson (1995) as well as a questionnaire developed by Rapee and Medoro (1994) to measure physical sensations. With regards to StressEraser® scores, the results indicated a significant main effect of condition, $F(2, 27) = 11.04$, $p < .001$, $\eta^2 = .45$. Post-hoc analysis revealed that the active biofeedback group scored significantly higher with $M = 53.60$ (19.47) than both the attention $M = 20.60$ (7.18) and the no-instruction $M = 26.20$ (20.43) conditions. However, the attention and no-instruction conditions did not significantly differ on the StressEraser® score. Analysis of affective and somatic experience revealed no significant differences amongst the three conditions.

Therefore, the active biofeedback instructional set was used in the present study for the high-HRV BF group. The instructional set of the attention group was used for the low-HRV BF group, as it had similar instructions to the high-HRV group, and resulted in significantly lower scores on the device. For the present study, the no-instruction condition had the screen of the hand-held device facing away from them. This was done to try to minimize the possible effects that concentrating on the wave may have had on participants. Actively concentrating on something could have theoretically led to changes in HRV.

Sensation Questionnaire

Please rate the maximum feelings experienced during the period of breathing.

	0=not at all	**1=mildly**	**2=moderately**	**3=markedly**
Numbness in extremities	0	1	2	3
Breathlessness	0	1	2	3
Buzzing in the head	0	1	2	3
Feeling distant	0	1	2	3
Feeling unreal	0	1	2	3
Fatigue	0	1	2	3
Fear	0	1	2	3
Pounding heart	0	1	2	3
Feeling trapped or helpless	0	1	2	3
Hot or flushed	0	1	2	3
Anxiety	0	1	2	3
Headache	0	1	2	3
Rising agitation	0	1	2	3
Feeling of suffocation	0	1	2	3
Dizziness	0	1	2	3
Feeling of losing control	0	1	2	3
Worrying that your actions are hurting your health	0	1	2	3
Tingling in the face	0	1	2	3
Lightheadedness	0	1	2	3
Numbness in the face	0	1	2	3
Tight or stiff muscles	0	1	2	3
Blurred vision	0	1	2	3
Weakness	0	1	2	3
Relaxation	0	1	2	3
Nervousness	0	1	2	3
Racing heart	0	1	2	3
Feel like passing out	0	1	2	3
Nausea	0	1	2	3
Tingling in extremities	0	1	2	3
Fear of a heart attack	0	1	2	3
Band across head	0	1	2	3
Tension	0	1	2	3
Feel like panicking	0	1	2	3

Appendix H

Instructional Sets

High-HRV BF Instructions

Today you will be taking part in a biofeedback session. To begin we will take the next 15 minutes to go over what biofeedback is, as well as look at specific instructions for your biofeedback session. Once we have completed the tutorial, including a few minutes to practice using the biofeedback device, you will have the opportunity to partake in an actual biofeedback session for 15 minutes. Before we begin the tutorial on what exactly biofeedback is, I need to emphasize a few things. It is important that you find a comfortable position on the chair, as you will have to minimize movement once you started the biofeedback. In addition, it is important that you ask any questions you may have during the tutorial session, as you will need to remain quiet during the actual 15 min biofeedback session.

Biofeedback is the process of becoming aware of various physiological functions using instruments that provide information on the activity of those same systems, with a goal of being able to manipulate them at will. Biofeedback is a technique in which you learn to control bodily functions, such as your heart rate, using your mind. With biofeedback, you're connected to electrical sensors that help you measure and receive information (feedback) about your body (bio). The biofeedback sensors teach you how to make subtle changes in your body, such as relaxing certain muscles, to achieve the results you want, such as reducing pain. In essence, biofeedback gives you the power to use your thoughts to control your body, often to help with a health condition or physical performance. Biofeedback is often used as a relaxation technique. Processes that can be controlled include brainwaves, muscle tone, skin conductance, heart rate and pain perception.

