

Is Orthorexia a Security Motivated Eating Behaviour? An Examination through Cognitive Bias
and Cardiac Reactivity to Food

By

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Abstract

Orthorexia is a rigid style of eating that aims to prevent illness that is characterized by a preference for natural foods was investigated as a biologically driven trait with evolutionary roots in a precautionary system of threat avoidance. Research has shown that a precautionary state of this nature is responsive to subtle indicators of potential threat and is detectable through cardiac monitoring. Cardiac monitoring was used to infer activation of this precautionary system in response to experimentally manipulated, food-related threat. In addition to this physiological investigation of orthorexia, cognitive and behavioural aspects were also evaluated. One hundred university students were exposed to natural and nonnatural food stimuli before ranking the stimuli in order of preference. They participated in a taste test in which food preferences were of interest. They completed an implicit association test assessing the relative attitudes toward natural and nonnatural food. Finally, they completed a simulated grocery shopping task assessing food preferences and behavioural intentions. A notable result was the predictive ability of orthorexia concerning the total volume of food consumed during the taste test. Conclusions were unable to be drawn with respect to precautionary system activation due to the failure of the threat manipulation. Performance on a novel task of orthorexia-related behavioural intention was significantly predicted by orthorexic tendency. It was also demonstrated that this relationship is contingent upon a third variable, BMI. Further, it was demonstrated that the predictive relationship between orthorexic tendency and performance on this behavioural task is moderated by food preference, operationally defined in terms of both (a) the rank-ordering of the food stimuli; and (b) the relative volume of natural and nonnatural food consumed during the taste test. The obtained results can be understood in the context of the theory of planned behaviour.

Table of Contents

Introduction.....	1
Orthorexia.....	2
Prevalence.....	4
Classification.....	7
Healthy Eating in the General Population.....	10
Measurement.....	13
Relevance.....	17
Security Motivation.....	19
Relevance.....	27
Vagal Tone.....	27
Vagal Tone and Security Motivation.....	30
Relevance.....	31
Cognitive Bias.....	31
Attentional Bias.....	32
Implicit Cognition.....	32
Relevance.....	33
The Present Study.....	35
Method.....	39
Participants.....	39
Materials.....	40
Demographic Questionnaire.....	40
Eating Attitudes Test.....	40
Body Image States Scale.....	41
Short Health Anxiety Inventory.....	42
ORTO-15.....	43
Balanced Inventory of Desirable Responding.....	43
Taste Test Stimuli.....	44
Procedure.....	45
Food Preference Task and Taste Test.....	45
Implicit Association Test.....	47
Shopping Task.....	50
Recording of the Electrocardiogram.....	50
Results.....	51
HRV Variables.....	52
Composite scores.....	53
Data Analytic Approach.....	53
Parametric Assumptions.....	54
Data Preparation.....	55
ECG recordings.....	56
Psychometric variables.....	56

Food exposure task variables.....	58
HRV variables.....	60
Threat Manipulation.....	60
Test of Hypotheses.....	61
Hypothesis 1.....	61
Hypothesis 2.....	63
Hypothesis 3.....	64
Hypothesis 4.....	66
Summary.....	66
Exploratory Analyses.....	67
Summary of exploratory analyses.....	69
Discussion.....	70
Threat Manipulation.....	70
Behavioural Intention and Realization.....	73
Ajzen's theory of planned behaviour.....	74
Hypotheses and Exploratory Analyses.....	76
Hypothesis 1.....	76
Hypothesis 2.....	79
Hypothesis 3.....	79
Hypothesis 4.....	83
Exploratory analyses.....	84
Clinical Implications.....	87
Limitations and Future Directions.....	90
Conclusions.....	91
References.....	93
Appendices.....	134

List of Tables

Table 1. The HRV Recording Blocks, Task Names, and Descriptive Information.....108

Table 2. Descriptive Statistics and Reliability Coefficients for Psychometric Variables.....109

Table 3. Intercorrelations Among Psychometric Variables.....110

Table 4. Descriptive Statistics for Food Exposure Task Variables.....111

Table 5. Intercorrelations Among Food Exposure Task Variables.....112

Table 6. Descriptive Statistics of Original and Log Transformed RMSSD, HF, and SD1 by
Recording Block.....113

Table 7. Descriptive Statistics of Baseline and Exposure Composite Scores of Original and Log
Transformed RMSSD, HF and SD1.....114

Table 8. Descriptive Statistics and Reliability Coefficients for Affective Psychometric
Variables.....115

Table 9. Unstandardized Regression Coefficients (SE) for Hypothesis 1 Predicting Food
Preference According to Sample Ranking and Consumption and Total Food
Consumed.....116

Table 10. Unstandardized Moderated Regression Coefficients (SE) for Moderated Regression
Investigating Hypothesis 2, where HRV Recording Block 3 is Criterion Variable and
Block 1 is Covariate117

Table 11. Unstandardized Moderated Regression Coefficients (SE) for Moderated Regression
Investigating Hypothesis 2, where HRV Recording Block 4 is Criterion Variable and
Block 2 is Covariate.....118

Table 12. Unstandardized Moderated Regression Coefficients (SE) for Moderated Regression
Investigating Hypothesis 2, where HRV Exposure Composite Score is Criterion Variable

and Baseline Composite score is Covariate.....	118
Table 13. Unstandardized Regression Coefficients (SE) for Hypothesis 3 Predicting Cognitive Bias According to Natural and Caloric Value of Foods.....	120
Table 14. Unstandardized Regression Coefficients (SE) for Hypothesis 4 Predicting Food Preference According to Shopping Task Score.....	121
Table 15. Unstandardized Regression Coefficients (SE) for Exploratory Regression Analysis Investigating Moderation of Orthorexia by BMI in the Prediction of Shopping Task Performance.....	122

List of Figures

Figure 1. Hypothetical model of the moderating effect of experimentally induced threat level on the relationship between trait orthorexia and security motivation.....	124
Figure 2. Timeline of experimental procedure for laboratory visit	125
Figure 3. Conceptual diagram of PROCESS Model 1 (Hayes, 2013).....	126
Figure 4. Shopping task score plotted as a function of Polish 9-item version of ORTO-15 Test (reciprocal; ORTO-P9r) by natural log transformed-body mass index ($BMI(ln)$) controlling for gender, $EAT-26(ln)$, $SHAI(ln)$, and BISS.	127
Figure 5. Shopping task score plotted as a function of Polish 9-item version of ORTO-15 Test (reciprocal; ORTO-P9r) by sample ranking controlling for gender, $EAT-26(ln)$, $SHAI(ln)$, and BISS.	128
Figure 6. Shopping task score plotted as a function of Polish 9-item version of ORTO-15 Test (reciprocal; ORTO-P9r) by sample consumption controlling for gender, $EAT-26(ln)$, $SHAI(ln)$, and BISS.	129
Figure 7. Conceptual diagram of theory of reasoned action (Madden, Ellen, & Ajzecz, 1992).....	130
Figure 8. Conceptual diagram of theory of reasoned action applied to the present study.....	131
Figure 9. Conceptual diagram of theory of planned behaviour (Madden, Ellen, & Ajzecz, 1992).....	132
Figure 10. Conceptual diagram of theory of planned behaviour applied to the present study.....	133

List of Appendices

Appendix A: Bratman Orthorexia Test (BOT).....	134
Appendix B: ORTO-15 Test and Scoring Chart.....	135
Appendix C: Participant Information Letter.....	138
Appendix D: Participant Consent Form.....	140
Appendix E: Eating Attitudes Test-26 (EAT-26).....	141
Appendix F: Body Image States Scale (BISS).....	147
Appendix G: Short Health Anxiety Inventory (SHAI).....	149
Appendix H: Balanced Inventory of Desirable Responding (BIDR).....	153
Appendix I: Heart Rate Electrode Placement.....	163
Appendix J: IAT Target Concept Images.....	165
Appendix K: Selected Screenshots of the Shopping Task.....	169

Is Orthorexia a Security Motivated Eating Behaviour? An Examination through Cognitive Bias and Cardiac Reactivity to Food

The adoption of a particular style of eating in the pursuit of improved health is undertaken by many and can have a beneficial impact on quality of life. Individuals vary in the extent to which attempts at improving health through dietary changes are adhered to, how strict the self-imposed rules are, and the impact that eating style has on other facets of one's life. This construct exists on a spectrum, labelled trait orthorexia, with a restrictive, inflexible, and life-impairing eating style on the extreme pole. Individual differences in this domain can be studied in the context of a security motivation system (SMS), an evolutionarily-based mechanism that orients individuals to novelty and potential threat with a specific behavioural output of information seeking (Szechtman & Woody, 2004). The SMS is thought to contribute to self-preservation by alerting the individual to environmental stimuli that may signal contamination, predators, or other threats to security. Activation of this system is physiologically identifiable by measuring changes in cardiac reactivity (Woody & Szechtman, 2011). Monitoring of SMS activity has been employed in the study of pathologies seemingly routed in evolutionary adaptations such as obsessive-compulsive disorder (OCD; Hinds, 2012; Hinds, Woody, Schmidt, Van Ameringen, & Szechtman, 2015; Szechtman & Woody, 2004). In the realm of orthorexia, one possibility is that certain foods, namely those that are considered to be unhealthy or nonnatural by the individual, are rigidly avoided because they serve as a cue to potential threat, thus activating the SMS. The purpose of this study was to investigate the relationship between trait orthorexia and SMS activation via cardiac reactivity, moderated by food-related threat. A number of other factors such as cognitive bias and food preferences were evaluated in an attempt to better understand the emerging construct of orthorexia.

Orthorexia

Orthorexia is a term used to describe an obsession with eating healthy food that is motivated by an attempt to improve health or prevent disease (Koven & Abry, 2015). This concept was first described in a nonacademic journal by Steven Bratman, a physician who practises holistic medicine (Bratman, 1997). Individuals who display tendencies of orthorexia are concerned with the quality of food rather than the quantity or caloric value. There is a noted preference for foods that are considered to be natural or biologically pure. Natural food is operationally defined as food that is produced with limited human intervention. This includes foods that are free of pesticides, hormones, and artificial ingredients (Koven & Abry, 2015). The fixation with consuming healthy food leads to a number of behaviours such as ritualized eating style, an excessive amount of time spent researching foods, planning or preparing meals, and documenting foods and nutritional information of the foods consumed (Koven & Abry, 2015). Individuals high in orthorexia report devoting a significantly larger amount of time to meal preparation than individuals who are lower in this trait (Missbach et al., 2015). They also report a significantly greater hesitance to consume food that has been prepared by others, where there is a loss of control over the quality, ingredients, and method of preparation (Missbach et al., 2015). An orthorexic style of eating is characterized by rigid beliefs about the health properties of foods, resulting in an inflexible set of rules regarding foods to be consumed and foods to be avoided (Bratman & Knight, 2000; Koven & Abry, 2005). Individuals higher in trait orthorexia are more likely to self-report two or more food intolerances and are more likely to adhere to a vegetarian or vegan diet than individuals who are lower in this trait (Missbach et al., 2015; Valera, Ruiz, Valdespino, & Visioli, 2014; Zuromski et al., 2015).

It is important to differentiate between trait orthorexia and a pathological eating

behaviour which has been labelled orthorexia nervosa (Bratman & Knight, 2000). Many studies have attempted to assess the prevalence of orthorexia nervosa using measures such as the Bratman Orthorexia Test (BOT; Bratman & Knight, 2000) or the ORTO-15 Test (Donini, Marsili, Graziani, Imbriale, & Cannella, 2004), which has resulted in gross overestimations of prevalence whereby over 50% of the sample, in some studies, are classified as orthorexic. These measures should be considered indices of trait orthorexia since, as articulated by Dunn and Bratman (2016), no information is obtained regarding functional or social impairment or state of physical health through the use of these measures. Trait orthorexia can be conceptualized as a collection of behaviours and cognitions related to healthful eating, existing on a bipolar continuum. At the most severe end of this spectrum is a pathological collection of symptoms associated with marked impairment and distress within the individual.

In extreme cases, the list of foods considered healthy by the individual becomes severely restricted, leading to nutritional deficiencies and making the individual at risk for a variety of health complications including osteopenia, anemia, hyponatremia, hypokalemia, metabolic acidosis, pancytopenia, testosterone deficiency, subcutaneous emphysema, mediastinal emphysema, pneumothoraxes, rhabdomyolysis, bradycardia and potentially refeeding syndrome (Koven & Abry, 2015; Moroze, Dunn, Holland, Yager, & Weintraub, 2015; Park et al., 2011). These health issues result from food restriction and are also observed in individuals with anorexia nervosa.

Individuals high in trait orthorexia have deficits in set-shifting, self-monitoring, and working memory (Koven & Senbonmatsu, 2013). The difficulty with set-shifting may account for the rigid set of guidelines about food that is typical in orthorexia (Koven & Abry, 2015). The attention of individuals high in trait orthorexia is very self-focused. In a correlational study by

Koven and Senbonmatsu (2013), trait orthorexia was positively associated with self-monitoring, assessed through a self-report measure of deficits in executive functioning. This finding may account for the impairment in attention to external cues that is also observed in trait orthorexia (Koven & Abry, 2015). Since there is a finite amount of information that can be stored in working memory, the observed deficit in individuals high in trait orthorexia is hypothesized to be the result of working memory being occupied by food-centered thoughts (Koven & Senbonmatsu, 2013).

Despite the relatively limited amount of attention that orthorexia has received in the scientific literature, it is not unheard of nor is it unrecognizable in the clinical domain. In a survey of mental health professionals mainly comprised of psychologists, 66.7% reported having observed a case of orthorexia within their practice, and 68.5% indicated that orthorexia is deserving of more attention (Vandereycken, 2011). Information from a small number of case studies has been published pertaining to relatively serious presentations of orthorexia. Some recurrent observations extracted from these case studies include reporting bizarre beliefs about food, a strong conviction of the benefit of consuming only biologically pure foods in their most natural state, onset following an initial attempt to improve some aspect of health, engaging in compulsive food rituals, purposeful isolation from others with different beliefs about food and health, and a lack of concern about weight change or body image (Catalina-Zamora, Bote-Bonaechea, García-Sánchez, & Ríos-Rial, 2005; Moroze et al., 2015; Park et al., 2011; Saddichha, Babu, & Chandra, 2012).

Prevalence. The prevalence of orthorexia is distributed relatively equally with respect to gender. Although two studies using the ORTO-15 (Aksoydan & Camci, 2009; Donini et al., 2004), and one study using the Turkish version of the ORTO-15 (Fidan, Ertekin, Işıkay, &

Kırpınar, 2010) have found higher point prevalence of orthorexia in males, other studies have found no gender differences using the ORTO-15 (Bağcı Bosi, Çamur, & Güler, 2007; Bo et al., 2014; Segura-García et al., 2012) the Polish version of the ORTO-15 (Brytek-Matera, Donini, Krupa, Poggiogalle, & Hay, 2015; Brytek-Matera, Krupa, Poggiogalle, & Donini, 2014), and the BOT (Bundros, Clifford, Silliman, & Neyman Morris, 2016). One study using the ORTO-15 found a higher prevalence in females (Ramacciotti et al., 2011).

There are a number of studies that report prevalence rates of orthorexia within a variety of populations. Before reporting on those rates, a number of limitations are first noted. The obtained rates are heterogeneous and often higher than would be expected of nonclinical samples. There are a few possible explanations for the variable and inflated estimates of prevalence that are reported in the published literature. First, there are a number of different scales, variations of individual scales, as well as more or less conservative cutoff scores used to indicate the presence of orthorexia. Second, a categorical approach is typically undertaken whereby orthorexia is treated as a discrete syndrome that is either present or absent within an individual. In other words, there is no effort made to tease apart individuals who fall at different points along the spectrum of trait orthorexia. Near the low end of the spectrum, individuals may display some mild tendencies characteristic of orthorexia whereas the more severe pole of the spectrum may include individuals who meet the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association, 2013) criteria of Avoidant/Restrictive Food Intake Disorder (ARFID). Another limitation is that the published studies that report point prevalence have been conducted in a number of different countries, using a variety of different samples for which there may in fact be true differences in prevalence. Finally, the existing measures of orthorexia do not determine degree of impairment, distress, or

health impact and thus do not provide an estimate of the number of individuals dealing with an impairing or distressing collection of symptoms (Dunn & Bratman 2016). As such, the reported rates should be interpreted as the proportion of sample individuals who displayed tendencies of orthorexia, or some degree of trait orthorexia.

Prevalence estimates from samples in the general population have been inconsistent. Donini et al. (2004) found a prevalence of 6.9% using a sample from the general population in Italy while Ramacciotti et al. (2011) found a prevalence of 56.7% nearly 10 years later. Using the German version of the ORTO-15, a prevalence of 69.1% was found using a sample from the general population in Germany (Missbach et al., 2015).

High trait orthorexia is observed more frequently in particular occupations where there is an emphasis on health, nutrition, or physical performance. A study in Italy demonstrated that athletes were more likely to display tendencies of orthorexia than nonathletes (Segura-García et al., 2012). Prevalence rates of 86% in yoga instructors (Valera et al., 2014), 82% in opera singers, 36% in symphony orchestra musicians, and 32% in ballet dancers (Aksoydan & Camci, 2009) have been reported. Within health-related occupations, rates of 44% among medical students (Fidan et al., 2010), 46% among medical residents (Bağcı Bosi et al., 2007), and 13% among female dieticians (Kinzl, Hauer, Traweger, & Kiefer, 2006), have been observed.

There are no reported differences across programs of study in postsecondary education using the BOT (Bundros et al., 2016; Korinth, Schiess, & Westenhoefer, 2010) or the ORTO-15 (Bo et al., 2014; Missbach et al., 2015). A positive correlation between age and trait orthorexia has been observed using the ORTO-15 (Aksoydan & Camci, 2009) although this effect was not replicated using the BOT (Bundros et al., 2016).

A key feature of the eating disorders that have been established and are recognized by the

American Psychiatric Association is a concern with body image and a desire to lose weight or to avoid weight gain (American Psychiatric Association, 2013). The relationship between body image and orthorexia is less clear, although it has been argued that weight concern is not an issue nor is it a motivating factor behind food choices in orthorexia (Brytek-Matera, 2012; Catalina-Zamora et al., 2005; Moroze et al., 2015; Varga, Dukay-Szabó, Túry, & van Furth, 2013). A negative association has been observed between trait orthorexia and a preoccupation with weight as well as a focus on dieting (Brytek-Matera, Donini, et al., 2015; Brytek-Matera, Rogoza, Gramaglia, & Zeppegno, 2015). Individuals with high trait orthorexia also perceived their physical appearance as being less important, but demonstrated higher levels of satisfaction with most areas of their bodies (Brytek-Matera, Donini, et al., 2015). Higher scores on the BOT were associated with the extent to which western ideals of physical appearance, slimness for women and muscularity for men, were accepted (Eriksson, Baigi, Marklund, & Lindgren, 2008). This latter finding is not, in itself, indicative of body image issues and could be explained as an acceptance of body types that are considered representative of optimal health.

The relationship between orthorexia and body mass index (BMI) remains unclear. Trait orthorexia was found to be positively correlated with BMI using the ORTO-15 (Aksoydan & Camci, 2009), the Turkish version of the ORTO-15 (Fidan et al., 2010), and the BOT (Bundros et al., 2016). Bağcı Bosi et al. (2007) found no relationship between trait orthorexia and BMI using the ORTO-15.

Classification. There is considerable debate in the literature regarding the nature of orthorexia, particularly with respect to the boundaries with eating disorders as well as with OCD (Brytek-Matera, 2012). There are a number of similarities between the recognized eating disorders and orthorexia. A study found high trait orthorexia, as measured by the BOT, to be

associated with eating pathology or eating disorder risk, as measured by the Eating Attitudes Test-26 (EAT-26; Bundros et al., 2016). This association was also found using the ORTO-15 to measure trait orthorexia (Segura-García et al., 2012). It has been speculated that trait orthorexia observed over the course of an eating disorder may serve as a socially acceptable manifestation of the underlying eating pathology, as healthy eating is typically idealized as a virtue (Brytek-Matera, Rogoza, et al., 2015). Musolino, Warin, Wade and Gilchrist (2015) describe how tendencies of orthorexia are used by some eating disorder patients in order to rationalize their illness or to maintain their pathological style of eating under the guise of a health-focused recovery. Additionally, trait orthorexia was found to be positively correlated with the number of diets undertaken in an individual's history (Missbach et al., 2015; Segura-García et al., 2012). Some personality aspects that are common to both orthorexia and anorexia include perfectionism, high trait anxiety, and a high need for control (Koven & Abry, 2015). Trait orthorexia is positively associated with restraint and cognitive control of eating behaviour (Kinzl et al., 2006). Impaired set-shifting, self-monitoring, and working memory are found in individuals with anorexia as well as in individuals high in trait orthorexia (Koven & Senbonmatsu, 2013). In addition, weight loss is an expected outcome of both orthorexia and anorexia, making low BMI a common aspect of presentation (Koven & Abry, 2015). Finally, both groups tend to perceive adherence to their eating style as a form of self-control that is highly valued (Koven & Abry, 2015).

Despite the aforementioned commonalities, there are also a number of differences between orthorexia and anorexia. There is a drive for thinness motivating the food restriction in anorexia, whereas the pursuit of health is motivating the restriction of certain types of food in orthorexia. Additionally, individuals high in trait orthorexia are more likely to advertise their

eating behaviours, which may be perceived as virtuous, while individuals with anorexia are more secretive (Koven & Abry, 2015). Individuals high in trait orthorexia are more likely to talk about their dietary regime and even encourage others to adopt their style of eating (Saddichha et al., 2012; Varga, Thege, Dukay-Szabó, Túry, & van Furth, 2014). It has been argued that orthorexia, in comparison with anorexia nervosa, is not driven by external social pressures (Babicz-Zielińska, Wądołowska, & Tomaszewski, 2013). A study of orthorexia in a sample of eating disorder outpatients diagnosed with anorexia or bulimia nervosa demonstrated that trait orthorexia was higher in those not preoccupied with weight gain (Brytek-Matera, Rogoza, et al., 2015). Further, adherence to a healthy lifestyle, importance placed on personal appearance, eating pathology, and concern over personal weight were all shown to negatively predict trait orthorexia (Brytek-Matera, Rogoza, et al., 2015). One study showed that 66.7% of dieters with an eating disorder indicated a hypocaloric diet compared to 45.5% of dieters that were high in trait orthorexia (Bo et al., 2014). Eating disorders were shown to be more likely in university students majoring in dietetics while high trait orthorexia was not (Bo et al., 2014).

Eating disorders also share a degree of overlap with OCD. Cognitions and behaviours typical of the eating disorders anorexia and bulimia nervosa are more common in the obsessive-compulsive population than in healthy controls (Grabe, Thiel, & Freyberger, 2000; Pigott et al., 1991). Obsessive-compulsive symptoms are also found in individuals with eating disorders (Halmi et al., 2005; Speranza, 2001). It has been argued that the observed overlap between OCD and eating disorders can be explained in part by a shared etiological background including facets of personality, the most notable being perfectionism (Altman & Shankman, 2009; Halmi et al., 2005). In addition, a number of symptoms are common to both orthorexia and OCD, including intrusive thoughts, deficient attention to the external environment, and excessive concern about

contamination and purity (Koven & Abry, 2015). The neuropsychological profile of OCD is similar to that of orthorexia in that they share deficits in executive functioning (Koven & Senbonmatsu, 2013). Trait orthorexia was found to be positively correlated with a measure of obsessive-compulsive traits (Bundros et al., 2016). In individuals diagnosed with OCD, obsessions and compulsions related to washing and cleaning were negatively correlated with a drive for thinness (Grabe et al., 2000). This is a characteristic also observed in orthorexia where there is a preoccupation with avoiding contamination in the absence of a pursuit of low body weight. OCD differs from orthorexia predominantly on the basis of the target of fixation; the obsessions and compulsions observed in orthorexia are related to food and health (Koven & Abry, 2015).

The food choices made by an individual high in trait orthorexia are fundamentally based on what the individual believes will help them to achieve optimal health or to prevent illness (Bratman & Knight, 2000). While diet can play an important role in the maintenance of health, individuals high in trait orthorexia subscribe to health-related beliefs about specific foods that are extreme, bizarre, and unsupported by science, a tendency referred to by Bratman and Knight (2000) as “kitchen spirituality”.

Healthy eating in the general population. The pursuit of health through proper nutrition is not exclusive to individuals with disordered styles of eating. There is an abundance of dietary information available advocating for the health properties of different types of foods or diets. There is not, however, anything approaching consensus regarding the ideal human diet. In the absence of clear guidance concerning proper diet for optimal health, confusion in this domain exists beyond the boundaries of orthorexia. Rangel, Dukeshire, and MacDonald (2012) discuss how the responsibility for evaluating the health-promoting or diminishing properties of foods

belongs to the individual, and not to healthcare professionals or governing bodies. Information about the right foods to eat in order to optimize health is abundant, yet contradictory, resulting in a plethora of differing opinions concerning healthy food choices (Rangel et al., 2012). Rozin, Ashmore, and Markwith (1996) found a number of cognitive heuristics about food and health in the general population that resemble the maladaptive beliefs that govern the behaviour of individuals high in trait orthorexia. Two such heuristics observed in the general population are dichotomous thinking in the form of categorization of foods as either good or bad, and “dose insensitivity”, which refers to the false belief that if a food item is harmful at high levels, complete abstinence is the healthiest choice (Rozin et al., 1996). Both of these cognitive heuristics could contribute to beliefs about food that are rigidly held by individuals high in trait orthorexia.

Skepticism about consuming food that has been genetically modified, a food category avoided by many high in trait orthorexia, is not uncommon in the general population (Rozin et al., 2004; Sparks, Shepherd, & Frewer, 1994). Genetically modified food products are more likely to be purchased by consumers if they are perceived as natural (Frewer, Howard, & Shepherd, 1995). This suggests that it is the nonnaturalness of genetically modified foods that is the deterring factor. As a result of the limited understanding of biological technology held by the average consumer as well as the variation in what can be considered natural, the perceptions driving food selection are subjective and heterogeneous. According to the results of a qualitative study in Europe assessing attitudes toward genetically modified beer and yogurt, respondents associated the consumption of genetically modified food products with negative health outcomes (Bredahl, 1999). The respondents indicated a preference for alternatives with less desirable properties (consistency, fat content, cost) rather than the genetically modified products (Bredahl,

1999).

Many consumers are aware of the same food-related health information, whether legitimate or not, that guides the food choices made by individuals high in trait orthorexia. In a review of a number of popular diets, Sellin (2014) highlights two predominant trends: consuming foods that are considered to make up the proper human diet in terms of ancestral history, and the avoidance of nonnatural or processed foods. Members of the general population are more likely to indicate a preference for natural foods: foods that have been produced without human intervention (Rozin et al., 2004). Rozin (2005) found that the perception of the naturalness of a food is largely affected by chemical changes and relatively unaffected by physical changes, meaning that the method of processing plays a large role in whether foods are considered natural. Natural foods tended to be perceived as healthier and purer (Rozin et al., 2004). Foods that are considered natural are viewed as morally superior to processed foods, even when participants are informed of chemical equivalency between both options (Rozin, 2005). An awareness of or interest in foods that are considered healthier or more natural does not, however, predict food choice or frequency of consumption of that food (Roininen & Tuorila, 1999). This suggests that individuals who are high in trait orthorexia are not simply more health conscious or educated about healthy nutrition.

Food preferences for individuals with high levels of trait orthorexia vary across individuals and even within a single individual over time (see Bratman & Knight, 2000 for a review of diets common to orthorexia). In general, the preferred foods of these individuals are described as “pure”, “clean”, “natural”, and “as nature intended” (Musolino et al., 2015). Preferred foods tend to be unprocessed, free from additives, and produced with limited human intervention (Musolino et al., 2015).

Håman, Barker-Ruchti, Patriksson, and Lindgren (2015) discuss orthorexia in combination with “healthism”, a perspective that health is the responsibility and moral obligation of the individual, and can be obtained through self-discipline pertaining to diet and exercise. In one study, however, trait orthorexia was negatively correlated with behaviour congruent with physical health (Brytek-Matera, Donini, et al., 2015). In addition, individuals with high trait orthorexia were less likely to endorse their own bodies as being physically fit (Brytek-Matera, Donini, et al., 2015). The authors speculate that the time, effort, and self-discipline required to maintain an eating style typical of orthorexia may lead to neglect in other facets of health (Brytek-Matera, Donini, et al., 2015). Contrary to these findings, another study demonstrated that trait orthorexia was inversely related to cigarette smoking and alcohol consumption (Aksoydan & Camci, 2009). In terms of other health-pursuant behaviours, individuals high in trait orthorexia are more likely to be using nutritional supplements (Bo et al., 2014). Trait orthorexia was also associated with more frequent physical exercise in female fitness center participants (Eriksson et al., 2008). The relationship between orthorexia and healthy behaviours that are unrelated to food is unclear. It seems as though individuals that are high in trait orthorexia make food choices that they believe will promote their personal health but may or may not adhere to health-related practices in other domains.

Measurement. A variety of instruments are used in the assessment of orthorexia with the BOT first among them (Bratman & Knight, 2000). It is a 10-item dichotomous questionnaire (Appendix A). This measure was not designed for clinical use nor research purposes, but as an informal tool for self-assessment (Dunn & Bratman, 2016). As such, there is no accompanying information regarding the psychometric properties, scoring, or interpretation of responses (Dunn & Bratman, 2016). The author did, however, provide some information directed at the individual

seeking help for impairing orthorexia by indicating that the endorsement of four or more of the items signifies the existence of a problem (Bratman & Knight, 2000).

The ORTO-15 (Donini et al., 2004; Appendix B) was developed, using the BOT as a model, to identify an obsessional preoccupation with consuming healthy food. Six of the items from the BOT were retained for the ORTO-15. This questionnaire comprises 15 items that are answered on a 4-point Likert-type scale with the response options of “always,” “often,” “sometimes,” and “never”. This is the most widely used measure of orthorexia in the extant research literature. A cutoff score of 40 is recommended, with lower scores indicating a greater degree of trait orthorexia. Some studies have used a more conservative cutoff score of 35 (Bo et al., 2014; Segura-García et al., 2012; Stochel et al., 2015) There are a number of concerns regarding the psychometric properties of the ORTO-15. The approach to test construction that was used in the development of this measure is lacking in clarity, information regarding its reliability is absent, and information regarding its validity is insufficient (Dunn & Bratman, 2016). Although some studies have found the reliability to be acceptable with Cronbach’s $\alpha = .78$ - $.79$ (Segura-García et al., 2012; Stochel et al., 2015; Varga et al., 2014), others have found it to be unacceptably low, ranging from $.30$ to $.44$ (Arusoğlu, Kabakci, Köksal, & Merdol, 2008; Missbach et al., 2015). The construct validity of the ORTO-15 was evaluated through comparison with a measure of health-oriented eating habits and a measure of obsessive-compulsive qualities (Donini, Marsili, Graziani, Imbriale, & Cannella, 2005).

The scale was validated using a sample of 110 Italian individuals from the general population, divided into four groups on the basis of the presence/absence of “health fanatic” eating habits and obsessive-compulsive traits (Donini et al., 2005). Participants were described as having health fanatic eating habits if their scores fell below the 25th percentile using a

questionnaire that assessed eating habits. The authors state that the eating habits data were analyzed with attention to the ratio of unhealthy foods, described as frozen or tinned, to healthy foods, for instance fresh and biological produce, that were selected by the respondent. It can be inferred from the descriptive information provided that the health/unhealthy distinction is similar to the natural/nonnatural distinction used elsewhere in the literature; the distinction is based on food processing and degree of human intervention. An elevated score on scale 7, Psychasthenia, of the Minnesota Multiphasic Personality Inventory (MMPI; McKinley & Hathaway, 1942) was used to determine if the participants belonged to the group identified as having obsessive-compulsive traits. Participants belonging to the group having both health fanatic eating habits and obsessive-compulsive traits were considered cases and the remainder of participants were considered noncases for the purpose of validating the ORTO-15 as a tool in identifying individuals with orthorexia. This validation study used the recommended cutoff score of 40 and yielded results of 100% sensitivity, 73.6% specificity, a positive predictive value of 17.6%, and a negative predictive value of 100% (Donini et al., 2005). The ORTO-15 was able to differentiate between respondents scoring high and low on the measure of health-oriented eating habits but was unable to distinguish differences in obsessive-compulsive tendencies. Due to the prominence of obsessive and compulsive tendencies in orthorexia, a limitation of the measure is its lack of specificity in this domain.

In attempt to remedy the problematic psychometric properties of the ORTO-15, a number of modified versions have been developed, all of which have eliminated specific items resulting in a shorter test. It should be noted that a lesser number of test items has the inherent potential to reduce test reliability. The Polish version of the ORTO-15 is a modified version that includes only nine of the items from the original measure (items 3, 4, 5, 6, 7, 10, 11, 12 and 14), and uses

a cutoff score of 24 (Brytek-Matera et al., 2014). The internal consistency of this modified version was found to be low (Cronbach's $\alpha = .64$) (Brytek-Matera et al., 2014). The Turkish version of the ORTO-15 includes only 11 of the items from the ORTO-15 (items 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14) and has no recommended cutoff score, although a cut-score of 27 has been used (Arusoğlu et al., 2008; Fidan et al., 2010). The internal consistency of this version is low (Cronbach's $\alpha = .62$; Arusoğlu et al., 2008). The German version of the ORTO-15 includes only nine of the items from the ORTO-15 (items 3, 4, 5, 6, 7, 10, 11, 12, 15) and has a recommended cutoff score of 26.7 (Missbach et al., 2015). The internal consistency of this version is low (Cronbach's $\alpha = .67$; Missbach et al., 2015). The Hungarian version of the ORTO-15 includes only 11 of the items from the ORTO-15 (items 1, 2, 3, 4, 7, 9, 10, 11, 12, 13, 15) and there is no recommended cutoff score (Varga et al., 2014). The internal consistency of this version is acceptable (Cronbach's $\alpha = .82$; Varga et al., 2014).

There are a number of concerns regarding the psychometric properties of the ORTO-15 that have not been remedied through numerous attempts at modifying the instrument. The ORTO-15 fails to tap into the obsessive-compulsive qualities typical of orthorexia. The existing modifications involve shortening the measure by eliminating certain items. As a future direction, it may be advisable to retain the items on the ORTO-15 and extend the measure with items that assess obsessive-compulsive traits. Despite the limitations, the ORTO-15 remains the current gold standard instrument used to evaluate the construct of orthorexia.

One factor that may be related to the lack of clarity regarding the nature of the construct as well as the limited scope of relevant research is that orthorexia nervosa is not a disorder that is currently recognized in psychological nor psychiatric nosology. Despite increased attention in the scientific literature in recent years, there still exists a considerable debate over the nature of

this collection of symptoms at the extreme pole of the spectrum of trait orthorexia. Kummer, Dias, and Teixeira (2008) argue that a continuum of restricted eaters exists on which dieting, orthorexia, and anorexia can all be placed. A number of versions of proposed diagnostic criteria have been suggested for the diagnosis of orthorexia nervosa in its pathological form (Dunn & Bratman, 2016; Moroze et al., 2015; Varga et al., 2013). On the basis of DSM-5 criteria, a clinical case of orthorexia nervosa would meet the criteria of ARFID (American Psychiatric Association, 2013). In a survey of mental health professionals, 31% of respondents endorsed a belief that orthorexia nervosa is a variant of another mental disorder (Vandereycken, 2011). This is likely a reflection of the overlap in presentation that orthorexia shares with both anorexia nervosa and OCD. Additionally, some argue that orthorexia nervosa is a new disorder deserving of its own diagnostic category. The proposed diagnostic criteria include the following components: rigid dietary rules that escalate over time, compensatory mechanisms in response to dietary transgressions aimed at detoxifying or cleansing the body of impurities, extreme concern regarding food quality, naturalness or purity; obsessions and compulsions related to food and health along with a fear of disease; exaggerated beliefs about the relationship between food and health; an excessive amount of time spent researching, cataloguing, or preparing foods; intolerance to beliefs of others about food and health; spending an excessive amount of money in relation to personal income to obtain foods perceived to be healthy; no excessive concern about body image, dieting, or the quantity of food; and impairment in physical health, social, occupational, or another important area of functioning (Dunn & Bratman, 2016; Moroze et al., 2015; Varga et al., 2013).

Relevance. There are no models in the extant literature that have been used to study the genesis and maintenance of orthorexia. One possibility is that orthorexia may be understood in

terms of a selective advantage that was provided to human ancestors at some point during evolutionary history. In a world where consuming a poisonous plant or spoiled food could be fatal, a preference for a limited range of familiar foods would be adaptive in the sense that it would promote survival and facilitate the propagation of genetic information. A reluctance to consume foods that have been produced with extensive human intervention can be understood in this manner because foods of this sort would not have been encountered historically and thus do not fall into the category of safe and familiar foods. From this perspective, nonnatural foods may be perceived as a potential threat to security by individuals high in trait orthorexia. These foods signal a potential threat because their status as toxic or safe has not been established or ingrained in human biology.

Individuals vary in trait sensitivity to disgust with respect to contaminated food. Calder et al. (2007) demonstrated that trait sensitivity to disgust was associated with activity in brain areas involved in the experience of disgust such as the anteroventral insula and ventral pallidum in response to viewing pictures of spoiled and mouldy foods. Brain activity in these areas was not observed when participants viewed images of appetizing or bland foods.

In the same way that an aversion response to rotten foods exists in varying degrees, individuals may vary in the degree of caution exhibited surrounding unfamiliar foods. Caution regarding the consumption of foods that would not be encountered in nature may be present because of the potential for unfamiliar foods to impact negatively on health.

Despite the absence of a model that accounts for the development of orthorexia, there is a model that postulates the etiological factors contributing to the development of OCD. As mentioned previously, there is a degree of overlap between OCD and orthorexia (see Classification section). OCD has been studied as biologically hardwired system of threat

detection that triggers a specific behavioural output when activated. This system, variously labelled as the hazard-precaution system, defense system, or security motivation system (SMS), may also be suited to the study of the construct of orthorexia.

Security Motivation

From an evolutionary perspective, virtually all aspects of human functioning exist today because of some selective advantage they historically subserved in terms of reproductive fitness (Darwin, 1859). Many behaviours that are currently observed may not be adaptive in modern society, but can be understood in terms of a selective advantage that was provided at some point during human evolution. One such behaviour may be an avoidance of foods that are unfamiliar or that seem to deviate from their natural state, as observed in orthorexia. The selective advantage provided by this avoidance is that it prevents the consumption of foods that may cause illness or spread disease.

Szechtman and Woody (2004) argue for the existence of an adaptive system controlling the activation of a biologically hardwired behavioural set that promotes self-preservation. This system, which Szechtman and Woody have termed the SMS, drives an individual to detect and remediate threats to personal security. The SMS is highly sensitive and responds to vague, indirect indications of possible danger (Woody & Szechtman, 2011). The utility of this precautionary approach is that there is minimal cost to the individual for a false positive (i.e., SMS activation in the absence of an actual threat), while a failure to respond could be lethal (Woody & Szechtman, 2011). SMS activation is not energy-costly, the triggered behaviours are predominantly associated with probing the environment for more information, and the threats that this system is equipped to detect are potentially catastrophic; for instance, disease epidemics and predator attacks (Woody & Szechtman, 2011). The SMS, when activated by subtle

environmental cues, elicits behaviours that promote the survival of the individual. For humans, such behaviours approximate behaviours frequently observed in OCD, including checking and washing as well as obsessional thoughts related to the target that is a threat to security (Szechtman & Woody, 2004). The security motivated behaviours also function as part of a negative feedback loop whereby the performance of the behaviours terminates the SMS (Hinds et al., 2010; Woody et al., 2005). These behaviours differ from classic danger-avoidance or escape behaviours which are adaptive in situations where danger is imminent. Security motivated behaviours are performed with the intent of gathering information to confirm the presence of danger in response to a potential threat (Szechtman & Woody, 2004; Woody & Szechtman, 2011). As such, the SMS enables a preventative strategy to avoid imminent danger through preparedness (Szechtman & Woody, 2004). The affective state associated with SMS activation is not the state of fear that is experienced in response to imminent danger. Woody et al. (2005) demonstrated that disgust, anxiety, and elevated heart rate resulted in healthy participants who were blocked from obtaining the full effect of the performance of security motivated behaviours after the SMS was activated via contamination imagery. The participants in this study were categorized based on their susceptibility to hypnosis. The participants were asked to imagine the emotional experience of either interacting with an object contaminated with germs and bacteria or to imagine the experience of being calm and relaxed. Next, half of the participants in each condition were told that they would not experience a sense of satisfaction during subsequent handwashing, whereas the other half of participants were told they would experience the typical level of satisfaction achieved during handwashing. The participants who were highly hypnotizable, who were instructed to imagine touching a contaminated object, and who were told that subsequent handwashing would not bring the usual level of satisfaction, washed their hands

for a significantly longer duration than the other groups. The participants who were asked to imagine interacting with a contaminated object reported higher levels of disgust and anxiety than the other groups. This group also demonstrated an increase in heart rate following the contamination imagery that returned to baseline after the participants washed their hands. The findings of this study support the idea that potential threat activates a distinct system whose behavioural output serves the dual purpose of avoiding danger and terminating the activation.

There is a degree of uncertainty that is an inherent by-product of SMS activation. The SMS is activated in response to potential threat and therefore has no definite indication of goal attainment; it is impossible to be certain that danger is no longer imminent when there was never any certainty that the danger existed in the first place (Woody & Szechtman, 2007; 2011). Woody and Szechtman (2011) argue that it is the uncertainty that incites the SMS, and that repeated encounters with a potential threat may extinguish the response. This also highlights the importance of engaging in security motivated behaviours in order to terminate the activation of the system (Hinds et al., 2010; Woody & Szechtman, 2007). The actual engagement in security motivated behaviours, such as surveillance, checking, and washing, gives the individual a feeling of certainty regarding security that cannot be obtained through alternative means. For example, a study by Hinds et al. (2010) showed that when participants were uncertain about whether they had been exposed to urinary contamination when handling baby diapers, they demonstrated changes in cardiac reactivity suggestive of SMS activation. This activation was not terminated by informing the participants that the diapers they had been exposed to were, in fact, not contaminated. It was only when the participants were allowed to engage in the security motivated behaviour of handwashing that the SMS activation dissipated. When the negating information about contamination was provided prior to contact, it prevented SMS activation

altogether.

The SMS has been proposed to underlie psychopathology in the form of OCD (Szechtman & Woody, 2004). The observation that compulsions often take the form of preventing harm or avoiding danger has also been discussed within the context of a “hazard-precaution system” which is synonymous with the SMS (Liénard & Boyer, 2006). This system is described as being separate from systems responding to imminent danger, activated by ambiguous and potentially threatening cues, and aimed at promoting safety and security (Liénard & Boyer, 2006). SMS activation is terminated by engaging in security motivated behaviours that are triggered by the system (Hinds et al., 2010). It has been argued that OCD is the cognitive and behavioural manifestation of a deficiency in turning off the SMS (Hinds, 2012; Hinds et al., 2015; Szechtman & Woody, 2004).

The SMS may be additionally suited to account for the cognitive and behavioural phenomena that are observed in individuals high in trait orthorexia. First, the species-specific nature of the SMS may account for the high prevalence of trait orthorexia that has been observed. It is logical that this trait would be detectable in most individuals if it is influenced by a system presumed to be universally present within humans. Second, in a number of case studies of severe presentations of orthorexia, the individuals report their initial dietary modifications were enacted in an attempt to remedy some aspect of perceived ill-health (Catalina-Zamora et al., 2005; Moroze et al., 2015; Park et al., 2011). In a discussion of various subtypes of self-protection systems, Neuberg, Kenrick, and Schaller (2011) suggest that domain-specific precautionary systems, such as the SMS, would be more frequently activated in individuals who perceive themselves to be especially vulnerable to a particular sort of threat. In addition, as Woody and Szechtman (2005) explain, the SMS model is most applicable to subtypes of OCD

involving checking and contamination. Contamination-related obsessions certainly resemble the fixation on pure, natural foods that is observed in orthorexia, further supporting the applicability of this model to account for the observed phenomena in orthorexia. Neuberg et al. (2011) differentiate between subtypes of a precautionary system, the most relevant to trait orthorexia being the disease-avoidance system. This system, it is argued, was designed by natural selection as protection from contamination in the form of pathogens carried by humans, animals, insects, or foods (Neuberg et al., 2011). The affective state that is associated with an ambiguous cue signalling potential exposure to a contaminant is disgust, and the security motivated behaviours would include washing (Neuberg et al., 2011). This process may prove similar to the attempts at “detoxification” that are practised by many individuals high in trait orthorexia after transgressing a self-imposed dietary rule.

There are no studies in the literature that investigate orthorexia as a security motivated behaviour. There are, however, a number of studies that have used cardiac reactivity to infer SMS activation in response to potential threat both in OCD and in healthy controls. A study by Hinds et al. (2012) involved participants with a diagnosis of OCD as well as healthy controls. Respiratory sinus arrhythmia (RSA) is an index of cardiac reactivity that was measured throughout the experiment using an electrocardiogram (ECG). A deviation from baseline in RSA was used to infer activation of the SMS. In this experiment, participants were told that they would eventually be asked to touch an object that may or may not be contaminated. The participants were instructed to sit quietly with their hands in their laps for 2 minutes during which a baseline measure of RSA was obtained. The participants were then asked to place their hands in bin filled with either Styrofoam beads, dry baby diapers, or baby diapers that had been wet. The three different stimuli represent different degrees of contamination threat, with the

beads presenting the lowest level of threat and wet diapers the highest. The participants were instructed to interact with the stimuli for 2 minutes. Next they were asked to sit quietly for 2 minutes. The participants then engaged in 30 seconds of handwashing, followed by another 2 minutes of sitting quietly. The participants were then allowed to wash their hands for as long as they desired, followed by 2 final minutes of sitting quietly. The purpose of having the participants sit quietly after each activity is to facilitate ECG recording that was compared to the baseline measure in order to infer the effect of each activity on cardiac reactivity. Both OCD and healthy controls displayed a change from baseline in RSA after interacting with the dry or wet diapers. After 30 seconds of handwashing, the RSA of the control group returned to baseline. In the OCD group however, the RSA only returned to baseline after they were able to wash their hands for an unlimited amount of time. In the context of the SMS, the diapers are the potential threat because the participant was unaware whether or not they are being exposed to urinary contamination. The handwashing is the security motivated behaviour. In the healthy controls, activation of the SMS can be inferred using RSA change after they are exposed to the potential threat. The SMS activation is terminated after they engaged in 30 seconds of handwashing. In the OCD group, the activation of the SMS occurs in response to the potential threat but it was not terminated by the 30 seconds of handwashing. In participants with OCD, an extended performance of the security motivated behaviour was required in order to terminate SMS activation. In addition, when participants were allowed to wash their hands for an unlimited duration, the OCD group washed for a longer duration than the control group. This supports the conclusion that OCD may be the manifestation of a deficit in terminating the SMS.