Biofeedback may be used to improve health or performance, and the physiological changes often occur in conjunction with changes to thoughts, emotions, and behavior. Eventually, these changes can be maintained without the use of extra equipment. Biofeedback has been found to be effective for the treatment of headaches and migraines

Biofeedback is a process whereby people are trained to improve their health by using signals from their own bodies. Physical therapists use biofeedback to help stroke victims regain movement in paralyzed muscles. Specialists in many different fields use biofeedback to help their patients cope with pain. Chances are you have used biofeedback yourself. You've used it if you have ever taken your temperature. The thermometer tells you whether you are running a fever, therefore the device "feeds back" information about your body's functioning. Now that you have that information, you can now start to take certain steps to improve the condition such as drink fluids, go to bed, etc.

There are machines available that work on the same basis and provide information about a person's internal bodily functions with far greater sensitivity and precision than a person can alone. Therefore, these machines help individuals learn about the activity inside their bodies. These machines serve as a way to provide biofeedback so that a person can monitor their performance on the activity being measured in order to be help the person learn how to manipulate that bodily function. Research has demonstrated that biofeedback can help in the treatment of many diseases and painful conditions. It has also shown that we have more control over so-called involuntary bodily function than we once thought possible.

Today you are going to be using a StressEraser®, which is a biofeedback device that helps you to learn how to calm your mind and relax your body. It is used primarily for relaxation, relaxation training and stress reduction. Biofeedback is a treatment technique in which people use signals from their own bodies to help improve their health. Using an infrared finger sensor, the StressEraser® measures how your breathing affects your real-time heart rate activity. You are able to observe the rhythm of how you are breathing on a screen on the front of the device. Once you have inserted your finger into the sensor, the device will begin to display your heart rate activity.

The goal of this breathing exercise is to produce wide, smooth waves. To start this exercise you should begin by taking a slow and gentle breath in. A triangle will appear at the top of the wave, which indicates the optimal time to exhale in a slow, gentle manner. You should continue to exhale until you notice the wave rise again, at which time you should commence inhaling until another triangle appears. In order to ensure that you are maximizing your state of relaxation it is important to slow the rate of your breathing. Research has shown that breathing at a certain pace will help you engage the nerves in your body associated with relaxation and health. The goal of this device is to teach you how to breathe in a rhythm that is most relaxing and healthy to your body. By breathing at your own proper pace-you can relax and calm yourself. While the optimal rate is different for everyone, on average this rate should be about six breaths/min.

I want to emphasize that you are not looking to take deep breaths. Often times when people think about relaxation they will automatically think about taking these deep long breaths; however, if you try doing that for 15 minutes you will feel lightheaded. It is important that you continue to breathe much like you are breathing right now. The only difference is that you will be slowing the rate of your breath and so the cycle will just be longer. Please observe what I mean (show them how to breathe properly).

The Stress eraser scores each wave with squares. Points are awarded for smooth wave-like patterns, which show that your breath cycles are relaxing your whole body. Three vertical squares underneath the wave means your body is relaxed and you receive 1 point. Two squares means you are half relaxed so you get 1/2 point. If you are active or not relaxed, you see one square and you receive zero points. Total points are indicated on the top left hand corner of the display.

During the next 15 minutes it is important for you to maximize the number of points you get. The number of points obtained on the device is an indicator of efficiency performing the activity correctly, with higher points indicating greater efficiency. This means that you should be trying to produce smooth, wide waves which will allow you to gain points. Again, the higher the score you achieve the better you are doing being relaxed and calm.

Tips For Using the StressEraser®

- Concentrate as much as you can on the exercise. Let worries or concerns float in and out of your mind.
- Some people find it helpful to slowly count to 4 while they exhale.
- Sometimes you will notice that triangles appear quickly after each other. If triangles appear too closely together, take a long, gentle inhale and then a long, gentle exhale.
- If you experience any discomfort such as sleepiness or lightheadedness, stop using the StressEraser® immediately. These symptoms are short-term and infrequent and should go away once you stop doing the procedure.