The course of SMS activation described above is also observed when the security motivated behaviour is checking as opposed to washing. In a study by Hinds et al. (2015),

participants were assigned to a candy group or a medication group. Participants in the medication group were asked to sort pills into appropriate dosages for specific times of day and different days of the week. They were told that they were testing a new pill-sorting strategy to help reduce the likelihood of patients consuming incorrect doses. The candy group sorted coloured candy. Next, the participants sat quietly for 2 minutes while their RSA was recorded using an ECG. The medication group was then given a speech about the importance of ensuring correct dosages and the consequences of dosing errors. They were also told that pill-sorting is difficult to do correctly and that people usually make a large number of mistakes that they do not realize. The candy group was not given this speech. All participants were then instructed to reflect on their performance on the task while their RSA was recorded. Half of the participants in each condition were then permitted to check over their performance on the previous sorting task for 90 seconds and then RSA was recorded again for 2 minutes. Finally, all participants were allowed to check over their performance for an unlimited period of time. In this study, the potential threat was the possibility of having made a mistake in sorting that could have serious health-related consequences for another person. The security motivated behaviour was the checking of one's own performance. The findings of the previous study by Hinds et al. (2012) involving handwashing as a security motivated behaviour were replicated in the present study on checking behaviour. The candy group showed no deviations from baseline in RSA over the course of the study because they were never exposed to a potential threat and, thus, never experienced SMS activation. By contrast, participants in the medication group demonstrated an RSA change from baseline after they were given a speech about the importance of accuracy and the high error rate before being asked to reflect on their own performance. This RSA change is indicative of SMS activation. RSA returned to baseline by the next ECG recording in the participants who were

allowed to check their performance for 90 seconds. The RSA of the group that was not allowed this 90 seconds of checking remained suppressed until they were allowed an unlimited duration of performance checking. Hinds et al. (2015) concluded that checking is another security motivated behaviour that is triggered by the SMS and serves as part of a negative feedback loop to terminate once activated. A second experiment was conducted as part of the same study to identify the course of SMS activation in individuals with OCD. The participants included individuals with OCD who were classified as “washers” or “checkers” according to their symptom presentation. All participants in the second experiment were asked to sort pills, given a speech about the importance of accuracy, and allowed to check their performance for 90 seconds, followed by an unlimited period of performance checking, as outlined previously. The results of the OCD group were compared to the results of the nonOCD individuals in the first experiment who were subject to the same procedure. The 90-second checking period did not terminate the SMS in OCD checkers, providing further support for the hypothesis that OCD is a manifestation of a deficit in SMS termination.

A study by Hinds et al. (2010) demonstrated that the performance of security motivated behaviour is required in order for SMS activation to be terminated in individuals without OCD. The participants were asked to interact with a stimulus bearing the potential threat of contamination and then performed a security motivated behaviour. The potential threat was wet baby diapers in a bin marked “Pediatrics” and the security motivated behaviour was handwashing. RSA was recorded via ECG at baseline and after each step of the experiment in order to infer SMS activity. Participants were assigned to one of three groups: information before contact, information after contact, or no information. The participants in the first group were given information that negated the threat before they were exposed to the stimulus. They were

told that the diapers had been wet with water but were not, in fact, contaminated with urine. This group demonstrated no SMS activation because they were never exposed to a potential threat. The second group interacted with the wet diapers prior to being provided with the negating information. This group demonstrated SMS activation in response to handling the wet diapers and activation was not terminated by the information that the diapers were not contaminated. The SMS activation ceased only when participants engaged in the security motivated behaviour of handwashing. The third group was not given any negating information but was allowed to wash their hands at the time interval when the second group was given the negating information. The third group demonstrated termination of the SMS at this time interval. The results of this study support the role of the performance of security motivated behaviour in terminating the SMS.

Relevance. The above three Hinds et al. studies provide an elegant research paradigm for the study of the maintenance of orthorexia. Specifically, they uniformly produce, in normal and OCD participants, security motivated behaviours—checking, washing—in response to perceived threat of contamination. The present study drew upon these observations to analyze security motivated behaviours among people with differing orthorexic tendencies with respect to food acquisition and ingestion. Specifically, different security motivated behaviours will be delineated in sections to follow with respect to how people responded to food exposure paradigms. Among these, cardiac reactivity is key to investigating activation of the SMS.

Vagal Tone

The SMS is an evolutionarily primitive system that operates outside of conscious control. The behavioural manifestations of SMS activation are managed by the autonomic branch of the peripheral nervous system. SMS activation, therefore, can be inferred through physiological monitoring of the activity of organs that are regulated by the autonomic nervous system.

Reactivity of the cardiovascular system, in concert with the respiratory system, occur in response to novelty, psychological stressors, and physical stressors, through action of the nervous system via the vagus and sympathetic nerves (Porges & Byrne, 1992). The vagus nerve is the 10th cranial nerve and belongs to the parasympathetic branch of the autonomic nervous system. According to polyvagal theory, the vagus nerve differs markedly between mammals and other classes, owing to significant deviations during mammalian evolution (Porges, 1995; 2001). The ancestral vagus nerve present in the reptilian class, among others, originates in the dorsal motor nucleus, which is located in the brainstem. It consists of unmyelinated fibers that innervate visceral organs. A novel development in mammalian phylogeny is the presence of a vagal branch, in addition to the ancestral branch, that originates in the nucleus ambiguus and sends myelinated projections to innervate the heart.

The rate of a beating heart oscillates in response to numerous factors, through feedback mechanisms via the central and peripheral branches of the nervous system. The greater the range spanned by these fluctuations is referred to as greater heart rate variability (HRV). Aspects of HRV, such as vagal tone, can be used as means of assessing the state of the central nervous system via measurement of cardiac electrical activity using an ECG (Porges & Byrne, 1992). Vagal tone refers to the medullary, respiratory center-modulated electrical outputs of the vagus nerve arriving at the sinoatrial node (the heart's natural pacemaker), which subsequently influences the rate of its beats as measured by the distance between two adjacent R-wave peaks of successive heartbeats (R-R interval; Porges & Byrne, 1992).

Measurement of RSA, that changes HRV in concert with spontaneous respiratory activity, provides an index of the vagal nerve output to the cardiac pacemaker (Porges & Byrne, 1992). Fluctuations in vagal tone occur in response to the energy demands of an individual.

Greater output from the vagal nerve to the heart produces a slowing of heart rate and can therefore be referred to as activation of the “vagal brake.” Increased vagal tone, or activation of the vagal brake, is associated with lower energy demands, whereas removal of this vagal brake is associated with higher energy demands.

Porges (2001) outlines three neural systems, with distinct effects on the autonomic nervous system, that arose during different stages of evolutionary development. Each of these three systems can be anatomically, physiologically, and behaviourally distinguished from each other. The most primitive of the three systems is under the control of the ancestral unmyelinated vagus nerve that originates in the dorsal motor nucleus. In response to imminent danger, entry into an autonomic state dominated by the ancestral unmyelinated vagus nerve occurs resulting in a decrease in energy output. The behavioural manifestation of this autonomic state involves a freezing or feigning death response. The second stage in phylogenetic development is associated with the emergence of an autonomic state under the dominance of the sympathetic nervous system. In response to threat, the sympathetic branch of the autonomic nervous system is predominately in control and facilitates the high energy output required for fight-or-flight behaviours. During this state, activity of the ancestral unmyelinated vagus nerve is inhibited. The most recent stage of phylogenetic development with respect to nervous control of autonomic state is associated with the appearance of a second vagal branch, originating in the nucleus ambiguus and extending to the sinoatrial node of the heart where it plays a regulatory function in cardiac activity. This phylogenetically recent branch of the vagal nerve is myelinated, enabling quick changes in cardiac regulation. Increased activity of the myelinated vagal branch, also referred to as activation of the vagal brake, is associated with a suppression of metabolic activity. The behavioural manifestation of this autonomic state involves social communication and

relaxation. Woody and Szechtman (2011) discuss SMS activation as a distinct autonomic state, the “novelty/potential threat” autonomic state, that lies intermediary between the second and third autonomic states outlined by Porges (2001). SMS activation is characterized by a removal of the vagal brake, or a decrease in cardiac output from the inhibitory myelinated vagal branch. The novelty/potential threat autonomic state is distinguishable from the second stage of phylogenetic development by the limited activity of the sympathetic branch of the autonomic nervous system. The behavioural manifestations of the novelty/potential threat autonomic state include hypervigilance to the environment and orientation to novelty. These behaviours are also the behavioural manifestations expected during SMS activation.

Vagal tone and security motivation. In addition to observable behaviours that indicate SMS activation, engagement of this system can also be monitored physiologically through cardiac reactivity (Woody & Szechtman, 2011). The security motivated behaviours triggered by SMS activation, which involve probing the environment for information, are not energy costly. Because the individual is probing for indicators of danger, there is always the chance that the initial suspicions will prove correct, and that high energy outputs will be required through activation of the fight-or-flight system (Woody & Szechtman, 2011). Thus, the most adaptive state would be one that is low in energy demands and that also allows for quick activation of a more energy-costly state if such a state is indicated (Woody & Szechtman, 2011). A specific balance of parasympathetic-sympathetic activity, as described by Woody and Szechtman (2011), encompasses the requirements that would enable this type of state. This state has been labelled the “novelty/potential threat” autonomic state (Woody & Szechtman, 2011). In addition, the response of orienting or attending to novelty, a hallmark of the security motivated state, is regulated by vagal innervation of the sinoatrial node of the heart (Porges, 1995). By measuring

cardiac reactivity, SMS activation can be inferred when entry into the novelty/potential threat autonomic state occurs.

Relevance. Activation of the SMS leads to security motivated behaviours which, in turn, terminate the activation. Suppression of RSA is associated with SMS activation and engagement in security motivated behaviours facilitates a return to baseline with respect to RSA. The research studies by Hinds et al. (2010; 2012; 2015) and by Woody et al. (2005) that have been discussed previously have drawn attention to two security motivated behaviours in particular: washing and checking. The present study aimed to illuminate other possible security motivated behaviours that may occur in individuals with orthorexic tendencies in response to food exposure. One potential security motivated behaviour of this nature is a cognitive bias in favour of natural foods. This hypothetical cognitive bias, whereby natural foods are perceived more positively than nonnatural foods as the result of an automatic judgment, may serve as a security motivated behaviour in that it contributes to the avoidance of foods that carry the potential threat of contamination.

Cognitive Bias

Cognitive bias refers to a judgement that is not made on the basis of objective information. There are many types of cognitive biases that are universally present and are adaptive for decision-making purposes. Cognitive heuristics, for example, are mental algorithms that are employed because they are efficient means that typically guide adaptive choices or behaviour, though they may not always prove correct. In the context of food choices, cognitive heuristics such as dichotomous thinking about good and bad foods or dose insensitivity with respect to potential for harm are two examples of cognitive biases that are widespread in the healthy population (Rozin et al., 1996).

Attentional bias. Attentional bias is a form of cognitive bias in which an individual's attention is disproportionately allocated such that more or less attention is paid to a given stimulus type. Attentional biases are notable in certain mental disorders. For example, reduced attention to external cues accompanied by an inward attentional bias has been observed in OCD and anorexia nervosa, as well as in individuals with high trait orthorexia (Koven & Abry, 2015). To the contrary, after a subtle cue triggers the SMS, an external attentional bias is demonstrated, where the individuals direct attention to the environment to gather information and search for threats to security (Woody & Szechtman, 2011).

Attentional bias can also affect food choices, as was demonstrated in a study in which individuals were trained using a modified dot-probe task to attend either to healthy or unhealthy food cues (Kakoschke, Kemps, & Tiggemann, 2014). The participants who were trained to attend to healthy food cues consumed more of healthy snacks in comparison to their own consumption pretraining and when compared to the group trained to attend to unhealthy food cues (Kakoschke et al., 2014). Another study showed that individuals high in trait food craving showed reduced approach and increased avoidance behaviours for palatable foods following training using a modified dot-probe task (Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015). In addition, there was a change in attentional bias that shifted from an attending bias to an avoidance bias for the palatable foods (Brockmeyer et al., 2015).

Implicit cognition. Implicit cognition is another form of cognitive bias in which an individual's previous experiences have an impact on their beliefs, attitudes, or judgements in a way that they cannot overtly identify (Greenwald & Banaji, 1995). Food choices tend to be largely governed by implicit attitudes rather than through conscious and effortful decision-making (Ellis, Kiviniemi, & Cook-Cottone, 2014). In contrast, a disconnect between implicit

attitudes and behavioural choices has been observed in eating disorders such as anorexia, possibly owing to the fact that an externally-constructed, thin ideal is dictating food choices (Ellis et al, 2014). It is unclear whether implicit attitudes about food held by individuals high in trait orthorexia would be aligned with observable behaviours in terms of food choices. External factors may be primarily responsible for influencing food choices. Information about healthy food choices, advertising, eating trends, for example, may have an influence. An alternative explanation, however, is that an internally generated motivation, the SMS, has a strong influence on food choice.

Explicit attitudes and beliefs can be assessed using direct questioning since individuals are aware of, and can articulate, these cognitions. Implicit attitudes are automatic judgements that often take place without conscious awareness and thus are more difficult to ascertain via direct probing. One method that has been used to investigate implicit cognitions is the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998). The IAT involves computerized presentation of target concepts (for example African-American and European-American faces) and attributes (for example positive and negative words) that are sorted by participants into appropriate categories according to presented instructions. The response times and error rates for different pairings (for example African-American faces paired with positive words compared to African-American faces paired with negative words) are used to infer the presence of implicit cognitions with respect to the target concepts.

Relevance. Modified IATs have been used in a number of studies in order to evaluate implicit attitudes about food choices and eating behaviour (Haynes, Kemps, Moffitt, & Mohr, 2015; Prestwich, Hurling, & Baker, 2011; Richetin, Perugini, Prestwich, & O’Gorman, 2007; Werle, Trendel, & Ardito, 2013). A modified IAT was employed in the present study in an effort

to delineate the association between trait orthorexia and one hypothetical security motivated behaviour of cognitive bias in favour of natural foods. The IAT constituted one of four different, experimentally contrived food exposures to participants, occurring third in the experimental sequence employed in the present study. Performance on this IAT, operationally defined in terms of response times and error rates, was used as an index of this cognitive bias. It was predicted that individuals higher in trait orthorexia would demonstrate quicker response times and make fewer errors when categorizing natural foods with positive words than when categorizing natural foods with negative words. Additionally, quicker response times and fewer errors were expected by individuals higher in trait orthorexia when categorizing nonnatural foods with negative words than when categorizing nonnatural foods with positive words. This prediction is in accordance with the core belief system regarding food that is held by individuals with high levels of trait orthorexia. Specifically, a dichotomy of healthy and unhealthy foods is created that dictates the types of foods that are approached and avoided. The modified IAT was used to assess the extent of the automatic associations of certain categories of food as positive and others as negative. This hypothetical bias constitutes a security motivated behaviour because it promotes the avoidance of food types that are considered a threat in terms of the potentially adverse health-related consequences of consumption.

In addition to the modified IAT, participants of the present study engaged in three other food exposure tasks, each of which was expected to illuminate a particular expression of security motivated behaviour. Security motivated food preference was expected to manifest in the first of the four food exposures called the food preference task. Given the choice of different foods from which to eventually consume in the laboratory (see taste test below), it was predicted that trait orthorexia would be associated with a preference for natural over nonnatural food offerings.

Within the context of the second food exposure—specifically, a taste test where food-related threat level was manipulated—it was expected that trait orthorexia in addition to threat level would predict security motivated behaviours that manifest as a preference for the natural food choices, operationally defined as the volume of natural versus nonnatural food consumed. The third experimentally contrived food exposure consisted of the modified IAT as outlined above. An additional IAT measure was completed by participants in which the target concepts comprised high- and low-calorie foods. This was included as a measure that would be able to offer data regarding discriminant validity for the first IAT in the assessment of orthorexia-related bias. Caloric value is not conceptualized as an important factor in the determination of food choice among those high in orthorexia.

Security motivated behaviour in the form of natural food preference and nonnatural food avoidance was expected to manifest during the fourth and final food exposure consisting of a simulated shopping task. Here participants were instructed to select food items from a grocery flyer and to shop within a given a nominal monetary limit. Participants' food preference elicited during the shopping task would constitute a security motivated behaviour because it promotes the avoidance of foods perceived as threatening which, in turn, reduces the perceived threat. The food preference in this task was operationally defined in terms of the proportion of selected items that are considered natural foods. It was expected that food preference in this task would be predicted by trait orthorexia.

The Present Study

There currently are no models that account for the genesis and maintenance of orthorexia. From an evolutionary perspective, the existence of orthorexia as a trait may be understood in terms of a selective advantage that it provided at some point during evolutionary history. The

advantage of restricting certain types of food with uncertain health-related impact would have been the minimization of the likelihood of consuming contaminated food, thereby reducing the chances of becoming ill. Consequently, the maintenance of this behaviour can be studied in the context of a biologically hardwired system that served an adaptive purpose throughout evolution by contributing to the probability of survival. The SMS is particularly relevant to the study of trait orthorexia. This system is activated in response to potential threat, such as that of contamination, and motivates the individual to perform behaviours in the interest of personal security. Security motivated behaviours that are elicited by the SMS also serve to terminate its activation. Although no security motivated behaviours specific to orthorexia have been investigated, a number of experiments have been conducted pursuant to the study of security motivated behaviour in response to the threat of contamination (Hinds et al., 2010; 2012; Woody et al., 2005). It is possible that threat of contamination underlies the avoidance of nonnatural foods in orthorexia, thus providing the bridge between this trait and the SMS.

An aim of the current study was to delineate a number of security motivated behaviours associated with exposure to food. SMS activation can be inferred through cardiac monitoring because of the suppression in RSA that occurs in conjunction with SMS activation. Several indices of HRV were recorded in the present study as means of assessing the activity of the SMS. Security motivated behaviours such as washing and checking have been investigated previously in studies involving the SMS (Hinds et al., 2010; 2012; 2015; Woody et al., 2005). The present study represents an investigation of the SMS and its potential involvement in the maintenance of orthorexia. The security motivated behaviours of interest included cognitive bias and food preference with respect to natural foods. SMS activation was also assessed as a function of trait orthorexia in response to exposure to nonnatural foods, thus bearing the threat of potential

contamination.

The purpose of the present study was to determine the extent to which orthorexia is associated with manifestations of security motivated behaviour when people were faced with four different forms of food exposure in a laboratory setting as follows:

1. **Food preference task.** A food preference task involving the rank ordering of six food items, half of which are considered natural food items, was used to investigate the security motivated behaviour of food preference. The independent variable, trait orthorexia, was expected to predict performance on the food preference task, sample ranking, operationally defined as the number of natural items ranked in the top three positions. Specifically, it was predicted that higher trait orthorexia would be associated with more natural than nonnatural items ranked in the top three positions.
2. **Taste test.** A taste test involving the same six food items from the food preference task, half of which are natural food items, was used to investigate activation of the SMS in response to threat level. Threat level was experimentally manipulated across two conditions such that participants were exposed either to a high or low level of threat. The threat was the uncertainty regarding the number of food samples the participant was instructed to taste. It was predicted that this feeling of uncertainty would not be experienced as equally threatening to all participants. As such, trait orthorexia was included as an individual differences variable that was expected to interact with experimentally-induced threat level (low vs. high) to predict SMS activation. It was predicted that the uncertainty regarding the number of food samples the participant was instructed to taste would be experienced as threatening only by individuals high in trait orthorexia. This is because three of the food choices include

nonnatural ingredients that are, presumably, avoided by individuals high in trait orthorexia. The uncertainty would be threatening because participants were unaware if they would be asked to taste the foods they might usually avoid. It was predicted that this potential threat would activate the SMS only in individuals high in trait orthorexia who were randomized to the high threat condition. SMS activation is a change in ANS functioning that occurs in response to potential threat in order to facilitate a state of preparedness in the individual in case the potential threat proves veridical. The expected change in ANS functioning was assessed through monitoring of changes in HRV over the course of the experiment. It was predicted that the individuals higher in trait orthorexia who were randomized to the high threat condition would demonstrate a change from baseline HRV during the period in which they would be uncertain about the number of food samples they would be instructed by the experimenter to taste. Specifically, it was predicted that the experimentally induced threat level would moderate the relationship between predictor variable—trait orthorexia—and criterion variable SMS activation, defined as deviation from resting baseline HRV; specifically, a reduction in HRV under threat condition relative to resting baseline (see Figure 1). Trait orthorexia was hypothesized to predict SMS activation only in individuals subjected to the experimentally induced high level of threat.

- 3. Implicit Association Test (IAT).** An Implicit Association Test was used to ascertain security motivated behaviour manifested as cognitive bias in the form of implicit attitudes about food categories. The automatic association of natural or nonnatural foods with positive or negative words was evaluated in order to determine the

existence of a cognitive bias whereby natural foods are perceived more positively than nonnatural foods. The independent variable trait orthorexia was expected to predict performance on the IAT, operationally defined in terms of response times and error rates. Specifically, it was predicted that higher trait orthorexia would be associated with quicker response times and fewer errors when associating images of natural foods with positive words and images of nonnatural foods with negative words, than when associating natural foods with negative words and nonnatural foods with positive words.

4. **Shopping task.** A simulated grocery shopping task was used to establish security motivated behaviour manifested as food preference. Food preference was evaluated given a choice between less expensive and nonnatural or more expensive and natural versions of a number of food items. A simulated grocery shopping list was constructed by participants who were instructed to adhere to a financial limit. The independent variable, trait orthorexia was expected to predict performance on the shopping task, operationally defined as the proportion of selected items that are considered nonnatural. Specifically, it was predicted that higher orthorexia would be associated with fewer nonnatural items selected.

Method

Participants

The present study recruited male and female students as the literature suggests no gender differences in orthorexia. Of the 100 total participants whose data were included in the present analyses, 77 were female. Regarding BMI, the mean was 24.38 ($SD = 4.88$). The participants BMI ranged from 18.21 to 40.94. Participants were recruited from Psychology undergraduate

courses at Lakehead University. Students were directed to the online Sona Experiment Manager System where they could view a description of the study, the inclusion criteria, and could sign up to complete the online questionnaire battery via SurveyMonkey that comprised the first part of the study. Upon visiting the SurveyMonkey website, the participant first viewed an information letter (Appendix C) and participant consent form (Appendix D). A total of 374 participants completed the online questionnaire battery, 103 of whom volunteered to complete the laboratory session as well. Participants received half of one (0.5) bonus point for completing the online questionnaire battery and two (2) bonus points for completing the laboratory visit. Bonus points were applied to participants' final grade in an undergraduate Psychology course eligible for bonus points.

Materials

Eating Attitudes Test-26. (EAT-26; Garner, Olmsted, Bohr, & Garfinkel, 1982; Appendix E). This measure is a shortened version of the original Eating Attitudes Test (Garner & Garfinkel, 1979), and was created through factor analysis. Three factors were identified, namely “dieting”, “bulimia and food preoccupation”, and “oral control,” (Garner et al., 1982). The EAT-26 is intended to assess abnormal concern over food and weight (Garner et al., 1982). The EAT-26 is composed of 26 items, each with six response options (*always, usually, often, sometimes, rarely, never*; Garner et al., 1982). The EAT-26 has shown high internal consistency with Cronbach's α values of .90 and .83 for females with anorexia and controls, respectively (Garner et al., 1982). Another study found slightly higher internal consistency (Cronbach's $\alpha = .92$; Rudiger, Cash, Roehrig, & Thompson, 2007). The corrected item-total correlations are within the acceptable range (.44 - .71; Garner et al., 1982). The concurrent validity of this measure was assessed through a comparison between a group of females with anorexia and a control group

consisting of female university students, revealing significantly different scores between the two groups (Garner et al., 1982). This instrument was used in the present study to measure disordered eating and was included in the analyses as a covariate. Disordered eating, as measured by this scale, is not characteristic of orthorexia per se; the underlying motivation for the restriction of food is not driven by weight or shape concerns. However, due to the significant degree of overlap between anorexia and orthorexia in presentation, a notable degree of shared variance observed with respect to these two constructs was expected in the context of the present study.

Body Image States Scale. (BISS; Cash, Fleming, Alindogan, Steadman, & Whitehead, 2002; Appendix F). This scale is intended to measure states of appraisal, satisfaction, and emotional reactions to one's own body. The domains assessed include satisfaction regarding physical appearance, body size and shape, and weight; feelings of attractiveness, and feelings about appearance compared to usual feelings and compared to others. There are six items on the scale, each with nine response options on a bipolar continuum. Higher scores on the BISS indicate more positive body image. The internal consistency of the measure was found to be acceptable by the authors for women (Cronbach's $\alpha = .77$) and for men (Cronbach's $\alpha = .72$; Cash et al., 2002). Another study in which participants completed the BISS once daily over a period of 10 days found higher internal consistency (Cronbach's $\alpha = .81 - .92$; Rudiger et al., 2007). The test-retest reliability over a two to three-week test interval was $r = .69$ for women and $r = .68$ for men (Cash et al., 2002). Construct validity of the scale was demonstrated by Cash et al. (2002) in a study where two groups, either showing a dysfunctional investment in personal appearance or not, differed significantly in their responses. The BISS was used in the present study to measure the construct of body image. This construct was included in the analysis as a covariate; it was expected that the predicted relationship between threat level, trait orthorexia,

and SMS activation would persist after controlling for body image. This prediction was guided by the fact that orthorexic eating behaviour is not driven by concerns of shape or weight. The motivation for the observed restriction of food is the pursuit of health, not weight loss.

Short Health Anxiety Inventory. (SHAI; Salkovskis, Rimes, Warwick, & Clark, 2002; Appendix G). This measure is a shortened version of the original Health Anxiety Inventory (Salkovskis et al., 2002) and was created using an empirical approach by selecting the items from the original measure that had the greatest item-total correlations in a study involving participants with hypochondriasis (Alberts, Hadjistavropoulos, Jones, & Sharpe, 2013). The SHAI is intended to assess the construct of hypochondriasis, described as an unfounded fixation with the idea of being or becoming ill, which manifests as hypervigilance to body and bodily functions, engagement in safety behaviours, and the experience of health-related anxiety (Abramowitz, Deacon, & Valentiner, 2007). The SHAI is composed of 18 items, each with four possible response options. One study in which the SHAI was administered four times over a 3-week period demonstrated high internal consistency of the measure (Cronbach's $\alpha = .84 - .89$) and test-retest reliability ($r = .87$; Olatunji, Etzel, Tomarken, Ciesielski, & Deacon, 2011). Another study also showed high internal consistency (Cronbach's $\alpha = .86$; Abramowitz et al., 2007). The construct validity of this measure was assessed by a study that looked at SHAI scores in relation to utilization of medical services and engagement in safety behaviours (Abramowitz et al., 2007). The SHAI was used in the present study to measure the construct of health anxiety. This construct was included in the analysis as a covariate; it was expected that the construct of health anxiety will covary with the construct of orthorexia. This prediction was made on the basis of health concern being the motivating factor behind the eating style observed in orthorexia.

ORTO-15. The ORTO-15 (Appendix B; Donini et al., 2004) is the most widely used instrument for the detection of orthorexia. Despite the psychometric limitations outlined previously (see pp. 15-16), it is the current gold standard test for this purpose and was therefore the first choice in terms of instrument with which to measure the construct of orthorexia. Another option for the assessment of orthorexia in the present study was the Polish version of the ORTO-15 (ORTO-P9), comprising only nine of the original items. Given the inconsistent findings regarding the reliability of the ORTO-15, it was decided that the scale used to measure the predictor variable would be contingent upon observed psychometric performance. The construct of orthorexia was included in the analysis as a predictor variable in all four hypotheses.

Balanced Inventory of Desirable Responding. (BIDR; Paulhus, 1988; Appendix H). The BIDR is intended to measure positive exaggerations in response style. Specifically, two constructs are assessed: self-deceptive positivity and impression management. The former refers to the endorsement of positively biased statements that are believed by the respondent and the latter refers to a deliberate attempt to present oneself in a positively exaggerated regard. Each of the two constructs may be assessed independently. Alternatively, all of the items may be summed to produce an overall index of desirable responding, as was done in the present study.

The scale comprises 40 statements for which the respondent must indicate the degree to which they agree, on a continuum from 1 to 7. Participants are given 1 point for extreme responses, defined as endorsing a rating of 1 or 2 (6 or 7 for reverse-scored items) and 0 points for nonextreme responses. After summing these values, higher scores are indicative of a greater extent of desirable responding. The internal consistency of the measure was found to be acceptable by the author (Cronbach's $\alpha = .83$; Ciarrochi & Bilich, 2006). In addition, a metaanalysis by Li and Bagger (2007) demonstrated that the average internal consistency of the

overall index of desirable responding was acceptable, taking 18 studies into consideration (Cronbach's $\alpha = .80$). The range of reliability coefficients reported in this article span from Cronbach's $\alpha = .68$ to $.86$. The BIDR was used in the present study to measure the construct of social desirability. Participants with extreme scores on this measure were excluded from analyses. Extreme scores were defined as statistical outliers and comprised values with standard deviations greater than 3.29 times the mean.

Taste test stimuli. The participants were asked to sample a variety of energy bars during the taste test, as described in the Procedure section. Three of the food samples are considered to be natural foods and include: mixed berry granola bars of the brand "Made Good™" peanut butter chocolate protein bars from the brand "Simply Protein™," and berry green superfood bars from the brand "Amazing Grass™". These foods are labelled as natural on the packaging information that was available to the participant during the food preference task and taste test. The nutritional information and ingredients lists were viewed by the participants during the food preference task. The remaining three samples are not considered to be natural foods and include: mixed berry cereal bars from the brand "Great Value™," peanut butter chocolate protein bars from the brand "Special K™," and berry burst energy bars from the brand "Vector™". These brands and flavours were chosen in an effort to match for different preferences that could affect choice. The natural and nonnatural groups contain one bar marketed as a diet food (Simply Protein™, Special K™), one bar with a greater caloric value (Amazing Grass™, Vector™), and one bar that is a cereal or granola bar rather than a protein or energy bar (Made Good™, Great Value™). Within each of these three categories, an attempt was made to choose flavours that were similar.

Procedure

A questionnaire battery was completed online via SurveyMonkey, including the EAT-26 (Appendix E), the BISS (Appendix F), the SHAI (Appendix G), and the ORTO-15 (Appendix B). The participants were then able to sign up through the online Sona Experiment Manager System to schedule a laboratory session to occur in the days or weeks ahead. The participants were advised not to consume any food or caffeine in the 2 hours prior to their scheduled laboratory session and not to consume any alcohol in the 12-hour period before their visit because these factors are known to affect HRV.

Upon arrival to the scheduled laboratory visit, the experimental procedure was explained to the participant. A timeline of this procedure is provided in Figure 2. The participant was asked to read and sign the consent form that was previously signed prior to the online completion of the questionnaire battery (Appendix D). The participant was then instructed to clean their skin with an alcohol solution and to attach three electrodes in a lead-II ECG configuration, below the right clavicle (positive), below the left rib (negative), and below the left clavicle (ground). Refer to Appendix I for electrode placement instructions. The placement of the electrodes was verified by the experimenter. The participant was then instructed to be seated and to remain as still as possible, with the exception of movements required to engage in tasks throughout the experiment. Seven ECG recording blocks occurred: the first four pertaining to the food preference task and the last three for the taste test, IAT, and Shopping Task, respectively. The first two recording blocks occurred in order to obtain a baseline ECG recording.

Food preference task and taste test. The participants were randomly assigned to either the high or low threat group. This randomization was conducted using a randomization option via SurveyMonkey. The participants were seated at a table facing a computer screen with a computer mouse in front of them and told that they were participating in a taste test in order to

examine heart activity that occurs when people interact with food. The food preference task consisted of four recording blocks. First, the participants viewed a series of household objects (*recording block 1*) and were asked to rate the items in order of preference. The duration of this slideshow was 3 minutes. The participants were then asked to sit quietly with their eyes closed for a period of 3 minutes, instructed to think about how they would use each of the household items viewed, one after the other (*recording block 2*). This instruction was provided in order to cognitively engage the participant in a way that approximated the food exposure portion of the task (description to follow) in an effort to minimize the differences between baseline and experimental blocks. Next, participants were told that the series of photos they were about to view was comprised of the six food samples that would be presented in the upcoming taste test. Those in the low threat condition were told they would soon be asked to “*sample three or more items in a taste test*”. Those in the high threat condition were told they would be asked to “*sample the items in a taste test*”, bearing the implication that all six of the samples would need to be tasted. All participants proceeded to view the series of images consisting of the packaging, nutritional label, and ingredients list of each of the food samples (*recording block 3*) for a duration of 3 minutes. The participants then rated the samples in order of preference and then were asked to engage in a second eyes-closed recording, instructed to think about the samples that would be tasted (*recording block 4*). It is only at this time that all participants were informed that they would be asked to taste three or more of the samples. Thus, for the duration of recording blocks 3 and 4, those in the high threat condition were presumably under the impression that they would be instructed to taste all six of the samples, three of which are nonnatural foods. This condition is considered high threat because three of the food items are not natural and therefore have the potential to be perceived as threatening to an individual high in

trait orthorexia.

Next, the experimenter provided the six samples, in bite size pieces, on a tray to the participants. Participants were provided with a page indicating where on the tray each sample was located. Plastic forks were provided for the participants to sample the food items. The samples were weighed using a scale without the participant's knowledge before and after their taste test in order to determine the exact quantity of each food type consumed. After the participant sampled the food, the experimenter removed the tray with the food and weighed each sample, out of the view of the participant. The participant was asked to rate the samples in order of preference for a second time. The purpose of this rating was to facilitate the guise of a taste test and these responses were not included in the analysis. The data of interest from this task included the physiological data obtained from the ECG recording as well as the behavioural data in terms of the amount of food consumed, both overall and proportionately between natural and nonnatural items.

Implicit Association Test. A modified version of the IAT using two target concept pairs and one attribute, as described by Greenwald et al. (1998) was completed by participants. The task involved three classification tasks: positive or negative words (attribute), pictures of natural or nonnatural foods (target concept 1), and pictures of high or low-calorie foods (target concept 2). The second target concept, caloric value, was included in effort to establish discriminant validity. Natural food was operationally defined for the purposes of this study as foods that would typically be preferred by an individual whose style of eating resembles that of an individual high in trait orthorexia. For example, target concept 1 included an image of an organically-labelled zucchini for the natural concept and an image of a slice of processed cheese for the nonnatural concept. Images for target concept 1 were obtained from an internet search

and can be found in Appendix J. Items were selected on the basis of labelling that indicated natural features and foods that were evidently nonnatural, regardless of one's familiarity with natural food products or level of orthorexia. Images for target concept 2 (caloric value) were obtained from the *Food-pics* image database and can be found in Appendix J (Blechert, Meule, Busch, & Ohla, 2014). Items were selected on the basis of caloric density. High-calorie items had greater than 200 calories per 100 grams and included a cookie and some cashews, for example. Low-calorie items had less than 50 calories per 100 grams and included a cucumber and some blueberries, for example¹. A subset of positive and negative words was selected for inclusion from the word lists provided by Greenwald et al. (1998). The positive words used were "happy," "honest," "health," "love," "peace," "cheer," "friend," and "pleasure." The negative words used included "hatred," "rotten," "filth," "poison," "sickness," "evil," "death," and "grief."

Each IAT measure consisted of five blocks each with a number of stimulus presentations (trials). *Blocks 1, 2, and 4* have 20 trials each and *Blocks 3 and 5* each have 60 trials: 20 practice trials (*block 3a + 5a*) and 40 test trials (*block 3b + 5b*). Two IAT measures were completed in immediate succession – the first assessing bias pertaining to the naturalness of food and the second assessing bias with respect to caloric value. *Block 1* was initial target-concept discrimination where the participant sorted nonnatural foods to the right side of the screen and natural foods to the left. *Block 2* was evaluative attribute discrimination where the participant sorted positive words to the right side of the screen and negative words to the left. *Block 3* was the first combined task in which positive words and nonnatural foods were sorted to the right side

¹ High-calorie items included image numbers 0004, 0022, 0045, 0092, 0110, 0113, 0174, and 0488 from the *Food-pics* image database. Low-calorie items included image numbers 0199, 0229, 0248, 0250, 0267, 0429, 0453, and 0508.. These images can be observed in Appendix J.

of the screen and negative words and natural foods to the left. *Block 4* was the reversed target-concept discrimination in which the participant sorted nonnatural foods to the left side of the screen and natural foods to the right. *Block 5* was the reversed combined task in which nonnatural foods and negative words were sorted to the left side of the screen and natural foods or positive words to the right. The second measure began immediately after *block 5* of the first measure and involved all five of the blocks with low and high-calorie foods replacing natural and nonnatural foods, respectively. The laterality of stimulus presentation was counterbalanced across participants such that half of the participants completed the IAT as outlined above and the remainder completed the same sequence but with the words “left” and “right” transposed in the description above. Each participant was given a sequential ID number upon commencing the laboratory component of the study. Participants were assigned to a counterbalancing condition on the basis of the ID number such that odd numbered participants were assigned to group 1 and even numbered participants were assigned to group 2. This counterbalancing was conducted in order to account for any observed differences in error rates or response times attributable to differences in the dominant hand of the participant rather than differences due to implicit attitude to food characteristics. Prior to the start of each block, instructions appeared on the screen to inform the participant how to sort the subsequently presented stimuli. Category labels remained on the screen in the upper corners throughout the block so the participant remained aware of the correct categories. The participant was asked to sort the stimuli that appear in the center of the screen into the appropriate categories as indicated in the top right and left corners of the screen by hitting the ‘E’ or ‘I’ keys, respectively, on a standard computer keyboard. The stimuli were presented until the participant categorized them using the keyboard. If a participant sorted a stimulus incorrectly, the word ‘error’ would appear in the center of the screen for 300 ms. Each

block included a number of trials and the interval between each trial was 400 ms. This procedure reflects the procedure described by Greenwald et al. (1998) in the original IAT employing two target concept pairs. The modified IAT was administered using Inquisit (Version 4.0) Software.

Shopping task. The participant was instructed to choose items from a catalogue of groceries presented on the computer screen to simulate a grocery shopping experience (see Appendix K). They were given a fake limit of \$100 and asked to select items as if they were grocery shopping for themselves for 2 weeks. For each type of food available, there was two options. One option was presumably nutritionally favourable from the perspective of an individual high in trait orthorexia, but was also more expensive. Items and prices were derived from actual prices of food items at local grocery stores and food shops in order to approximate the typical decisions made regarding food. For example, there was two types of apples to choose from: apples at a cost of \$0.97/lb or organic apples at a cost of \$2.49/lb. The images were identical for the orthorexia-favourable and nonfavourable version of the food and were obtained from the *Food-pics* image database (Blechert et al., 2014). This task served as a behavioural index of food choices and also provided data to make inferences about the willingness to expend more financial resources in order to adhere to a particular eating style. After the completion of this task, participants were instructed to remove the electrodes from their body, had their height and weight measured, were thanked for their participation and excused.

Recording of the electrocardiogram (ECG). ECG was recorded during seven recording blocks (Table 1). Blocks 1 and 2 occurred while the participant viewed the household items and sat quietly with their eyes closed, respectively. These blocks served as the ECG baseline. Blocks 3 and 4 occurred while the participant viewed the food label images and sat quietly with their eyes closed, respectively. The ECG recordings of blocks 1 through 4 were each three minutes in

length. These blocks served as the first food exposure. Blocks 5, 6, and 7 occurred while the participant engaged in the taste test, the IAT, and the shopping task, respectively. These recording blocks were included for the purposes of future exploratory analysis unrelated to the purposes of the present study. A 72-channel amplifier (Advanced Neuro Technology, Enschede, Netherlands) was used to record ECG activity at a sampling frequency of 1024 Hz.

Results

HRV Variables

HRV reactivity is defined as the deviation from baseline in response to an event or stressor. A commonly used research practice for the determination of HRV reactivity is to calculate a difference score by subtracting the baseline variable (block 1 and 2 household item exposure) from the HRV variable pertaining to the period of interest (block 3 and 4 food exposure). Difference scores, however, can be artificially augmented by regression to the mean or other artefactual processes. As such, it is recommended that, rather than calculate difference scores, the final state variable be included in the analysis as an outcome variable and the baseline variable included as a covariate (Hayes & Rockwood, 2016). The present study abided by the aforementioned recommendation and did not employ difference scores. The variables included for evaluating HRV reactivity depended upon the recording period of interest. HRV recording block 1 was included as a covariate when HRV recording block 3 was the final state as both recordings were obtained while the participants viewed a series of stimuli (control or food exposure). HRV recording block 2 was included as a covariate when HRV recording block 4 was the final state as both recordings were obtained while the participants sat with their eyes closed and were instructed to think about the previously viewed stimuli (control or food exposure). A composite baseline score obtained by averaging blocks 1 and 2 was used as a covariate when the

final state was a composite food exposure score obtained by averaging blocks 3 and 4 (see Composite scores section below).

The HRV indices of interest were as follows: the square root of the mean squared successive differences (RMSSD) in the cardiac inter-beat interval; the absolute power of the high frequency band (HF); the standard deviation of data points perpendicular to the line of identity on a Poincaré plot (SD1). The RMSSD variable is derived from a time-domain method of analysis. It is calculated using the distance between successive R-wave peaks (R-R intervals) in the cardiac rhythm and is a measure of short term variability suited to short recording durations employed in the present study. RMSSD is expressed in units of milliseconds (*ms*; Tarvainen, 2014). The HF variable is derived from a frequency-domain method of analysis which involves the calculation of a power spectrum density for the inter-beat intervals. HF falls within the band of 0.15-0.4 Hz, and is expressed in absolute power and units of milliseconds squared (m^2 ; Tarvainen, 2014). By contrast to these linear measures of HRV, the SD1 variable is derived from a non-linear method of calculation. A Poincaré plot is constructed in which each R-R interval is plotted against the subsequent R-R interval to display the successive correlations (i.e., the correlation between the first and second R-R interval, the correlation between the second and third R-R interval, etc.) A line of identity is then constructed that fits best through the cloud of points. The standard deviation of the points measured perpendicular to the line of identity is a measure of the breadth of the cloud of data points (Piskorski, 2007). This standard deviation comprises the HRV variable SD1 which is a measure of short term variability that is predominantly attributed to respiratory sinus arrhythmia. SD1 is expressed in units of milliseconds (*ms*; Tarvainen, 2014).

Composite scores. In addition to the HRV variables for individual blocks, two composite

HRV variables were calculated. These variables were created to facilitate data reduction. The baseline composite score, indicated by the subscript B, was calculated by averaging blocks 1 and 2. The exposure composite score, indicated by the subscript E, was calculated by averaging blocks 3 and 4. Prior to the calculation of these composite scores, two paired t-tests were performed to detect any significant differences that would contraindicate the amalgamation of the scores. With respect to the baseline composite, no significant differences were found in the comparison of blocks 1 and 2 for RMSSD, $t(99) = 1.59, p = .115$; for HF, $t(99) = 0.41, p = .683$; or for SD1, $t(99) = 1.60, p = .115$. With respect to the exposure composite score, no significant differences were found in the comparison of blocks 3 and 4 for RMSSD, $t(99) = -1.17, p = .245$; for HF, $t(99) = -1.09, p = .280$; or for SD1, $t(99) = -1.17, p = .245$. Thus, no contraindications to the formation of composite scores for baseline (blocks 1 and 2) and food exposure (blocks 3 and 4) were observed.

Data Analytic Approach

This study relied upon ordinary least squares simple linear regression, multiple regression, and moderated regression analyses as techniques for data analysis. Hypotheses 1, 3, and 4 comprised attempts to explain variation in the criterion variable, given an individual differences predictor and a number of covariates. Multiple linear regression was thus used to analyze hypotheses 1, 3, and 4. Hypothesis 2 was tested using simple moderation analysis. Simple moderation describes a relationship such that the effect of variable X (predictor) on variable Y (criterion) is contingent upon the size, strength, or sign of a third variable M (moderator; Hayes, 2013; Figure 3). Moderation analyses are used to identify the boundary conditions of an effect. Moderation analyses provide information about when an effect can be observed or for whom a relationship between two variables exists.

Parametric Assumptions

Data included in the present analyses were evaluated for violation of parametric assumptions in order to ensure the accuracy of obtained results and facilitate the validity of subsequent interpretations and inferences. Linear models, and their variations, are based on a number of assumptions including additivity and linearity, normality, homoscedasticity, and independence. The assumption of linearity assumes that the true relationship between predictor and criterion variables is in fact, linear. Additivity means that, given several predictors, the criterion would be best accounted for by summing the predictor effects. To check for violations of linearity, residual scatterplots were visually inspected for curvature in the standardized residuals (Field, 2013). No observed curves in the data points were noted, indicating that the assumption of linearity was not violated.

The assumption of normality concerns the shape of the distribution of data. Variables were assessed for normality by calculating Z_{skewness} defined as skewness / SE . An obtained Z_{skewness} statistic with an absolute value greater than 1.96 would be considered a significant departure from normality at the $p < .05$ level in need of transformation (Field, 2013). When the transformation remedied or largely attenuated the skew, the transformed variable was used in subsequent analyses. Prior to any transformation, outliers were dealt with using a variation of winzorizing. Standardized scores were calculated for the variables of interest. Outliers, or values that had absolute standardized scores of 3.29 or greater, were manually changed to values equal to the mean plus 3.29 times the standard deviation (Field, 2013). In other words, they were modified to fit within the boundary of what would be considered an outlier, given the original nonwinzorized data.

The assumption of homoscedasticity of variance assumes that the variance of one

variable does not differ with changes in the level of another variable. Visual inspection of residual scatterplots revealed evidence of a systematic relationship. Specifically, the residual scatterplots revealed less variability in the standardized residuals for lower predicted HRV values. Heteroscedasticity is a problem because it leads to biased standard errors which in turn affect the validity and power of statistical tests and confidence intervals. In accordance with the recommendation of Hayes and Cai (2007), heteroscedasticity consistent standard errors estimators were used in the analysis of hypothesis 2, which involves the HRV recording variables.

The assumption of independence assumes that the errors in estimation are statistically unrelated (Hayes, 2013). This assumption was tested by checking for serial correlations between errors using the Durbin-Watson test (Field, 2013). This analysis revealed no evidence of serial correlations between errors among psychometric and task variables with Durbin-Watson test statistics ranging from 1.93-2.44.

Data Preparation

All psychometric, HRV recording, and food exposure task data were entered in IBM SPSS Statistics v.24. Among ECG data, three individuals had incomplete recordings for block 1 because of technical errors. A paired t-test revealed no significant difference between ECG recording blocks 1 and 2 in the remainder of the sample. The block 1 recording for these three participants was replaced with the ECG recording from block 2.

Three participants were dropped from all analyses. One participant was excluded due to lack of adherence to the procedure in the laboratory component of the experiment. One additional participant was excluded from the analysis due to acute illness that prevented the completion of the entire laboratory component. The third participant was excluded due to an

extreme response bias in the online questionnaire battery detected as a statistical outlier value on the BIDR (Paulhus, 1988). This resulted in 100 participants who completed both the online and laboratory components of the study who were included in the present analysis. One participant did not complete the STAI measures at baseline or exposure and so his data was excluded from analyses involving the STAI variable. Technical malfunctions resulted in missing ECG data for one participant during the IAT (HRV recording block 6).

There were some missing data from the online questionnaire battery. These missing values were replaced using a prorating strategy based on the available responses given by the participant on the measure of interest. A cutoff of 20% of missing values was utilized; if more than 20% of a participant's responses were missing for a given measure, the missing values would not be replaced. No participants included in the present analysis were missing more than 20% of response on any measure. As such, no psychometric data was excluded from the present analysis.

ECG recordings. Artifacts in ECG data resulting from movements or muscle activity were visually inspected using ASA-LAB software (Version 16; Advanced Neura Technology, Enschede, Netherlands). Analysis of ECG data used a high-pass filter with a low cut-off frequency of 1 Hz and a high cut-off frequency of 100 Hz. The ECG recordings were then visually inspected, remaining artifacts corrected for, and ECG recordings analyzed using Kubios HRV specialized analysis software (Biosignal Analysis and Medical Imaging Group; <http://kubios.uef.fi/>; version 2.2).