Low-HRV BF Instructions

Today you will be taking part in a biofeedback session. To begin we will take the next 15 minutes to go over what biofeedback is, as well as look at specific instructions for your biofeedback session. Once we have completed the tutorial, including a few minutes to practice using the biofeedback device, you will have the opportunity to partake in an actual biofeedback session for 15 minutes. Before we begin the tutorial on what exactly biofeedback is, I need to emphasize a few things. It is important that you find a comfortable position on the chair, as you will have to minimize movement once you started the biofeedback. In addition, it is important that you ask any questions you may have during the tutorial session, as you will need to remain quiet during the actual 15 min biofeedback session.

Biofeedback is the process of becoming aware of various physiological functions using instruments that provide information on the activity of those same systems, with a goal of being able to manipulate them at will. Biofeedback is a technique in which you learn to control bodily functions, such as your heart rate, using your mind. With biofeedback, you're connected to electrical sensors that help you measure and receive information (feedback) about your body (bio). The biofeedback sensors teach you how to make subtle changes in your body, such as relaxing certain muscles, to achieve the results you want, such as reducing pain. In essence, biofeedback gives you the power to use your thoughts to control your body, often to help with a health condition or physical performance. Biofeedback is often used as a relaxation technique. Processes that can be controlled include brainwaves, muscle tone, skin conductance, heart rate and pain perception.

Biofeedback may be used to improve health or performance, and the physiological changes often occur in conjunction with changes to thoughts, emotions, and behavior. Eventually, these changes can be maintained without the use of extra equipment. Biofeedback has been found to be effective for the treatment of headaches and migraines

Biofeedback is a process whereby people are trained to improve their health by using signals from their own bodies. Physical therapists use biofeedback to help stroke victims regain movement in paralyzed muscles. Specialists in many different fields use biofeedback to help their patients cope with pain. Chances are you have used biofeedback yourself. You've used it if you have ever taken your temperature. The thermometer tells you whether you are running a fever, therefore the device "feeds back" information about your body's functioning. Now that you have that information, you can now start to take certain steps to improve the condition such as drink fluids, go to bed, etc.

There are machines available that work on the same basis and provide information about a person's internal bodily functions with far greater sensitivity and precision than a person can alone. Therefore, these machines help individuals learn about the activity inside their bodies. These machines serve as a way to provide biofeedback so that a person can monitor their performance on the activity being measured in order to be help the person learn how to manipulate that bodily function. Research has demonstrated that biofeedback can help in the treatment of many diseases and painful conditions. It has also shown that we have more control over so-called involuntary bodily function than we once thought possible.

Today you are going to be using a StressEraser®, which is a biofeedback device that helps you to learn how to calm your mind and relax your body. It is used primarily for relaxation, relaxation training and stress reduction. Biofeedback is a treatment technique in which people use signals from their own bodies to help improve their health. Using an infrared finger sensor, the StressEraser® measures how your breathing affects your real-time heart rate activity. You are able to observe the rhythm of how you are breathing on a screen on the front of the device. Once you have inserted your finger into the sensor, the device will begin to display your heart rate activity.

To learn any new skill it is important to receive feedback. As such, feedback is necessary in order to gain control over one's physiology. The StressEraser® provides external, objective information about your heart activity. Biofeedback involves becoming aware of one's physiological functioning so that one can gain better control over its activity. The StressEraser® provides the opportunity for you to observe your heart rate in real-time.

To start this exercise you should begin by taking in a short, shallow breath. During this activity, you should be observing the wave on the screen and attempting to keep the wave as flat as possible, while letting go of stressful thoughts. Again, the goal of this breathing exercise is to produce short, shallow breaths. This device serves to teach you how to breathe at your own pace. While the optimal rate is different for everyone, for this exercise you should be aiming at a rate of about 12 breaths/min. At the top left hand corner of the display you will notice a box depicting the number 0. How well your breathing matches the instructions is indicated by the number in that part of the screen. Like golf, the aim of this exercise is for you to achieve the lowest score possible.

I realize this may seem counterintuitive to what you normally hear about relaxation breathing; however, it is important that you continue to breathe much like you are breathing right now. The only difference is that you will be speeding the rate of your breath and so the cycle will just be shorter. I want to emphasize that you are not looking to take quick shallow breaths. In other words, you do not want to breathe as if you are hyperventilating. If you do start taking rapid shallow breaths for 15 minutes you will feel lightheaded. Please observe what I mean (show them how to breathe properly).