Psychometric variables. Descriptive information and reliability coefficients of psychometric variables are presented in Table 2. These variables represent either a predictor or a covariate in the subsequent analyses. The psychometric data that were found to be significantly

positively skewed were subjected to the natural logarithmic transformation (Field, 2013). $Z_{skewness}$ was used to determine the skew of each psychometric variable. A Z score of ± 1.96 was indicative of a significant degree of skew. A significant and positive skew was observed for EAT-26 which was subjected to the natural logarithmic transformation producing a $Z_{skewness}$ statistic of -0.34 , thus remedying the skew. The transformed variable $EAT-26(\ln)$ was retained for subsequent analyses. A significant and positive skew was observed for SHAI which was subjected to the natural logarithmic transformation producing a $Z_{skewness}$ statistic of -1.59 , thus remedying the skew. The transformed variable $SHAI(\ln)$ was retained for subsequent analyses.

The two variables under consideration for the index of orthorexia in the present study were ORTO-15 and ORTO-P9. Of primary concern was the internal consistency of these measures which has been demonstrably inadequate in the literature. The internal consistency of the ORTO-15 was found in the present study to be inadequate (Cronbach's $\alpha = .26$). Recall that the ORTO-P9 is comprised of nine of the original 15 items of the ORTO-15 (Brytek-Matera, et al., 2014). The internal consistency of the ORTO-P9 (Cronbach's $\alpha = .69$) was found to be higher yet still below the standard of $.7$ that is recommended for group comparison (Bland & Altman, 1997). The ORTO-P9, however, demonstrated clear superiority over the ORTO-15 in terms of internal reliability and was therefore retained for subsequent analyses involving the construct of orthorexia. No significant skew was observed for ORTO-P9.

Both ORTO-15 and ORTO-P9 were designed such that lower scores indicate greater orthorexic tendency. However, to facilitate interpretation of findings in the present study, these variables were subjected to a reciprocal transformation by subtracting all values from the highest obtained score such that high scores now indicate greater orthorexic tendency. The resulting reciprocals are denoted hereafter by ORTO-15r and ORTO-P9r.

An intercorrelation matrix of the five psychometric variables is displayed in Table 3. Also included is the original ORTO-15r for comparative purposes. Significant correlations were obtained among all variables. Orthorexia was associated with greater disordered eating, health anxiety, and low body image satisfaction. ORTO-P9r is the predictor variable. The other psychometric variables comprise covariates that were included in subsequent analyses.

Food exposure task variables. This section explores the statistical properties of six dependent variables obtained over the four food exposure tasks completed by participants during the laboratory component of the study (see Tables 4 & 5). Regarding the first task—the food preference task—participants were instructed to rank order the six food bars using untied ranks according to preference. Scoring was accomplished by assigning each bar a value of 1 if it was ranked in one of the top three ranks 1-3 by a given participant. Otherwise, the bar was given a value of 0 if it was in rank 4-6. These dichotomous scores were then summed to produce two indices of food preference; a natural score which was the sum total of the natural bars ranked 1-3, and a nonnatural score which was the sum total of the nonnatural bars ranked 1-3. These two preference indices were then entered into the following food preference equation, $FP = \frac{\text{natural score} - \text{nonnatural score}}{\text{natural score} + \text{nonnatural score}} * 100$, to obtain a single score ranging from -100 to 100. This score constituted the sample ranking variable. Positive scores denote a preference for natural food such that ranking the three natural bars in the top three positions would yield a score of 100, and ranking the three nonnatural bars in the top three positions would yield a score of -100.

With respect to the second food exposure—the taste test—the data was obtained by measuring the weight of the food samples before and after they were presented to the participant. This produced an index of the weight in grams (g) of each bar that was consumed by the participant. The weight of the three natural bars and the three nonnatural bars were then summed

to produce two scores: (a) natural food consumed (g); and (b) nonnatural food consumed (g).

These weights were then entered into the following taste test equation, $TT =$

$\frac{\text{natural food consumed} - \text{nonnatural food consumed}}{\text{natural food consumed} + \text{nonnatural food consumed}} * 100$, to produce a single score ranging from -

100 to 100. Positive scores indicate a preference for natural food such that consuming exclusively natural food bar samples would yield a score of 100 and consuming exclusively nonnatural food bar samples would yield a score of -100. Also measured was the total weight of food consumed (g), including both natural and nonnatural samples.

For the third food exposure—the IAT—the data was scored using the scoring algorithm outlined by Greenwald, Nosek, and Banaji (2003). Data from *blocks 3* and *5* from both IAT measures were used in the analysis. Trials with a response latency greater than 10,000 ms were eliminated. Data from respondents for which more than 10% of trials had response times quicker than 300 ms were excluded from analysis, due to the higher than expected error rate that has been associated with this speed of responding (Greenwald et al., 2003). The mean response latency for correct categorizations were calculated for *blocks 3a*, *3b*, *5a*, and *5b* for each measure. Two pooled standard deviations were calculated for each measure for a total of four pooled standard deviations. A pooled standard deviation of the response latencies of the practice trials (*block 3a* + *block 5a*) for each measure as well as a pooled standard deviation of the response latencies of the test trials (*block 3b* + *block 5b*) for each measure were computed. Incorrect categorizations were replaced with the mean + 600 ms. The following steps were conducted for each IAT measure. An average for the obtained values for each block was computed and used to calculate difference scores in the following equations [*block 5a* – *3a*] and [*block 5b* – *3b*] and each was divided by its associated pooled standard deviation. The two resulting values were averaged. This produced two final values for each participant, each

representing an index of implicit attitude toward food: one for the measure related to the caloric value of foods, and one related to the naturalness of foods. Each of these single scores ranged from -2 to positive 2. A positive score indicated an implicit bias in favor low-calorie or natural foods. A negative score indicated an implicit bias in favour of high-calorie or nonnatural foods.

Regarding the fourth and final food exposure—the shopping task—the data was obtained by counting the number of natural and the number of nonnatural selections made by the participants.

These numbers were then entered into the following shopping task equation, $ST =$

$$\frac{\text{natural selections} - \text{nonnatural selections}}{\text{natural selections} + \text{nonnatural selections}} * 100, \text{ to produce a single score ranging from -100 to 100.}$$

Positive scores indicate a preference for natural food such that choosing exclusively natural selections on the shopping task would yield a score of 100 and exclusively nonnatural selections would yield a score of -100.

HRV variables. Descriptive information pertaining to the HRV variables recorded during all seven blocks, and the two calculated composite scores are displayed in Tables 6 and 7, respectively. Positively skewed HRV variables for all seven recording blocks were subjected to the natural logarithm transformation as is customary in this area of reasearch. This transformation attenuated the positive skew observed in the HRV variables although did complete remedy the skew for all variables. Because of the notable improvement in skew, the logarithm transformed HRV variables were retained for the analysis despite the skew not having been completely remedied.

Threat Manipulation

Recall, the STAI was used to gauge the degree to which the independent variable—threat manipulation—actually induced anxiety as intended among participants higher in trait orthorexia. Descriptive statistics and reliability coefficients for these affective psychometric variables can be

seen in Table 8. A significant and positive skew was observed for STAI_B and the skew was remedied by a natural logarithmic transformation. The transformed variable STAI_B(*ln*) was retained for subsequent analyses. A significant and positive skew was observed for STAI_E which was subjected to the natural logarithmic transformation producing a Z_{skewness} statistic of 1.26, thus remedying the skew. The transformed variable STAI_E(*ln*) was retained for subsequent analyses.

A simple moderated regression analysis was conducted to determine whether criterion variable STAI_E(*ln*) varied as function of predictor variable ORTO-P9r and moderator variable threat condition. STAI_B(*ln*) was included in this analysis as a covariate. Results did not reveal significant predictive ability for condition, $b = 0.12$ [$SE\ b = .09$], $t = 1.42$, $p = .159$; for orthorexia $b = 0.01$ [$SE\ b = 0.01$], $t = 1.57$, $p = .119$; or for condition \times orthorexia interaction, $b = -0.01$ [$SE\ b = 0.01$], $t = -0.96$, $p = .341$. In an effort to further probe the potential effect of the threat manipulation, a paired t-test was performed. The purpose of this analysis was to test for group differences between STAI_B(*ln*) and STAI_E(*ln*). The difference was not statistically significant $t(98) = 1.56$, $p = .121$, 95% CI [-0.01, 0.06]. Results suggest the independent variable of threat manipulation failed to achieve its intended effect of inducing self-reported state anxiety among participants high in trait orthorexia.

Test of Hypotheses

Hypothesis 1. The first hypothesis stated that orthorexia would predict food preference. Food preference was defined in two ways: (a) sample ranking, defined as performance on the food preference task; and (b) sample consumption, defined as performance on the taste test. Regarding the former, it was expected that orthorexia would predict higher scores on the food preference task. Orthorexia was operationally defined by the ORTO-P9r variable. The food preference task was scored based on the proportion of natural bars rated in the top three rank-

ordered positions with higher scores indicating a natural food preference. In addition, it was expected that orthorexia would predict higher scores on the taste test. The taste test was scored based on the proportion of food consumed that was considered natural food, with higher scores indicating a natural food preference.

To examine these hypotheses, two multiple regression analyses were performed using the ordinary least squares method to produce unstandardized regression coefficients, standard errors, and 95% confidence intervals for the predictor while holding the remaining covariates constant. These analyses were also performed without the inclusion of the covariates for comprehensiveness and to allow for greater statistical power through maximization of the number of degrees of freedom in the models. Orthorexia, ORTO-P9r, was the predictor variable in both analyses. Food preference defined by the rank-ordering of the food bars was the criterion variable in the first analysis. Gender, EAT-26(*ln*), SHAI(*ln*), and BISS were included in the model as covariates. The overall model was not found to be significant, $F(5,94) = 1.20, p = .316$. Only gender demonstrated significance in the prediction of food preference such that females (dummy coded as 1 and males as 0) displayed a greater preference for natural food, $t(94) = 2.24, p = .028, 95\% \text{ CI } [3.20, 53.73]$. The unstandardized regression coefficients are presented in Table 9. The model without the inclusion of the covariates was not significant $F(1,98) = 0.04, p = .842$.

Sample consumption defined by the proportion of natural to nonnatural food consumed was the criterion variable in the second analysis. Gender, EAT-26(*ln*), SHAI(*ln*), and BISS were included in the model as covariates. The overall model was not found to be significant, $F(5,94) = 0.19, p = .968$. The regression coefficients and 95% confidence intervals are presented in Table 9. The model without the inclusion of the covariates was not significant $F(1,98) = 0.02, p = .903$.

A third criterion variable, total food consumption, operationally defined as the total amount of food (g), including natural and nonnatural samples, that was consumed during the taste test was also analyzed. Gender, EAT-26(*ln*), SHAI(*ln*), and BISS were included in the model as covariates. The overall model was found to be significant, $F(5,94) = 2.81, p = .021$. Orthorexia predicted total food consumption, and males consumed more food than females. This model accounts for a minimal degree of variance, however, with an $R^2 = 0.13$. The regression coefficients and 95% confidence intervals are presented in Table 9. The model remained significant without the inclusion of the covariates $F(1,98) = 3.97, p = .049$. This model accounted for an even smaller degree of variance with an $R^2 = 0.04$.

Hypothesis 2. The second hypothesis stated that threat level would moderate the relationship between predictor orthorexia, and criterion HRV change. HRV change was operationally defined in terms of three different comparisons: (a) HRV recording block 4 and 2; (b) HRV recording block 3 and 1; and (c) HRV composite exposure and baseline. It was expected that orthorexia would predict greater HRV change in each of these comparisons, when threat level was high. HRV was operationally defined in three different ways: RMSSD, HF, and, SD1. The comparisons were facilitated by including the HRV exposure recording (block 4, 3, or exposure composite) as the criterion variable and including the HRV baseline recording (block 2, 1, or baseline composite) as a covariate.

To examine these predictions, nine moderated regression analyses were performed using the SPSS *PROCESS* macro for model 1 (Hayes, 2013). In all analyses, orthorexia was the predictor and threat level was the moderator. The criterion variables were RMSSD, HF, or SD1 for block 3, 4, or exposure composite. Due to the inclusion of the baseline measure as a covariate (blocks 1, 2, or baseline composite), significance of the overall model was expected regardless of

the predictive power for HRV change by ORTO-P9r and threat level. As such, the test statistics for the R^2 increase due to interaction are presented.

Regarding the comparison of blocks 3 and 1, the R^2 increase due to interaction was not found to be significant in the models predicting RMSSD, $p = .444$, HF, $p = .201$, and SD1, $p = .294$. The regression coefficients and 95% confidence intervals for the comparison of HRV recording blocks 3 and 1 are presented in Table 10.

The R^2 increase due to interaction were not found to be significant regarding the comparison of blocks 4 and 2 in the model predicting RMSSD, $p = .236$, HF, $p = .575$, and SD1, $p = .236$. The regression coefficients and 95% confidence intervals for the comparison of HRV recording blocks 4 and 2 are presented in Table 11.

Finally, no significant R^2 increases due to interaction were obtained regarding the comparison of exposure and baseline composite scores in the model predicting RMSSD, $p = .377$, HF, $p = .944$, or SD1, $p = .438$. The regression coefficients and 95% confidence intervals for the comparison of HRV baseline composite and exposure composite are presented in Table 12.²

Hypothesis 3. The third hypothesis stated that orthorexia would predict cognitive bias. Specifically, it was expected that orthorexia would predict higher scores on the two successive components of the IAT. The score on the first IAT component was indicative of an implicit association between the valence of words and the natural value of food. Recall that the possible scores on the IAT ranged from -2 to 2 with higher scores indicating an implicitly positive view of natural foods and lower scores indicating an implicitly positive view of nonnatural foods. A

² The nine models predicting (a) RMSSD₃; (b) HF₃; (c) SD1₃; (d) RMSSD₄; (e) HF₄; (f) SD1₄; (g) RMSSD_E; (h) HF_E; and (i) SD1_E were also run with the inclusion of gender, EAT-26(*ln*), SHAI(*ln*), and BISS as covariates. The results did not appreciably differ and thus are not reported here.

score of 0 indicated no bias with the respect to the natural value of food. An overall bias in favour of natural food was observed; 99% of respondents obtaining a positive score on this IAT measure.

The score on the second IAT component was indicative of an implicit association between the valence of words and the caloric value of foods. Specifically, it was expected that orthorexia would predict higher scores on the IAT. Recall that the possible scores on the IAT ranged from -2 to 2 with higher scores indicating an implicitly positive view of low-calorie foods and lower scores indicating an implicitly positive view of high-calorie foods. A score of 0 indicated no bias with the respect to the caloric value of food. An overall bias in favour of low-calorie food was observed; 94% of respondents obtaining a positive score on this IAT measure. Interestingly, a correlation was observed between performance on the IAT pertaining to the caloric value of food and the BIDR which assessed impression management, $r = .213, p = .034$. No significant association was observed between the BIDR and the IAT related to the natural value of food, $r = .162, p = .108$.

Two multiple regression analyses were used to examine these predictions. ORTO-P9r was the predictor variable and IAT score was the criterion variable. Gender, $EAT(ln)$, $SHAI(ln)$, and BISS were included in the model as covariates. The first model, predicting implicit associations on the basis of the natural value of food, was not found to be significant, $F(5, 94) = 0.79, p = .562$. The regression coefficients and 95% confidence intervals are presented in Table 13. This model was not found to be significant without the inclusion of the covariates $F(1,98) = 0.18, p = .669$.

The second model, predicting implicit associations on the basis of the caloric value of food was not found to be significant, $F(5, 94) = 1.95, p = .093$. Only BISS was found to

significantly predict implicit association such that those with higher body image satisfaction demonstrated a stronger positive bias for low-calorie foods, $t(94) = 2.62$, $p = .009$, 95% CI [0.02, 0.12]. The regression coefficients and 95% confidence intervals are presented in Table 13. This model was not found to be significant without the inclusion of the covariates $F(1,98) = 1.27$, $p = .262$.

Hypothesis 4. The fourth hypothesis stated that orthorexia would predict performance on the shopping task. Specifically, it was expected that orthorexia would predict higher scores on the shopping task. Orthorexia was operationally defined by the ORTO-P9r variable. The shopping task was scored based on the proportion of selections that were considered natural food, with higher scores indicating a natural food preference.

A multiple regression analysis was used to examine this prediction with ORTO-P9r as the predictor variable and shopping task score as the criterion variable. Gender, $EAT(ln)$, $SHAI(ln)$, and BISS were included in the model as covariates. The model was found to be significant, $F(5, 94) = 4.23$, $p = .002$. Orthorexia predicted a higher shopping task score, indicative of a higher number of natural choices made during the shopping task, $t(94) = 3.22$, $p = .002$, 95% CI [1.84, 7.77]. In addition, BISS demonstrated significant predictive ability, $t(94) = 2.58$, $p = .011$, 95% CI [2.18, 16.61], such that higher body image satisfaction predicted more natural choices. The regression coefficients are presented in Table 14. This model was also found to be significant without the inclusion of the covariates, $F(1,98) = 11.63$, $p = .001$.

Summary. Contrary to hypothesis one, orthorexia was not found to be predictive of food preference defined by either (a) food sample ranking; or (b) food sample consumption. It was demonstrated, however, that gender is involved in food preference with females indicating a greater preference for the natural food samples via sample ranking. Additionally, orthorexia

demonstrated predictive ability with respect to the total amount of food consumed; those higher in trait orthorexia consumed more food overall. Males also consumed more total food than females. Support was not obtained for hypothesis two which is unsurprising given the failure of the threat manipulation. Both components of hypothesis three were unsupported; orthorexia did not predict cognitive bias with respect to the natural or caloric value of food. Nonetheless, an overall bias in favour of both natural food and low-calorie food was observed. In addition, the IAT pertaining to the caloric value of food was found to be correlated with desirable responding and body image satisfaction. In accordance with hypothesis four, the results indicate evidence for the predictive ability of orthorexia concerning performance on the shopping task. Interestingly, performance on the shopping task is also predicted by body image satisfaction.

Exploratory Analyses

Exploratory analyses aimed to further probe the significant relationship between orthorexia and performance on the shopping task. Specifically, the question of whether the inclusion of a moderating variable would interact with orthorexia in the prediction of shopping task performance was addressed. A number of contenders for inclusion in this model were available including BMI and the food exposure task variables: (a) sample ranking; (b) sample consumption; (c) total food consumption; (d) IAT (natural value); and (e) IAT (caloric value). Each of these variables were tested in turn using moderated regression analyses and the SPSS *PROCESS* macro for model 1 (Hayes, 2013). Variables gender, $EAT-26(\ln)$, $SHAI(\ln)$, and BISS were included in all subsequent analyses as covariates.

BMI is a factor that may be both predictive, and consequential, of food preference. BMI was correlated with both total food consumption, $r = .24, p = .017$, and BISS, $r = -.32, p = .001$. Higher BMI is associated with a greater volume of food samples consumed and with lower body

image satisfaction. BMI was thus investigated in relation to orthorexia and food preference, operationally defined as performance on the shopping task. A significant and positive skew was observed for BMI which demonstrated a Z_{skewness} statistic of 5.61. BMI was subjected to the natural logarithmic transformation producing a Z_{skewness} statistic of 3.55. Although this transformation did not remedy the skew, it did produce an improved Z_{skewness} statistic and, thus, was retained for subsequent analysis.

This exploratory analysis investigated whether the regression of shopping task performance (Y) on ORTO-P9r (X) was moderated by BMI (M). The significant interaction between BMI and ORTO-P9r is displayed in Table 15. The relationship between orthorexia and performance on the shopping task is contingent upon BMI. Decomposing the interaction into simple slopes revealed that individuals with low BMI ($-1 SD$) evidenced the strongest association between ORTO-P9r and natural food preference indicated by the shopping task, $b = 7.78$, $t(92) = 3.92$, $p < .001$, 95% CI [3.84, 11.73]; among those with high BMI ($+1 SD$), the association did not prove significant, $b = 0.42$, $t(92) = 0.17$, $p = .866$, 95% CI [-4.48, 5.31] (see Figure 4).

Next, it was tested whether the regression of shopping task performance (Y) on ORTO-P9r (X) was moderated by sample ranking (M). The significant interaction is revealed in Table 15. The relationship between orthorexia and shopping task performance is moderated by sample ranking. Probing the interaction showed the conditional effect of ORTO-P9r on shopping task performance to be significant for those participants whose sample ranking score was average, $t(92) = 3.19$, $p = .002$, 95% CI [1.71, 7.34] and also for those whose score demonstrated a preference in favour of the natural choices ($+1 SD$), $t(92) = 3.55$, $p < .001$, 95% CI [3.14, 11.10]. ORTO-P9r did not significantly predict shopping task performance for those participants whose

sample ranking score demonstrated a preference for the nonnatural choices ($- 1 SD$), $t(92) = 1.11$, $p = .268$, 95% CI [-1.51, 5.37] (see Figure 5).

The potential moderator sample consumption was investigated in relation to the prediction of shopping task performance (Y) by ORTO-P9r (X). The significant interaction can be seen in Table 15. Sample consumption was demonstrated to moderate the relationship between orthorexia and shopping task performance. Analyzing the conditional effect of X and Y at values of the moderator revealed that ORTO-P9r predicts shopping task performance for those participants whose sample consumption was average, $t(92) = 3.79$, $p < .001$, 95% CI [2.38, 7.63], or in favour of the natural choices ($+ 1 SD$), $t(92) = 3.87$, $p < .001$, 95% CI [4.12, 12.79], but not for those whose sample consumption favoured the nonnatural choices ($- 1 SD$), $t(92) = 1.23$, $p = .221$, 95% CI [-0.95, 4.07] (see Figure 6).

It was then investigated whether the regression of shopping task performance (Y) on ORTO-P9r (X) was moderated by total food consumption (M). This interaction was not found to be significant, $t(92) = 0.34$, $p = .738$

The moderation of the regression of shopping task performance (Y) on ORTO-P9r (X) by both IAT measures (M) were each tested in turn. Regarding the IAT – natural value, the interaction was not significant, $t(92) = 0.32$, $p = .753$. The interaction with respect to the IAT – caloric value also did not achieve significance, $t(92) = 0.15$, $p = .884$. The unstandardized regression coefficients can be seen in Table 15.

Summary of exploratory analyses. The exploratory moderated regression models revealed that the significant relationship between orthorexia and performance on the shopping task is moderated by BMI, and food preference variables sample ranking and sample consumption. Alternatively, total food consumption and cognitive bias related to the natural and

caloric value of food were not found to exert a moderating role in the predictive relationship between orthorexia and shopping task performance.

Discussion

The discussion begins with an examination of the effectiveness of the threat manipulation that was employed in the present study. Next, a social theory of behavioural intention and realization is presented that may help to reconcile the obtained findings. The results of each of the hypotheses are then discussed, followed by an investigation of the results obtained through exploratory analysis. Potential clinical implications of the knowledge gained from this study are presented. A commentary of the study's limitations as well as a number of recommendations for future research consideration are provided. The discussion concludes with final remarks.

Threat Manipulation

Threat was manipulated with the intention of creating a state of uncertainty only in those participants randomized to the high threat condition. It was intended that a state of uncertainty regarding the nature and quantity of what would be eaten during the taste test, would arise. Those participants randomized to the low threat condition were provided with the information about the nature and quantity of what they would be asked to taste, prior to the presentation of the food stimuli. In contrast, those participants randomized to the high threat condition were simply informed that they would be asked to "*taste the samples*" in the upcoming taste test, prior to the presentation of the food stimuli. The ambiguity of the instruction provided to those participants randomized to the high threat condition was intended to create a state of uncertainty. This state of uncertainty was hypothesized to be threatening only to those high in orthorexia. SMS activation was expected to occur in response to this hypothesized perception of threat. It was expected that the uncertainty regarding the nature and quantity of food to be consumed would be

perceived as threatening in this population because only half of the food stimuli conformed to the food-related rules presumed to epitomize orthorexia. These three food stimuli, the nonnatural stimuli, were not organic nor free from genetically modified ingredients. They contained a large number of ingredients, many of which could be considered as artificial. They were heavily processed, typical “snack foods” that should—in theory—be avoided by individuals high in orthorexia. Although an effort was made to select three such food stimuli, the appropriateness of the selected bars may have impacted on the validity of the threat manipulation. The natural food stimuli may not have met the standards of some individuals high in orthorexia. There may be characteristics of greater importance used in the appraisal of food quality by these individuals that were not attended to in the present study. As such, instructions to the effect of tasting any number of the samples might not have differed in terms of perceived threat and physiological arousal.

The STAI, a short affective index administered via self-report, was completed by participants after the food preference task baseline and again after the food preference task exposure. This measure was included as a check of the internal validity of the study to assess whether the threat manipulation had the intended effect. The results of the moderated regression suggest that the threat manipulation did not, in fact, function as intended. No interaction between trait orthorexia and threat condition was observed in the prediction of STAI score at exposure, with STAI score at baseline included as a covariate. Further, no predictive ability was observed for trait orthorexia alone, nor for threat condition alone, with respect to STAI score.

The failure of the manipulation of threat to induce anxiety or stress in the target group is a major limitation of the current study and has implications, particularly for hypothesis 2 which includes threat condition as a moderator. There are a couple of possibilities as to why the threat

manipulation did not demonstrate the intended effect. First, the food stimuli for the natural and nonnatural categories were selected based on a number of qualities that are thought to be important to individuals high in orthorexia in terms of food selection. Although a concerted effort was made to be comprehensive with respect to the food qualities taken into consideration, the possibility of the natural food samples not being considered “healthy” or “natural” by some participants cannot be discounted. Individuals high in trait orthorexia are unified on the basis of a diet driven by the pursuit of health that emphasizes the quality of food (Dunn & Bratman, 2016). The idiosyncratic nature of what types of food are considered healthy and what characteristics are given priority in the assessment of food quality may have affected the validity of the threat manipulation. The natural food bars utilized were organic, free from artificial ingredients, and subjected to minimal processing. Notwithstanding, the food samples were in fact prepackaged bars which may not conform to the dietary rules espoused by some individuals high in orthorexia.

Another component of orthorexia is the desire to have control over the contents and preparation of food. Although participants had access to the nutritional information and ingredients list for each food sample, the lack of personal control over the ingredients may have affected the validity of the threat manipulation regarding the food stimuli. In addition, these resources were available to the participants for the limited duration of 30 seconds per food sample. It is possible that more time with the nutritional information would have been required in order for those high in trait orthorexia to establish the appropriateness of the food samples to their diet.

The second possibility as to why the threat manipulation failed to demonstrate the intended effect is related to the recruitment strategy of the study. The study was advertised as a

“clean eating study” that involved a taste test. Individuals displaying extreme particularities regarding food preference, and for whom the prospect of consuming nonnatural food might be especially threatening, may have been dissuaded from participation in the laboratory component of the study. This possibility, however, is unlikely for the following reason. Using the original ORTO-15, 80% of the laboratory sample fell into the category of “orthorexia” using the original cutoff score of 40, and 29% fall into this category using the more recently suggested cutoff score of 35. Considering that reported prevalence estimates range from 6.9% (Donini et al., 2004) to 86% (Valera et al., 2014) using the ORTO-15 and a cutoff score of 40, the present sample seems to be on the high end of the spectrum regarding orthorexic tendency (See review article by Dunn & Bratman (2016), for a summary of point prevalence reports).

The failure of the threat manipulation to induce the intended effect undermines the internal validity of the study. The hypothesized security motivated behaviours were unable to be investigated as such because of the absence of the physiological data that would indicate activation of the SMS. Nonetheless, the obtained findings do not provide evidence against the hypothesized role of the SMS in the maintenance of orthorexia. Alternatively, interesting findings were obtained. A novel measure of behavioural intention surrounding orthorexic food preferences was developed which will be discussed (see Hypothesis 4). In addition, despite the absence of expected findings concerning a number of the stated hypotheses, the results can be reconciled and understood with reference to social psychological theory of planned behaviour.

Behavioural Intention and Realization

Physiologically speaking, no data was obtained to support the role of the security motivation system in the maintenance of orthorexia. In terms of the cognitive component, however, the sample as a whole expressed a relatively more positive implicit attitude toward

natural as opposed to nonnatural food (Table 5). This suggests an overwhelmingly favourable attitude toward natural food on an implicit level. Surprisingly, the strength of this positive attitude was unrelated to self-reported orthorexic tendency, suggesting the involvement of other factors that may serve to intercept the progression from attitude to behavioural intention.

The shopping task was a behavioural measure intended to gather information concerning typical grocery shopping patterns and food preferences. As expected, performance on the shopping task was predicted by orthorexia such that individuals higher in orthorexia selected proportionately more natural items relative to their counterparts lower in orthorexia. The question then remains why implicit attitude does not translate into behaviour with regards to orthorexic food preference.

Ajzen's theory of planned behaviour. The shopping task can be conceptualized as a measure of behavioural intention rather than actual behaviour, because it was in fact a simulation task designed to provide inferential data regarding actual behavioural tendencies. Behavioural intention refers to one's perceived probability of engaging in a certain behaviour (Hensel, Leshner, Logan, 2013). Behavioural intention can be explained in the context of the theory of reasoned action, originally posited in 1975 by Fishbein and Ajzen, which stipulates that behavioural intention is influenced by two factors: attitude toward the behaviour, and subjective norms regarding the behaviour (Madden, Ellen, & Ajzen, 1992). Attitude toward the behaviour develops in response to behavioural beliefs regarding the likely consequences of engaging in the behaviour (Ajzen, 2002). Subjective norms develop in response to normative beliefs or one's perception of how others regard the behaviour. A favourable attitude toward a behaviour, paired with the perception that others also regard the behaviour in favourable terms, should increase the likelihood of the development of behavioural intention by an individual. Behavioural intention is

the immediate antecedent to realization of the behaviour (Madden et al., 1992; Figure 7).

With respect to the present study, performance on the IAT is representative of the attitude of the participant toward the preferential consumption of natural food and avoidance of nonnatural food. The shopping task is a measure of behavioural intention, regarding these same orthorexia-related tendencies. Natural food-related norms, as discussed previously (see section *Healthy eating in the general population*), tend to dictate that natural foods are perceived as healthier and more desirable than nonnatural foods which have a tendency to be viewed with skepticism (Rozin et al., 2004). From this, it can be assumed that subjective norms, for most people, tend to regard the consumption of natural foods in a favourable way.

The theory of reasoned action stipulates that favourable personal attitudes and favourable subjective norms would lead to the development of behavioural intention. This model applied to the present study, which can be visualized in Figure 8, is not supported given the obtained data. Assuming that subjective norms are favourable toward natural food consumption, the theory of reasoned action would predict a correlation between performance on the IAT regarding the natural value of food and performance on the shopping task, which was not observed (see Table 6). Other factors must be involved in this pathway that stipulate the boundary conditions under which a favourable attitude toward the behaviour, paired with positive subjective norms regarding the behaviour, is predictive of behavioural intention.

The theory of reasoned action has since been extended to include a fifth variable: perceived behavioural control. Perceived behavioural control refers to factors that are subjectively beyond the control of the individual and that may exert effects at the level of behavioural intention or at the level of behavioural realization (Ajzen, 2002). Perceived behavioural control develops in response to one's beliefs regarding the degree of control that is

held regarding behavioural outcome or the degree of control that is held in ensuring the translation of behavioural intention into behavioural realization (Ajzen, 2002). Perceived behavioural control takes into consideration all the aspects that the individual believes will help or hinder their behavioural performance. This revised theory, put forth by Ajzen in 1985, can be visualized in Figure 9.

Ajzen's theory of planned behaviour adds a moderating component to the model, stipulating that behaviours and behavioural intentions are also under the influence of factors beyond the perceived control of the individual. Applied to the present topic (see Figure 10), a number of factors might affect the perceived control held by the individual regarding adherence to the eating style characteristic of orthorexia. Financial considerations, for example, may play an important role. Currently, natural foods are considerably more expensive than analogous food products that are unable to boast organic certification or other characteristics that are presumably valued by those high in orthorexia. One may hold a favourable attitude toward natural food as well as the subjective perception that others hold this view as well, but without the willingness to expend a considerably greater amount of financial resources to obtain this type of food, these attitudes and beliefs may not translate into measurable behavioural intention. It is only when all conditions are met and perceived control is maximized that the behaviour may be realized. The theory of planned behaviour is applied here to the topics of the present study in an attempt to reconcile the seemingly contradictory nature of the obtained results.

Hypotheses and Exploratory Analyses

Hypothesis 1. Hypothesis 1 explored the predicted security motivated behaviour of food preference in relation to orthorexic tendency. Food preference was measured first by instructing participants to rank order the food stimuli in order of preference and second by covertly

measuring the amount (g) of natural and nonnatural food consumed by the participant during the taste test. The two food preference indices were regressed on predictor variable orthorexia, in an effort to delineate this relationship. Contrary to what was expected, orthorexia did not predict food preference according to rank ordering of the food stimuli. The inclusion of covariates gender, EAT-26(*ln*), SHAI(*ln*), and BISS did not render the model significant. Gender, however, did demonstrate predictive ability within this model regarding food preference such that females demonstrated a greater tendency to rank the natural food stimuli higher. This gender disparity may be explained by gender differences in beliefs concerning the importance of healthy eating, since natural food has a tendency to be perceived as healthy (Bredahl, 1999; Sellin, 2014). The natural food stimuli utilized in the present study bore characteristics of foods typically perceived as being “healthy.” Wardle et al. (2004) demonstrated that females, in general, have a stronger belief in the importance of healthy eating and that this belief accounts for a portion of the variation in food preferences observed by gender. In addition, it has been shown that women endorse greater concern regarding the consequences of their eating habits in terms of their health (Adriaanse, Evers, Verhoeven, & de Ridder, 2015). Taken together, these cognitive factors paired with the common perception of natural food as “healthy” could account for the natural food preference demonstrated by females regarding sample ranking.

Contrary to what was expected, orthorexia did not predict food preference according to volume of the food stimuli consumed during the taste test. The inclusion of covariates gender, EAT-26(*ln*), SHAI(*ln*), and BISS did not render the model significant. Both portions of hypothesis 1 were dependent upon the food stimuli. As described previously (see section *Threat Manipulation*), the food stimuli may not have been perceived as intended by all participants due to the idiosyncratic nature of what types of food are considered healthy/natural by those high in

orthorexia and what characteristics are given priority in the assessment of food quality.

The total volume of food consumed (g) including both natural and nonnatural stimuli was also calculated. This was undertaken with the intent of uncovering further information from the taste test, without consideration for the nature of the selected food stimuli. Orthorexia significantly predicted total volume of food consumed, with and without the inclusion of covariates gender, EAT-26(*ln*), SHAI(*ln*), and BISS, such that those higher in orthorexic tendency consumed a greater amount of food during the taste test. This finding is surprising given the restrictive nature of orthorexia and the tendency to avoid nonnatural foods because three of the food stimuli employed in the taste test could be described as nonnatural.

It has been demonstrated that both psychological and physiological restriction of food can lead to uncontrolled overeating once the availability, or permissibility, of food is restored (Polivy, 1996). Among restrained eaters, dietary rule-breaking often precipitates the onset of an uncontrolled eating event. Studies have shown that restrained eaters behave differently in the context of food studies where they are asked to taste and rate different high energy foods. When participants are given a high-energy milkshake “preload” before a taste and rate task, they typically consume less of the samples than they would otherwise, presumably as a result of their energy needs having been met by the preload. Restrained eaters, by contrast, consume more of the samples after being given the preload (Polivy, 1996). This effect is not observed if the preload does not violate a dietary rule held by the restrained eater (Knight & Boland, 1989).

The observed effect of a greater amount of food consumed by those with greater orthorexic tendency may be explained in the context of rule-breaking and psychological restraint. If the natural food stimuli did not conform to the health rules of those high in orthorexia, as postulated, then food rules would have to be broken by these individuals during the taste test.

The participants high in orthorexia may have eaten more during the taste test due to a temporary relaxing of their food rules in response to a perceived rule violation. These results should be interpreted with caution, however, due to the miniscule amount of variance in the total volume of food consumed accounted for by orthorexic tendency; that is, 3.9%.

An additional finding was that males consumed more total food than females during the taste test. Previous research suggests that some gender differences do exist in terms of the psychological determinants of food intake. For example, greater restrained and emotional eating have been observed among females (Adriaanse et al., 2015). It is unclear, however, if these previous findings, obtained through the completion of self-report measures and the submission of a food diary, would translate to observable behaviour in a contrived laboratory setting such as the one employed in the present study. In addition, the present study was unable to recruit a balanced sample in terms of gender: 77% of the sample was female. As such, this finding may simply be an artefact of a gender imbalance in the sample and not reflective of any true gender differences.

Hypothesis 2. The second hypothesis stated that threat level would moderate the relationship between orthorexia and SMS activation, inferred through HRV change. Unfortunately, this hypothesis could not be empirically tested due to the failure of the selected stimuli to elicit the intended threat response (see section *Threat Manipulation*). Based on the obtained results, there is insufficient evidence to support the stated hypothesis. This can be attributed, however, to a methodological failure, and does not serve as evidence against the potential moderating role of food-related threat in the activation of the SMS in those individuals high in orthorexia.

Hypothesis 3. The third hypothesis stated that orthorexia would predict cognitive bias in the form of implicit preference for certain types of food. Specifically, it was expected that

orthorexia would predict an implicitly more positive attitude toward natural foods in relation to nonnatural foods as evidenced by IAT performance. This prediction was not supported by the evidence obtained from this portion of the study.

The IAT is a relative measure of implicit attitudes toward a dichotomous concept (i.e., the natural value of food: natural or nonnatural). Although it was hypothesized that the strength and direction of this attitude could be predicted by orthorexia, no relationship was observed. Additionally, as can be seen in Table 5, performance on the IAT pertaining to the natural value of food and performance on the shopping task are uncorrelated. Given the present findings, it seems that one's attitude toward a behaviour, in this case the favourable view of the preferential consumption of natural food, is unrelated to one's intentions regarding the behaviour, in this case performance on the shopping task. This finding is supported by previous research which demonstrated that interest in healthier or more natural foods is not necessarily predictive of actual food choice (Roininen & Tuorila, 1999). These seemingly contradictory observations can be reconciled with reference to Ajzen's theory of planned behaviour. One's attitude toward a behaviour, whether the behaviour is regarded as favourable or unfavourable, is only one factor in the determination of whether an intention to engage in the behaviour will develop (Hansen, Jensen, & Solgaard, 2004). Further, behavioural intention does not equate realization of the behaviour. There are multiple components that contribute to the likelihood of a behaviour being performed. With regards to the present study, the IAT is simply a measure of one single component, that is, one's attitude toward natural food. Additionally, there was virtually no variation in the direction of preference (i.e., natural versus nonnatural) and minimal variation in the strength of positive attitude toward natural food. Attitude is not the sole determinant of whether one intends to preferentially approach natural food, nor would this intention equate

acting on the intention to preferentially approach natural food.

An overwhelming majority of the individuals who participated in this study demonstrated a relatively more positive implicit attitude toward natural food compared to nonnatural food. Recall that possible scores obtained on the IAT ranged from -2 to 2 where an obtained score of -2 would indicate the strongest positive implicit attitude toward nonnatural food and an obtained score of 2 would indicate the strongest positive implicit attitude toward natural food. As revealed in Table 4, the obtained scores on the IAT pertaining to the natural value of food ranged from -0.02 to 1.51. Only one out of 100 participants obtained a negative score and this score is close enough to zero to be considered indicative of no preference in either direction (natural or nonnatural). This finding is consistent with the literature concerning attitudes toward natural food which are viewed more favourably and being perceived as healthier than nonnatural foods (Bredahl, 1999; Frewer et al., 1995; Rozin, 2005; Rozin et al., 2004; Sellin, 2014; Sparks et al., 1994). Nonetheless, it is surprising that a positive attitude toward natural food would be a universal phenomenon in a university population, especially given the high palatability of the nonnatural stimuli used for the IAT.

The magnitude of the IAT score has been used infer strength of implicit attitude. Absolute values greater than 0.2, 0.5, and 0.8 have been suggested to indicate small, medium, and large effect sizes of preference (Greenwald et al., 1998). Application of these interpretive guidelines to the IAT regarding the natural value of food would yield the following percentages: 3% of participants displayed no preference; 7% displayed a small implicit preference for natural food; 14% displayed a medium implicit preference for natural food; and 76% displayed a large

implicit preference for natural food.³ Given the proportion of those participants having obtained a score indicating a strong preference for natural foods, it is unlikely that the direction of preference was artificially induced. The magnitude of the preference, however, may have been inflated.

As such, the Hawthorne effect, defined as an experimentally-induced change in participant attitude or behaviour unrelated to the experimentally-manipulated variables, cannot be ruled out. Some aspect of this study leading up to the third food exposure task, the IAT, may have inadvertently induced a bias in favour of natural food which artificially inflated the IAT score. This effect could also have impacted the high proportion of participants who demonstrated a preference for low-calorie foods given the tendency for both natural and low-calorie foods to be associated with health. In fact, impression management was demonstrated to be associated with performance on the IAT pertaining to the caloric value of food. Participants who demonstrated greater social desirability in response style on the BIDR also obtained higher scores on this IAT measure, indicative of a stronger preference for low-calorie food. A few different factors may have influenced the participants to endorse a more favourable view of natural and/or low-calorie food. First, the recruitment strategy of the present study may have played a role. The study was, in fact, advertised as “The Clean Eating Study,” language which is known in common parlance to connote a biologically pure, unprocessed, and natural style of eating. With an awareness of the title of the study, participants may have been influenced toward a preference for natural and low-calorie foods.

³ By contrast, concerning the caloric-value IAT, the same guidelines would yield the following percentages: 3% of participants displayed a small preference for high-calorie food; 8% displayed no preference; 19% displayed a small preference for low-calorie food; 38% displayed a medium preference for low-calorie food; and 32% displayed a large preference for low-calorie food.

Second, the participants were exposed to the food preference task and the taste test prior to engaging in the IAT. The influence of participation in these tasks which involved exposure to the natural food stimuli as well as their packaging and nutritional labels, cannot be ruled out as having primed the participants in terms of their performance on the IAT. Despite these potentially confounding factors, the IAT is a measure of implicit preference which, by definition, is beyond the explicit control of the individual. These factors may have activated some health-focused cognitions in favour of natural and low-calorie foods but it is unlikely that a conscious effort to exhibit a preference for these foods would manifest as a positive score on the IAT. Instead, it is likely that the participants held biases in favour of natural and low-calorie foods, and these biases were amplified in strength in response to aspects of the study that called out existing thoughts and beliefs surrounding healthy eating and natural food.

Hypothesis 4. The fourth and final hypothesis stated that orthorexia would predict performance on the shopping task, a novel behavioural measure of food preference that is indicative of natural vs. nonnatural food selections purportedly chosen by the participant for themselves on a typical grocery shopping excursion. More specifically, the shopping task is an index of behavioural intention, defined as the subjective likelihood of engagement in a specified behaviour (Hensel et al., 2013). This prediction was supported; orthorexia demonstrated significant predictive ability regarding a natural food preference on the shopping task. Conclusions regarding the conceptualization of this behaviourally indicated preference as an expression of security motivated behaviour cannot be formulated due to the absence of corroborative HRV data. Nonetheless, the obtained findings provide interesting information regarding attitudes and behaviours purported to be characteristic of orthorexia that can be understood with reference to Ajzen's theory of planned behaviour.

The support gained for this hypothesis was expected. This was surprising, however, in the context of the inability of orthorexia to predict cognitive bias. The obtained findings suggest that behavioural intention to act in a way that is consistent with the orthorexia presentation, is predicted by orthorexia. By contrast, one's attitude toward behaviour consistent with the presentation of orthorexia, is not predicted by orthorexia. This may seem counterintuitive since perceptions of a behaviour as favourable or unfavourable generally account for a portion of the variance in the realization of such behaviour (Hansen et al., 2004). The findings suggest that additional factors that are beyond the perceived behavioural control of the individual may play a more prominent role than attitudes in the execution of behaviours in the domain of orthorexia.

Another noteworthy finding was the inability of EAT-26(*ln*) to predict performance on the shopping task (see Table 14). Despite the strong correlation between the EAT-26(*ln*) the ORTO-P9r (see Table 3), this task is a measure of orthorexia-related food preferences and disordered eating is not predictive of performance. This result demonstrates the discriminant validity of the shopping task; it provides support that this task is a behavioural measure of orthorexia rather than a behavioural measure of disordered eating characteristic anorexia or bulimia nervosa.

Exploratory analyses. Exploratory analyses were undertaken with the intent of further probing the significant predictive ability of orthorexia regarding performance on the shopping task. A number of potential moderators were explored in order to ascertain whether the predictor variable, ORTO-P9r, interacted with another construct in the prediction of shopping task performance.

First, BMI was explored as a potential moderator of the significant relationship between orthorexia and performance on the shopping task. BMI was demonstrated to moderate this

relationship such that the greatest predictive ability of orthorexia for shopping task performance was observed when BMI was low, and no predictive ability was observed when BMI was high. What is being observed here is a disconnect between behavioural intention and realization of the intended behaviour among those higher in BMI. With reference to Ajzen's theory of planned behaviour, this disconnect can be explained in terms of perceived behavioural control. Beliefs regarding self-efficacy exert their control at the level of behavioural intention and also at the level of behaviour. Self-efficacy beliefs, therefore, can either augment or attenuate the relationship between behavioural intention and realization of that behaviour (Ajzen, 2002). Ovaskainen et al. (2015) demonstrated that health-related self-efficacy, defined as one's perceived ability to control their health-related behaviour, was negatively correlated with BMI. After controlling for actual health behaviours and eating style, individuals with greater BMI did not hold the belief that they were in control of the behaviours needed to improve or maintain their health. In the context of the present study, this weak health-related self-efficacy may be interfering with the realization of intentions to consistently follow through with a style of eating that one perceives to be beneficial in terms of health status. These individuals may regard the preferential consumption of natural food favourably, they may perceive that others share this view, and they may intend to act in accordance with these beliefs and attitudes, thus obtaining higher scores on the shopping task. However, it is at the point where behavioural intention translates to into behaviour when this weak health-related self-efficacy exerts its effect. Without the strength of the belief one has the capability to control their behaviour and subsequently their health status, the ability to consistently adhere to the potentially restrictive eating pattern characteristic of orthorexia is unlikely to be realized. It is important to remember that the connection between the preferential approach of natural foods and avoidance of nonnatural foods

with improved health is subjective. The connections in the pathway according to the theory of planned behaviour are in accordance with what is subjectively perceived by the individual. An actual relationship between orthorexia and physical health is not necessary for the connection between attitudes, subjective norms, behavioural intention, perceived behavioural control and behaviour to occur.

Next, sample ranking and sample consumption were demonstrated to moderate the relationship between ORTO-P9r and shopping task performance. In contrast to food preference measured by the IAT which was implicit, sample ranking was an explicit measure of food preference. The participants were asked to rank order the six food samples in order of preference. Higher scores on this task indicated a higher proportion of the natural food samples ranked in the top three rank positions. The strength of the positive relationship between ORTO-P9r and shopping task performance was greatest among those participants who demonstrated the greatest preference for the natural food samples via ranking them in order of preference.

Sample consumption was another index of food preference, inferred on the basis of the participants' behaviour in the contrived laboratory setting. This variable was calculated based on the relative amount of natural and nonnatural food samples consumed by the participants during the taste test. Higher scores on this task indicated that a greater proportion of overall food (g) consumed came from the natural food bars. The relationship between ORTO-P9r and shopping task performance was moderated by sample consumption such that ORTO-P9r demonstrated the greatest predictive ability regarding shopping task performance among those participants whose consumption behaviour suggested the greatest preference for the natural food samples.