During the next 15 minutes it is important for you to minimize the number of points you get. The number of points obtained on the device is an indicator of efficiency performing the activity correctly, with lower points indicating greater efficiency. This means that you should be trying to produce short, shallow breaths in order to avoid getting points.

Tips For Using The StressEraser®

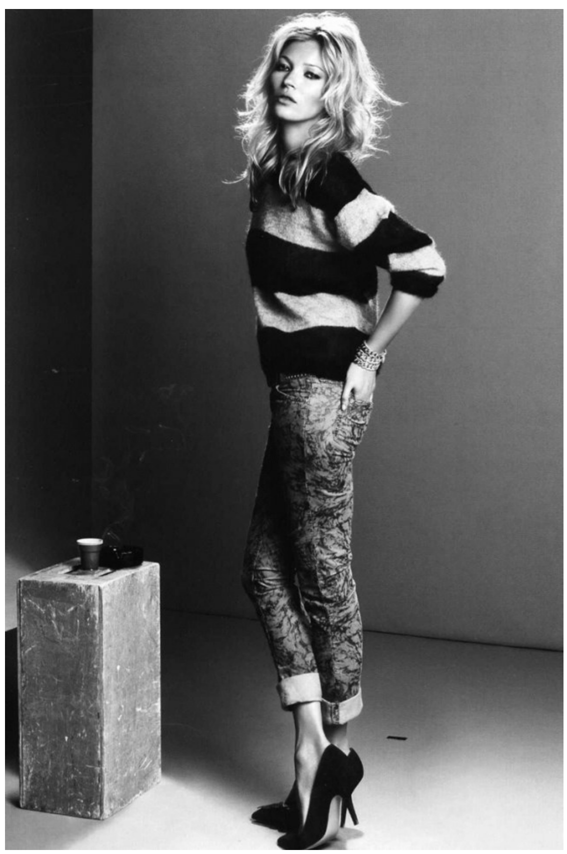
- Concentrate as much as you can on the exercise. Let worries or concerns float in and out of your mind.
- If you experience any discomfort such as sleepiness or lightheadedness, stop using the StressEraser® immediately. These symptoms are short-term and infrequent and should go away once you stop doing the procedure.

No Biofeedback Instructions

Participants in this group were instructed to remain seated and to be as still as possible. They were asked to put their finger on the infrared sensor on the StressEraser®; however, the screen was facing away from them and therefore they did not receive any feedback from the device.

Appendix I

Sample of advertisements




Silk/cotton
radzimir top
and dress,
$1,200, Marc
Jacobs. Bracelet,
Rebekah Price
Designs; shoes,
Christian
Louboutin, Holt
Renfrew.

Appendix J

Debriefing Form

Dear Participant:

This sheet gives you brief summary of the experience that you just completed in this study on the physiological responses to media advertisements. Please read carefully so that you can correctly answer two questions at the bottom of the page.

Research has shown that viewing media images can be a negative experience for many individuals and can result in psychological and physiological changes. Psychological effects include changes in *mood* and *self-esteem*.

When individuals react to such stressors, cardiac activity can also change. This usually includes increases in sympathetic activation of our autonomic nervous system. This manifests itself as increases in heart rate (*HR*) and decreases in the variability of timing between heart beats (called heart rate variability or *HRV*). We have your heart rate recordings from the chest strap that you wore so we will be able to look at people`s cardiac responses to the media images.

Over the next many months we plan to analyze the way in which psychological reactions are statistically related to the bodily reactions of people like you who participated in this study. Just to make sure that you understand the basic science behind this study, we would like you to take a moment and answer the following two questions:

Name one *psychological* variable that this study is investigating:____________________
Name one *biological* variable that the study is investigating:________________________

If you have any questions about the study, please ask now. Do you want a brief summary of the results of this study? If so, print your LU email address and we will send it to you when it is available:

Email address:____________________________________
Again, thank you for participating in our study!