One possible explanation for the obtained findings involves the idiosyncratic nature of food preferences among those high in trait orthorexia. Recall that no predictive ability was

observed for ORTO-P9r concerning sample ranking or sample consumption. A subgroup of participants who are high in trait orthorexia but whose dietary preferences were not adequately represented by the selected food stimuli of the present study may be responsible for the absence of an association between ORTO-P9r and shopping task performance. Further, the food characteristics that were of focus during the selection of items employed in the shopping task may be faulted with a failure to generalize to all individuals high in trait orthorexia. The characteristics that were thought to be of universal importance among those high in trait orthorexia included being organic, free from genetically modified organisms, and produced with limited human intervention. It would appear that some individuals identified as being high in trait orthorexia through the endorsement of items on the ORTO-15 and ORTO-P9, yet do not endorse a preference for the food stimuli utilized in the present study. These food stimuli were selected on the basis of a suspected universal preference by this population. Further research is required in order to ascertain the range of characteristics that are considered important and that are taken into consideration in the selection of food with the intent of improved health status.

Clinical Implications

The insights gained from the current study are clinically applicable in a number of ways. First, this study provides more evidence in support of the theory of planned behaviour. Applied to the topic of eating behaviour, it is demonstrated that prevalent positive attitudes toward a style of eating is unrelated to an intention to follow that style of eating. In this study, the style of eating that was assessed was a preference for natural foods and an avoidance of nonnatural foods which is not necessarily supported as the style of eating that will optimize health. However, if the principle observed here is applied to healthy eating in general, the clinical implications become evident. Currently, a number of chronic health problems in western society including diabetes

and heart disease are, at least in part, preventable and manageable with dietary modifications. Despite the widespread availability of information surrounding eating choices that facilitate health, this information is not being translated into practice. According to a report by the National Center for Chronic Disease Prevention and Health Promotion, Division of Nutrition, Physical Activity and Obesity (2013), 38% of adults in the United states indicated that they consumed fruit less than once per day, and 23% indicated consuming vegetables less than once per day. Concerning adolescents, these figures were 36% and 38% for fruits and vegetables, respectively.

Typical approaches to aid in the prevention and management of health problems tend to be awareness-focused. Education about healthy eating and its consequences has an undeniably important role. People need to have the information available to make informed decisions. With respect to the theory of planned behaviour, education would facilitate the development of attitudes toward different styles of eating. Information about the benefits of healthy eating may contribute to a favourable view of this behaviour because these behavioural beliefs develop based on belief concerning the likely consequences of engaging in the specified behaviour (Ajzen, 2002). What is known from the theory of planned behaviour, and from the results of the present study, is that attitudes do not necessarily translate into behavioural intention if this pathway is intercepted by issues with perceived behavioural control (Ajzen, 2002). The findings of this study support the idea that barriers to healthy eating (subjective or otherwise) do not lie in the attitudes of people toward the behaviour, suggesting that this aspect need not be the primary target of change. Rather, the emphasis should be placed upon targeting the factors that are perceived to be beyond the control of the individual. The elevated cost of food discussed previously, is not isolated to natural food products. In the United States, an inverse relationship

exists between food cost and energy density, with most energy-dense foods comprising highly refined ingredients as well as added fats and sugars (Drewnowski & Specter, 2004).

Additionally, associations have been demonstrated between low family income and (a) low fruit and vegetable consumption; and (b) lower-quality diets, where quality is defined in terms of adherence to recommendations surrounding daily intake of the food groups (i.e., grains, vegetables, fruits, milk products, meats; Drewnowski & Specter, 2004).

Another variable that may attenuate perceived behavioural control and, thus, serve as a moderator in the relationship between attitude and intention is health-related self-efficacy. As discussed previously, the perception of one's ability to manage and exert control over one's health status is imperative in determining whether or not the individual takes an active role in the pursuit of improved health. The finding of the present study concerning the moderating role of BMI in the pathway between behavioural intention (shopping task) and behavioural realization (orthorexia), paired with the finding by Ovaskainen et al. (2015) that health-related self-efficacy is weaker in those of higher BMI, strengthens the argument of these aspects of perceived behavioural control as points of intervention to foster changes in eating style. Programs and educational information directed at fostering health-related self-efficacy may aid with the translation of positive attitudes toward healthy eating to intention and realization of this positive behaviour.

Another important contribution of the present study is the development of a novel measure of behavioural intention regarding food preference. Performance on the shopping task was predicted by orthorexia, supporting this task as a valid measure of this trait. This task may prove useful for research purposes along the lines of those undertaken in the present study. Further, this task could be modified to assess behavioural intention with respect to alternate

styles of eating. For example, the task could be scored on the basis of high- and low-calorie items rather than natural and nonnatural items, or on the basis of other food characteristics, depending on the quality of interest.

Limitations and Future Directions

This study was not without limitations, the most evident being the failure of the food selected and/or the the instructional set utilized to attempt to elicit the intended experience of uncertainty and perceived threat. Future research of this nature should involve a pilot study in order to ascertain a procedure that will be perceived as threatening, specifically to those high in orthorexia.

With respect to the IAT, an attempt was made to render the distinction between natural and nonnatural items as clear and obvious as possible, even to those who are less well-versed in the characteristics important to those high in orthorexia. As such, the majority of the natural stimuli utilized contained labels and words indicative of their natural status, whereas the nonnatural stimuli did not. This could have had an effect on the results of the IAT since the scores are calculated on the basis of reaction time, and since stimuli that require reading may take a longer time to process and categorize. The likelihood of this having significantly affected the results is low, however, since 99% of the sample categorized the stimuli that required reading (i.e., the natural stimuli) more quickly and with fewer errors than the nonnatural stimuli. If anything, this fact may have attenuated the strong implicit preference for natural food that was observed.

Future studies should expand upon the present findings through inclusion of the variables that have been postulated to play a contributory role in the pathway from attitude to realization of behaviour. This discussion was developed on the basis of the assumption that the subjective

norms toward natural food reflected reported societal norms but this aspect was not actually measured. A brief questionnaire tapping into participants' thoughts about the attitudes of others toward natural and nonnatural food would ensure that this assumption was based on measured fact. Further, studies should directly probe the hypothesized moderator of perceived behavioural control and attempt to delineate the different aspects that comprise this concept. Participants could be directly asked what barriers they perceive to be in the way of following an eating style that they view in a demonstrably positive regard. Alternatively, the hypothesized monetary and self-efficacy barriers could be tested.

In addition, a greater understanding of the food characteristics that are important in determining food quality and preference among those high in trait orthorexia is required. Qualitative research with the aim of ascertaining the variations in orthorexic food preference would be beneficial to inform research design in the future.

Conclusions

Hypothesis testing and exploratory analyses revealed two main findings. First, orthorexia demonstrated significant predictive ability surrounding a behavioural intention indicative of a preference for natural food, demonstrated by performance on the shopping task. The EAT-26(*ln*), a measure of disordered eating, did not demonstrate predictive ability, thus providing support for the validity of this novel task in the assessment of behavioural intention in line with the preferences characteristics of those high in orthorexia.

Secondly, this relationship appears to be contingent upon BMI. The predictive ability of orthorexia regarding shopping task performance is greatest for those of low BMI and is not significant for those high in BMI. Although further research is required to verify the following speculation, previous research suggests a lower health-related self-efficacy to be associated with

greater BMI (Ovaskainen et al., 2015). The theory of planned behaviour suggests that perceived behavioural control may moderate the relationship between behavioural intention and behavioural realization. Thus, the absence of association between intention (i.e., shopping task performance) and realization (i.e., orthorexia) among those high in BMI is quite possibly due to the lesser degree of perceived behavioural control over health status that has been demonstrated in this population.

The present study expanded upon the orthorexia literature by contributing a novel task of behavioural intention with demonstrated concurrent and discriminant validity. This study also provided support for the theory of planned behaviour in regard to eating behaviour characteristic of orthorexia. The knowledge gained can be applied to whatever eating style is subjectively considered to be healthy by the individual or group specified, and supports alternative targets of intervention for the promotion of healthy eating on a population level. These findings contribute to our understanding of eating behaviour and the disconnect between attitude, behavioural intention, and behavioural realization.

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Table 1

The HRV Recording Blocks, Task Names, and Descriptive Information.

Recording Block	Eyes	Task	Activity	Duration
1	Open	Food Preference	View series of 6 household items	3 min.
2	Closed	Food Preference	Think about using the household items	3 min.
3	Open	Food Preference	View series of 6 food bars	3 min.
4	Closed	Food Preference	Think about tasting the food bars	3 min.
5	Open	Taste Test	Taste 3 or more of the food bars	Variable
6	Open	Implicit Association Test	Sort presented stimuli according to task instructions	Variable
7	Open	The Shopping Task	Select items for simulated shopping list	Variable

Table 2

Descriptive Statistics and Reliability Coefficients for Psychometric Variables

Variables	<i>M</i>	<i>SD</i>	Items	Actual Range	Z_{skewness}	α
ORTO-15	37.38	3.66	15	28.00-45.00	-1.98	.26
ORTO-P9	22.34	3.80	9	13.00-31.00	-0.78	.69
EAT	8.39	7.93	26	0.00-34.60	6.52	.83
SHAI	14.87	6.28	18	4.00-36.00	3.00	.83
BISS	5.18	1.44	6	1.67-8.83	-0.77	.82

Note. $N = 100$. ORTO-15 = ORTO-15 Test; ORTO-P9 = Polish 9-item version of ORTO-15 test; EAT-26 = Eat Attitudes Test; SHAI: Short Health Anxiety Inventory; BISS = Body Image States Scale; α = Cronbach's alpha internal consistency.

Table 3

Intercorrelations Among Psychometric Variables

Variables	ORTO-15r	ORTO-P9r	EAT-26(ln)	SHAI(ln)	BISS
ORTO-15r	—	.802**	.351**	.116	-.082
ORTO-P9r		—	.538**	.281**	-.218*
EAT-26(ln)			—	.433**	-.277**
SHAI(ln)				—	-.382**
BISS					—

Note. $N = 100$. ORTO-15r = ORTO-15 Test (reciprocal); ORTO-P9r = Polish 9-item version of ORTO-15 Test (reciprocal); EAT-26(ln) = Eating Attitudes Test (logarithmic transformation); SHAI(ln) = Short Health Anxiety Inventory (logarithmic transformation); BISS = Body Image States Scale.

** $p < .01$

Table 4

Descriptive Statistics for Food Exposure Task Variables

Variables	<i>M</i>	<i>SD</i>	Actual Range	<i>Z</i> _{skewness}
Sample Ranking	8.00	53.42	-100.00-100.00	0.83
Sample Consumption	-15.90	34.04	-100.00-100.00	0.98
Total Food Consumption	50.54	23.73	3.71-129.68	2.60
IAT (Natural)	0.99	0.32	-0.02-1.51	-3.29
IAT (Caloric)	0.62	0.35	-0.47-1.34	-2.57
Shopping Task	-58.00	51.01	-100.00-100.00	5.90

Note. *N* = 100.

Table 5

Intercorrelations Among Food Exposure Task Variables

Variables	SR	SC	TF	IAT (N)	IAT (C)	ST
SR	—	.561**	-.030	.010	-.079	.323**
SC		—	-.065	.009	-.010	.198*
TF			—	.087	.020	.024
IAT (N)				—	.531**	-.071
IAT (C)					—	-.016
ST						—

Note. $N = 100$. SR=Sample Ranking; SC = Sample Consumption; TF = Total Food Consumption; IAT (N) = Implicit Association Test (Natural); IAT (C) = Implicit Association Test (Caloric); ST=Shopping Task.

** $p < .01$; * $p < .05$

Table 6

Descriptive Statistics of Original and Log Transformed RMSSD, HF, and SD1 by Recording Block

Block	Original RMSSD			RMSSD(ln)		
	<i>M</i>	<i>SD</i>	<i>zskewness</i>	<i>M</i>	<i>SD</i>	<i>zskewness</i>
1	48.99	36.00	8.95	3.70	0.59	2.71
2	47.10	34.93	9.18	3.66	0.58	2.89
3	46.35	34.68	8.85	3.64	0.59	2.89
4	48.27	35.36	8.21	3.68	0.61	1.80
5	36.19	28.21	10.74	3.39	0.58	3.54
6	50.81	37.59	8.73	3.73	0.61	2.14
7	51.26	40.07	8.29	3.72	0.63	2.45
Block	Original HF			HF(ln)		
	<i>M</i>	<i>SD</i>	<i>zskewness</i>	<i>M</i>	<i>SD</i>	<i>zskewness</i>
1	1449.84	2543.76	17.44	6.53	1.16	1.66
2	1401.95	2257.51	13.63	6.47	1.23	0.86
3	1319.84	2203.15	14.32	6.41	1.17	2.18
4	1446.07	2365.69	17.49	6.53	1.23	0.09
5	676.06	1381.24	22.77	5.70	1.20	1.31
6	1348.55	2261.71	16.20	6.47	1.17	1.18
7	1424.86	2438.05	12.97	6.42	1.24	1.53
Block	Original SD1			SD1(ln)		
	<i>M</i>	<i>SD</i>	<i>zskewness</i>	<i>M</i>	<i>SD</i>	<i>zskewness</i>
1	34.74	25.53	8.96	3.36	0.59	2.73
2	33.39	24.78	9.18	3.32	0.58	2.89
3	32.86	24.60	8.86	3.30	0.59	2.90
4	34.22	25.08	8.21	3.33	0.61	1.80
5	25.63	19.99	10.74	3.05	0.58	3.54
6	35.96	26.60	8.73	3.38	0.61	2.14
7	36.31	28.39	8.29	3.37	0.63	2.45

Note. $N = 100$ except block 6 where $N = 99$. $RMSSD(ln)$ = log transformed RMSSD. $HF(ln)$ = log transformed HF. $SD1(ln)$ = log transformed SD1.

Table 7

Descriptive Statistics of Baseline and Exposure Composite Scores of Original and Log Transformed RMSSD, HF and SD1

Variable	Original			Log Transformed		
	<i>M</i>	<i>SD</i>	<i>z</i> _{skewness}	<i>M</i>	<i>SD</i>	<i>z</i> _{skewness}
RMSSD _B	48.05	34.96	8.85	3.68	0.58	2.88
RMSSD _E	47.31	34.05	8.76	3.66	0.58	2.95
HF _B	42.94	19.66	2.11	6.50	1.17	1.32
HF _E	38.57	19.02	3.61	6.47	1.14	1.90
SD1 _B	34.06	24.80	8.85	3.34	0.58	2.90
SD1 _E	33.54	24.15	8.76	3.31	0.58	2.95

Note. *N* = 100. B = baseline HRV composite score; E = exposure HRV composite score.

Table 8

Descriptive Statistics and Reliability Coefficients for Affective Psychometric Variables

Variables	<i>M</i>	<i>SD</i>	Items	Actual Range	<i>Z</i> _{skewness}	α
STAI _B	8.96	2.14	6	6.00-16.00	3.28	.66
STAI _E	8.75	2.15	6	6.00-16.00	3.79	.68

Note. *N* = 99. STAI_B = State-Trait Anxiety inventory (short) Baseline; STAI_E = State-Trait Anxiety inventory (short) Exposure; α = Cronbach's alpha internal consistency.

Table 9

Unstandardized Regression Coefficients (SE) for Hypothesis 1 Predicting Food Preference According to Sample Ranking, Sample and Total Food Consumption

Covariates	Sample Ranking		
	Coefficient	SE	95% CI
ORTO-P9r	0.331	1.676	-2.997, 3.659
Gender	28.464	12.724	3.200, 53.727
EAT-26(ln)	-2.330	8.122	-18.455, 13.796
SHAI(ln)	15.489	14.046	-12.401, 43.378
BISS	1.735	4.085	-6.375, 9.846
$R^2 = .060, F(5, 94) = 1.20, p = .316$			
Covariates	Sample Consumption		
	Coefficient	SE	95% CI
ORTO-P9r	0.039	1.096	-2.138, 2.216
Gender	3.717	8.323	-12.808, 20.243
EAT-26(ln)	0.273	5.313	-10.275, 10.821
SHAI(ln)	-7.163	9.188	-25.407, 11.080
BISS	-0.847	2.672	-6.152, 4.458
$R^2 = .010, F(5, 94) = 0.19, p = .968$			
Covariates	Total Food Consumption		
	Coefficient	SE	95% CI
ORTO-P9r	1.748	0.716	0.326, 3.171
Gender	-15.144	5.438	-25.942, -4.346
EAT-26(ln)	-4.580	3.471	-11.473, 2.312
SHAI(ln)	-1.872	6.004	-13.793, 10.048
BISS	-0.201	1.746	-3.667, 3.266
$R^2 = .130, F(5, 94) = 2.81, p = .021$			

Note. $N = 100$. ORTO-P9r = Polish 9-item version of ORTO-15 Test (reciprocal); EAT-26(ln) = Eating Attitudes Test (logarithmic transformation); SHAI(ln) = Short Health Anxiety Inventory (logarithmic transformation); BISS = Body Image States Scale; bolded CIs do not straddle zero.

Table 10

Unstandardized Moderated Regression Coefficients (SE) for Moderated Regression Investigating Hypothesis 2 where HRV Recording Block 3 is Criterion Variable and Block 1 is Covariate

Variable	Criterion Variable		
	RMSSD ₃ (ln)		
	Coefficient	SE	95% CI
ORTO-P9r <i>X</i>	-0.003	0.010	-0.022, 0.017
Threat level <i>M</i>	0.028	0.109	-0.189, 0.245
<i>X</i> × <i>M</i>	-0.010	0.013	-0.037, 0.016
RMSSD ₁ (ln) <i>C</i>	0.940	0.052	0.836, 1.044
Constant	0.213	0.200	-0.185, 0.611
$R^2 = .857, F(4, 95) = 113.00, p < .001$			
$R^{2\text{-chng}} = .001, F(1, 95) = 0.59, p = .444$			
Variable	HF ₃ (ln)		
	Coefficient	SE	95% CI
	ORTO-P9r <i>X</i>	0.034	0.029
Threat level <i>M</i>	0.246	0.289	-0.328, 0.821
<i>X</i> × <i>M</i>	-0.042	0.033	-0.107, 0.023
HF ₁ (ln) <i>C</i>	0.881	0.048	0.787, 0.975
Constant	0.426	0.378	-0.323, 1.176
$R^2 = .790, F(4, 95) = 95.93, p < .001$			
$R^{2\text{-chng}} = .005, F(1, 95) = 1.66, p = .201$			
Variable	SDI ₃ (ln)		
	Coefficient	SE	95% CI
	ORTO-P9r <i>X</i>	0.001	0.009
Threat level <i>M</i>	0.059	0.105	-0.150, 0.267
<i>X</i> × <i>M</i>	-0.014	0.013	-0.039, 0.012
SDI ₁ (ln) <i>C</i>	0.938	0.052	0.834, 1.041
Constant	0.168	0.183	-0.196, 0.531
$R^2 = .859, F(4, 95) = 110.77, p < .001$			
$R^{2\text{-chng}} = .002, F(1, 95) = 1.11, p = .294$			

Note. $N = 100$. ORTO-P9r = Polish 9-item version of ORTO-15 Test (reciprocal); $R^{2\text{-chng}} = R$ square increase due to interaction; *ln* = logarithmic transformation.

Table 11

Unstandardized Moderated Regression Coefficients (SE) for Moderated Regression Investigating Hypothesis 2, where HRV Recording Block 4 is Criterion Variable and Block 2 is Covariate

Variable	Criterion Variable		
	RMSSD ₄ (ln)		
	Coefficient	SE	95% CI
ORTO-P9r <i>X</i>	-0.335	0.228	-0.091, 0.022
Threat level <i>M</i>	-0.333	0.224	-0.777, 0.111
<i>X</i> × <i>M</i>	0.035	0.030	-0.024, 0.094
RMSSD ₂ (ln) <i>C</i>	0.930	0.047	0.836, 1.024
Constant	0.590	0.315	-0.035, 1.215
$R^2 = .764, F(4, 95) = 133.41, p < .001$			
$R^{2\text{-chg}} = .012, F(1, 95) = 1.42, p = .236$			
Variable	HF ₄ (ln)		
	Coefficient	SE	95% CI
	ORTO-P9r <i>X</i>	-0.029	0.060
Threat level <i>M</i>	-0.297	0.485	-1.260, 0.667
<i>X</i> × <i>M</i>	0.036	0.063	-0.090, 0.161
HF ₂ (ln) <i>C</i>	0.845	0.053	0.741, 0.950
Constant	1.311	0.582	0.156, 2.467
$R^2 = .708, F(4, 95) = 68.67, p < .001$			
$R^{2\text{-chg}} = .003, F(1, 95) = 0.32, p = .575$			
Variable	SDI ₄ (ln)		
	Coefficient	SE	95% CI
	ORTO-P9r <i>X</i>	-0.035	0.028
Threat level <i>M</i>	-0.333	0.224	-0.778, 0.111
<i>X</i> × <i>M</i>	0.035	0.030	-0.024, 0.094
SDI ₂ (ln) <i>C</i>	0.930	0.047	0.836, 1.024
Constant	0.566	0.302	-0.034, 1.167
$R^2 = .764, F(4, 95) = 133.43, p < .001$			
$R^{2\text{-chg}} = .016, (1, 95) = 1.42 p = .236$			

Note. $N = 100$. ORTO-P9r = Polish 9-item version of ORTO-15 Test (reciprocal); Bolded 95% CI do not straddle zero. $R^{2\text{-chg}}$ = R square increase due to interaction; *ln* = logarithmic transformation.

Table 12

Unstandardized Moderated Regression Coefficients (SE) for Moderated Regression Investigating Hypothesis 2, where HRV Exposure Composite Score is Criterion Variable and Baseline Composite score is Covariate

Variable	Criterion Variable		
	RMSSD _E (ln)		
	Coefficient	SE	95% CI
ORTO-P9r <i>X</i>	-0.020	0.013	-0.045, 0.006
Threat level <i>M</i>	-0.153	0.112	-0.376, 0.070
<i>X</i> × <i>M</i>	0.013	0.015	-0.016, 0.042
RMSSD _B (ln) <i>C</i>	0.955	0.043	0.870, 1.041
Constant	0.335	0.189	-0.041, 0.711
$R^2 = .893, F(4, 95) = 163.23, p < .001$			
$R^{2\text{-chg}} = .002, F(1, 95) = 0.79, p = .377$			
Variable	HF _E (ln)		
	Coefficient	SE	95% CI
	ORTO-P9r <i>X</i>	<0.001	0.033
Threat level <i>M</i>	-0.022	0.275	-0.568, 0.524
<i>X</i> × <i>M</i>	-0.003	0.035	-0.072, 0.067
HF _B (ln) <i>C</i>	0.895	0.036	0.824, 0.966
Constant	0.671	0.310	0.056, 1.286
$R^2 = .848, F(4, 95) = 166.34, p < .001$			
$R^{2\text{-chg}} < .001, F(1, 95) = 0.01, p = .944$			
Variable	SDI _E (ln)		
	Coefficient	SE	95% CI
	ORTO-P9r <i>X</i>	-0.018	0.013
Threat level <i>M</i>	-0.138	0.112	-0.361, 0.084
<i>X</i> × <i>M</i>	-0.011	0.014	-0.017, 0.040
SDI _B (ln) <i>C</i>	0.955	0.043	0.870, 1.040
Constant	0.304	0.178	-0.049, 0.657
$R^2 = .894, F(4, 95) = 162.32, p < .001$			
$R^{2\text{-chg}} = .001, F(1, 95) = 0.61, p = .438$			

Note. $N = 100$. ORTO-P9r = Polish 9-item version of ORTO-15 Test (reciprocal); Bolded 95% CI do not straddle zero. $R^{2\text{-chg}}$ = R square increase due to interaction; *ln* = logarithmic transformation.

Table 13

Unstandardized Regression Coefficients (SE) for Hypothesis 3 Predicting Cognitive Bias According to Natural and Caloric Value of Foods

Covariates	Natural Value		
	Coefficient	SE	95% CI
ORTO-P9r	0.010	0.010	-0.010, 0.031
Gender	-0.074	0.078	-0.229, 0.081
EAT-26(ln)	-0.068	0.050	-0.167, 0.031
SHAI(ln)	0.077	0.086	-0.094, 0.248
BISS	0.019	0.025	-0.030, 0.069
$R^2 = .040, F(5, 94) = 0.786, p = .562$			
Covariates	Caloric Value		
	Coefficient	SE	95% CI
ORTO-P9r	0.018	0.011	-0.003, 0.040
Gender	0.070	0.083	-0.095, 0.234
EAT(ln)	-0.017	0.053	-0.122, 0.088
SHAI(ln)	0.013	0.091	-0.168, 0.195
BISS	0.070	0.027	0.017, 0.123
$R^2 = .098, F(6, 93) = 1.679, p = .135$			

Note. $N = 100$. ORTO-P9r = Polish 9-item version of ORTO-15 Test (reciprocal); EAT-26(ln) = Eating Attitudes Test (logarithmic transformation); SHAI(ln) = Short Health Anxiety Inventory (logarithmic transformation); BISS = Body Image States Scale; Bolded 95% CI do not straddle zero.

Table 14

Unstandardized Regression Coefficients (SE) for Hypothesis 4 Predicting Food Preference According to Shopping Task Score

	Coefficient	SE	95% CI
ORTO-P9r	4.806	1.492	1.844, 7.767
Gender	17.579	11.323	-4.904, 40.062
EAT(ln)	-1.565	7.228	-15.916, 12.785
SHAI(ln)	18.760	12.500	-6.060, 43.580
BISS	9.394	3.635	2.176, 16.611

$$R^2 = .183, F(5, 94) = 4.23, p < .002$$

Note. $N = 100$. ORTO-P9r = Polish 9-item version of ORTO-15 Test (reciprocal); EAT-26(ln) = Eating Attitudes Test (logarithmic transformation); SHAI(ln) = Short Health Anxiety Inventory (logarithmic transformation); BISS = Body Image States Scale. Bolded 95% CI do not straddle zero.

Table 15

Unstandardized Regression Coefficients (SE) for Exploratory Regression Analysis Investigating Moderation of Orthorexia by BMI, Sample Ranking, Sample Consumption, Total Food Consumption, IAT Natural Value and IAT Caloric Value in the Prediction of Shopping Task Performance

Variable	Shopping Task Performance		
	Coefficient	SE	95% CI
ORTO-P9r <i>X</i>	67.627	23.709	20.538, 114.716
BMI(<i>ln</i>) <i>M</i>	187.152	65.443	57.177, 317.126
<i>X</i> × <i>M</i>	-20.002	7.565	-35.027, -4.977
Constant	-807.047	215.823	-1235.692, -378.402
Gender	21.070	11.412	-1.596, 43.736
EAT-26(<i>ln</i>)	-3.131	8.985	-20.986, 14.713
SHAI(<i>ln</i>)	22.785	11.660	-0.373, 45.942
BISS	9.858	4.231	1.455, 18.260
$R^2 = .236, F(7, 92) = 3.76, p = .001$			
$R^2\text{-chng} = .052, F(1, 92) = 6.99, p = .010$			
Variable	Coefficient	SE	95% CI
ORTO-P9r <i>X</i>	4.137	1.402	1.353, 6.922
Sample Ranking <i>M</i>	-0.169	0.219	-0.604, 0.266
<i>X</i> × <i>M</i>	0.049	0.023	0.003, 0.094
Constant	-175.984	46.907	-269.147, -82.822
Gender	9.330	11.314	-13.141, 31.801
EAT-26(<i>ln</i>)	0.830	7.497	-14.061, 15.720
SHAI(<i>ln</i>)	13.601	11.369	-8.979, 36.181
BISS	6.827	4.075	-1.266, 14.920
$R^2 = .299, F(7, 92) = 3.20, p = .004$			
$R^2\text{-chng} = .036, F(1, 92) = 4.50, p = .037$			
Variable	Coefficient	SE	95% CI
ORTO-P9r <i>X</i>	6.617	1.674	3.292, 9.942
Sample Cons. <i>M</i>	-0.532	0.309	-1.145, 0.081
<i>X</i> × <i>M</i>	0.101	0.035	0.031, 0.171
Constant	-223.823	48.517	-320.183, -127.463
Gender	17.928	10.508	-2.941, 38.798
EAT-26(<i>ln</i>)	-1.237	7.438	-16.010, 13.536
SHAI(<i>ln</i>)	23.857	11.943	0.137, 47.577
BISS	7.756	4.198	-0.582, 16.093
$R^2 = .278, F(7, 92) = 3.50, p = .002$			
$R^2\text{-chng} = .051, F(1, 92) = 8.28, p = .005$			

	Coefficient	SE	95% CI
ORTO-P9r X	3.873	3.041	-2.166, 9.912
Total Food Cons. M	-0.196	0.525	-1.238, 0.847
$X \times M$	0.022	0.065	-0.107, 0.150
Constant	-196.157	64.371	-324.003, -68.310
Gender	16.395	12.104	-7.632, 40.421
EAT-26(\ln)	-2.487	10.317	-22.978, 18.004
SHAI(\ln)	18.525	12.104	-5.514, 42.564
BISS	9.282	4.535	0.274, 18.289
$R^2 = .185, F(7, 92) = 2.21, p = .041$			
R^2 -chng = .001, $F(1, 92) = 0.11, p = .738$			
	Coefficient	SE	95% CI
ORTO-P9r X	3.442	5.193	-6.872, 13.754
IAT (Natural) M	-29.289	44.549	-117.767, 59.189
$X \times M$	1.482	4.700	-7.849, 10.813
Constant	-179.395	71.617	-321.634, -37.157
Gender	15.602	11.227	-7.133, 38.337
EAT-26(\ln)	-2.927	9.824	-22.437, 16.584
SHAI(\ln)	19.687	12.243	-4.628, 44.002
BISS	9.595	4.505	0.648, 18.542
$R^2 = .194, F(7, 92) = 2.37, p = .029$			
R^2 -chng = .001, $F(1, 92) = 0.10, p = .753$			
	Coefficient	SE	95% CI
ORTO-P9r X	4.788	2.821	-0.814, 10.390
IAT (Caloric) M	-24.506	41.084	-106.102, 57.090
$X \times M$	0.617	4.226	-7.776, 9.010
Constant	-203.736	52.000	-307, 012, -100.459
Gender	18.904	10.630	-2.208, 40.016
EAT-26(\ln)	-2.145	9.769	-21.547, 17.257
SHAI(\ln)	19.040	12.030	-4.852, 42.931
BISS	10.747	4.769	1.275, 20.219
$R^2 = .199, F(7, 92) = 2.58, p = .018$			
R^2 -chng < .001, $F(1, 92) = 0.21, p = .884$			

Note. $N = 100$. ORTO-P9r = Polish 9-item version of ORTO-15 Test (reciprocal); BMI = Body Mass Index; Sample Cons. = Sample Consumption; Total Food Cons. = Total Food Consumption. Bolded 95% CI do not straddle zero. R^2 -chng = R^2 increase due to interaction.

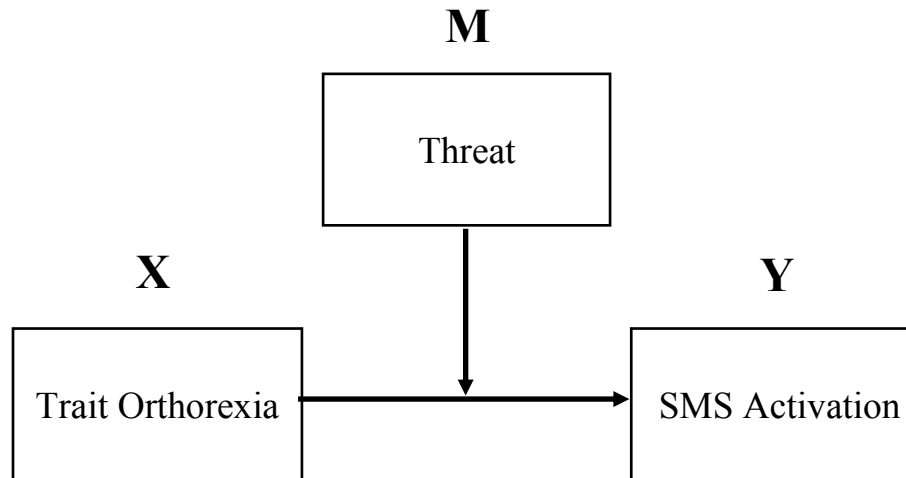


Figure 1. Hypothetical model of the moderating effect of experimentally induced threat level on the relationship between trait orthorexia and security motivation.

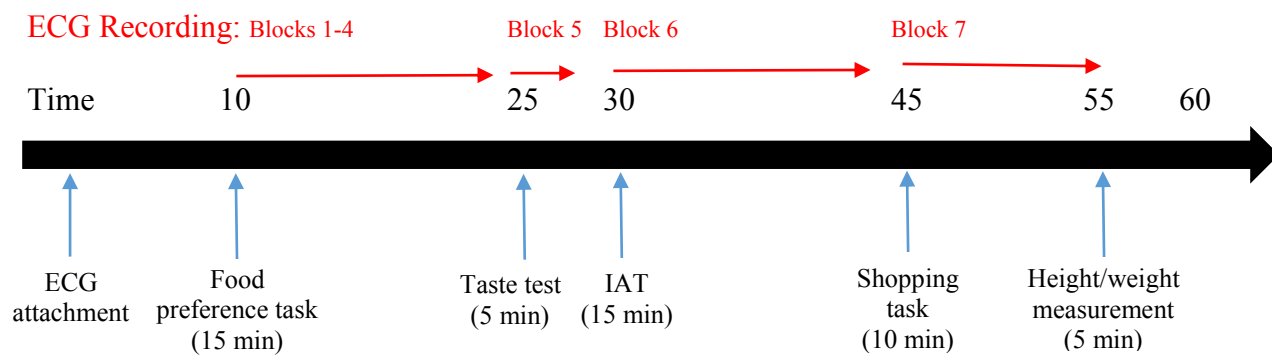


Figure 2. Timeline of experimental procedure for the laboratory visit.

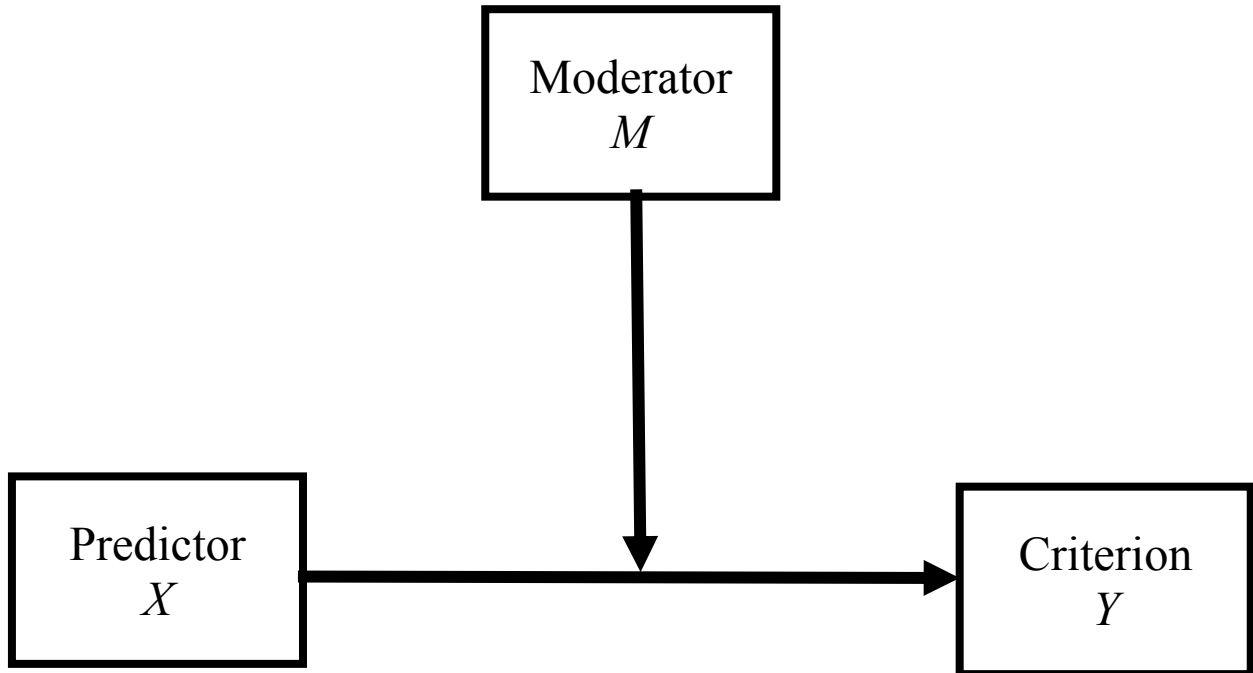


Figure 3. Conceptual diagram of PROCESS Model 1 (Hayes, 2013).

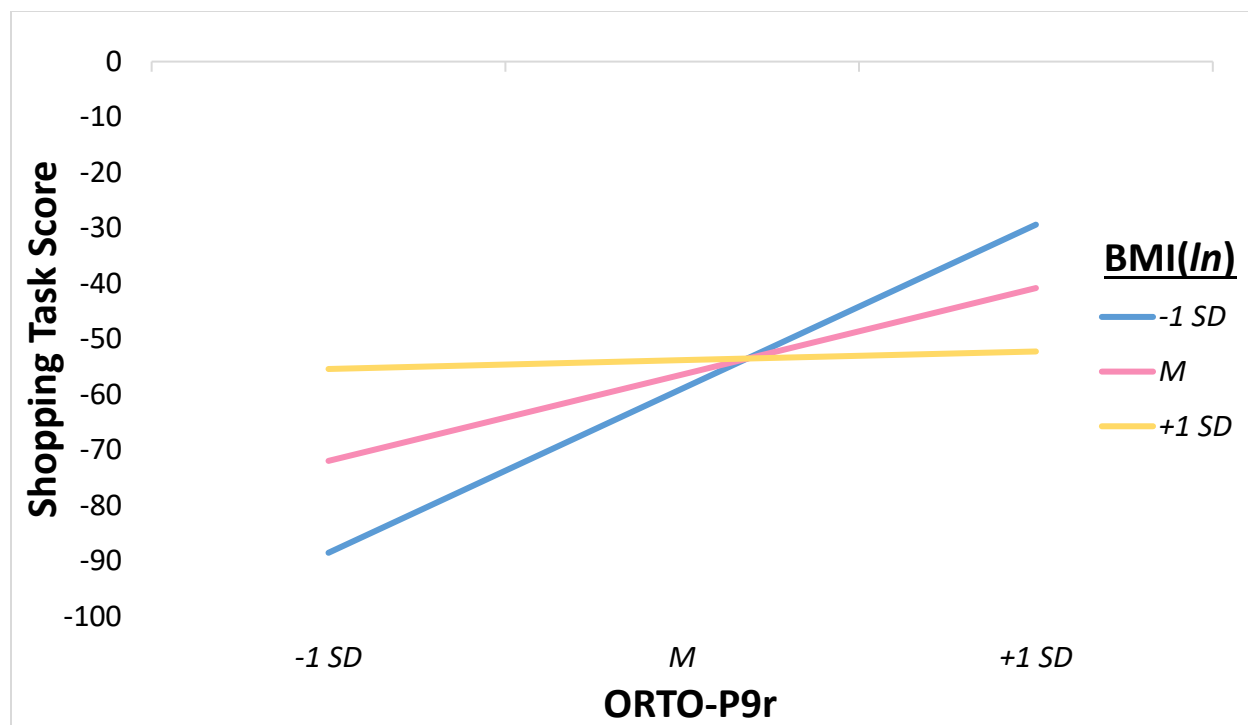


Figure 4. Shopping task score plotted as a function of Polish 9-item version of ORTO-15 Test (reciprocal; ORTO-P9r) by natural log transformed-body mass index ($BMI(ln)$), controlling for gender, $EAT-26(ln)$, $SHAI(ln)$, and BISS.

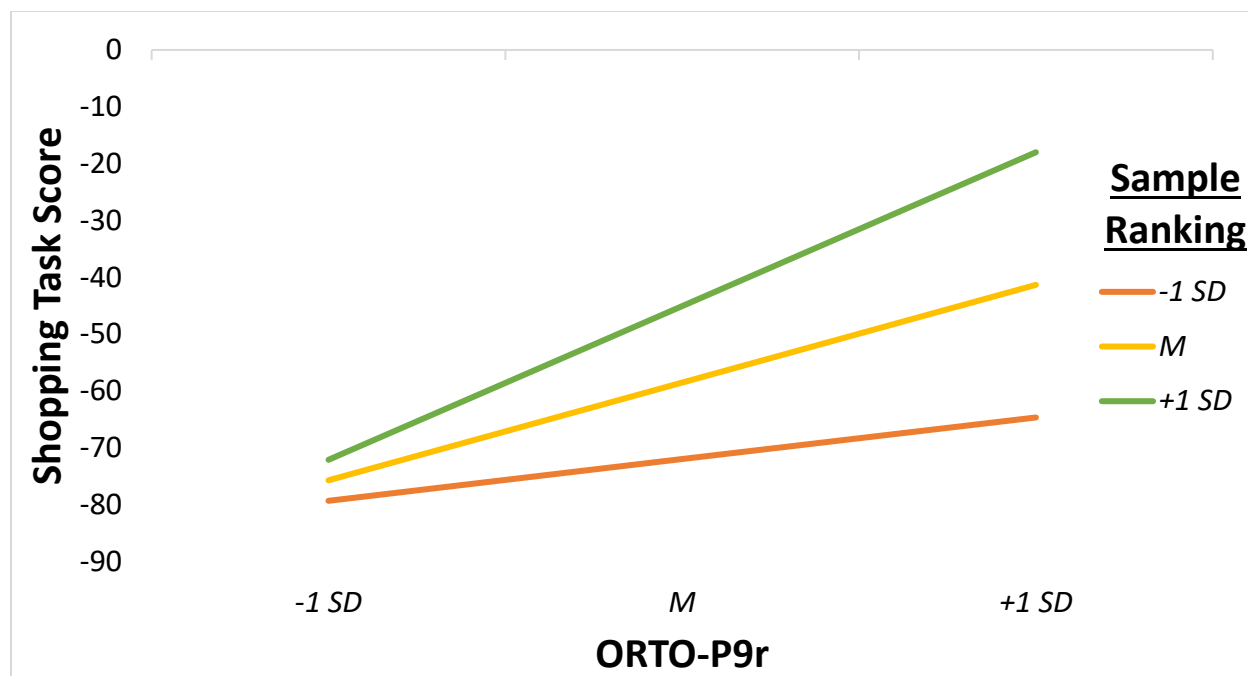


Figure 5. Shopping task score plotted as a function of Polish 9-item version of ORTO-15 Test (reciprocal; ORTO-P9r) by sample ranking controlling for gender, $EAT-26(ln)$, $SHAI(ln)$, and BISS.

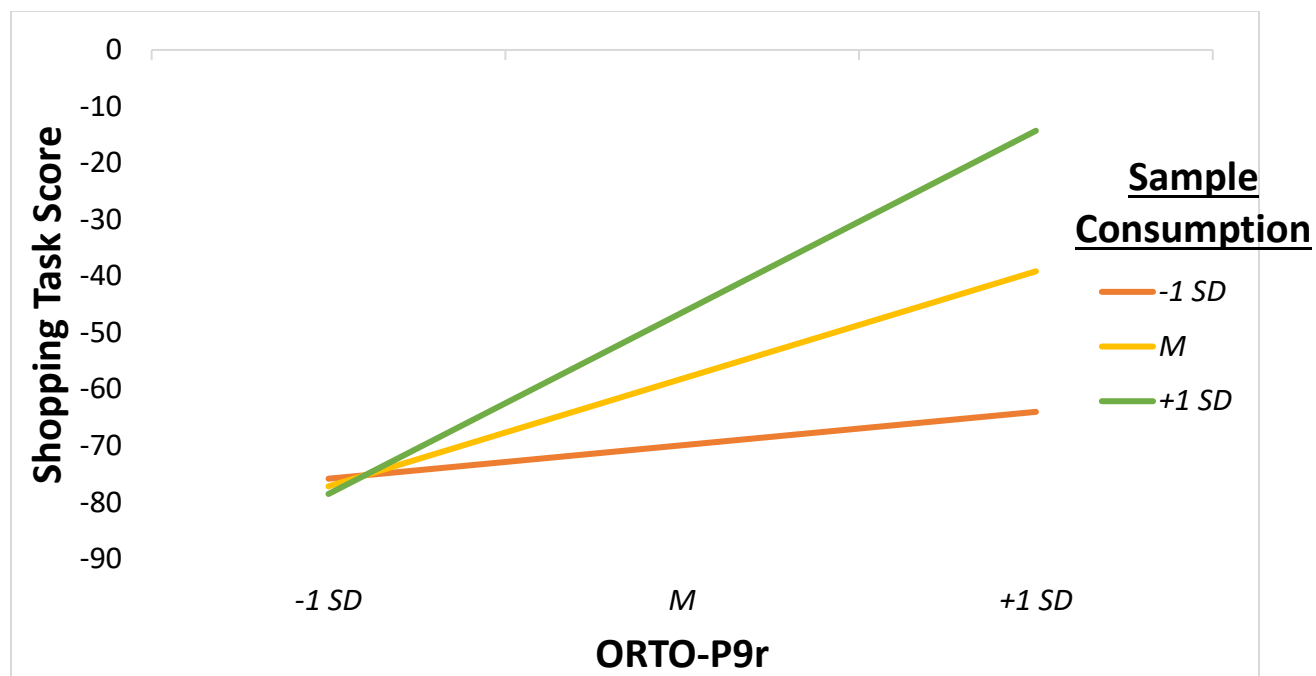


Figure 6. Shopping task score plotted as a function of Polish 9-item version of ORTO-15 Test (reciprocal; ORTO-P9r) by sample consumption controlling for gender, EAT-26(*ln*), SHAI(*ln*), and BISS.

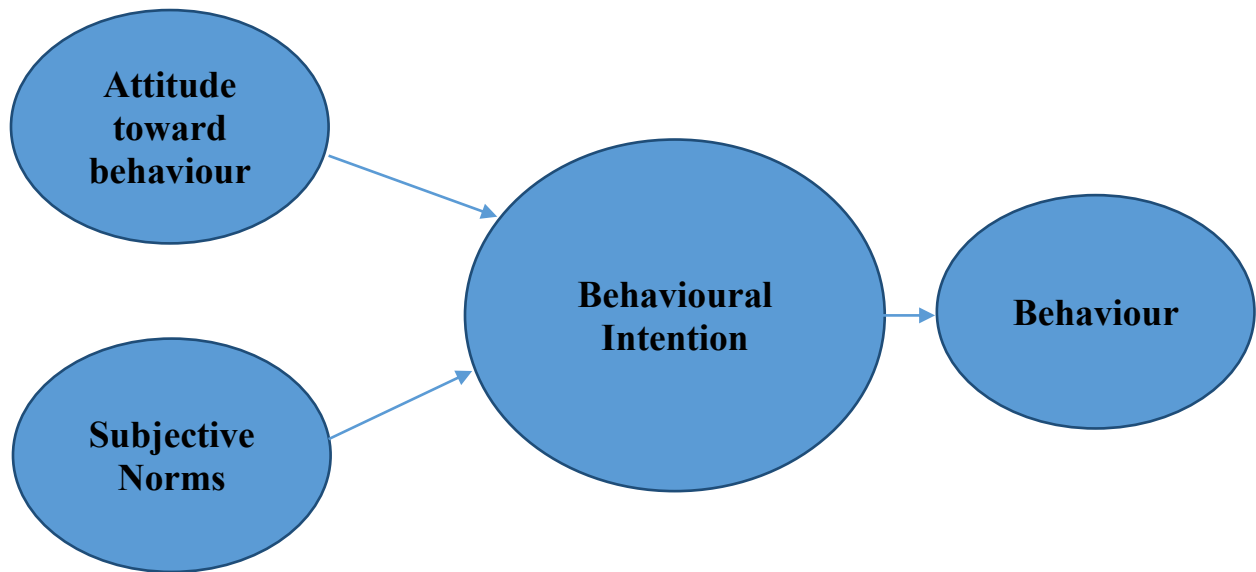


Figure 7. Conceptual diagram of theory of reasoned action (Madden, Ellen, & Ajzec, 1992).

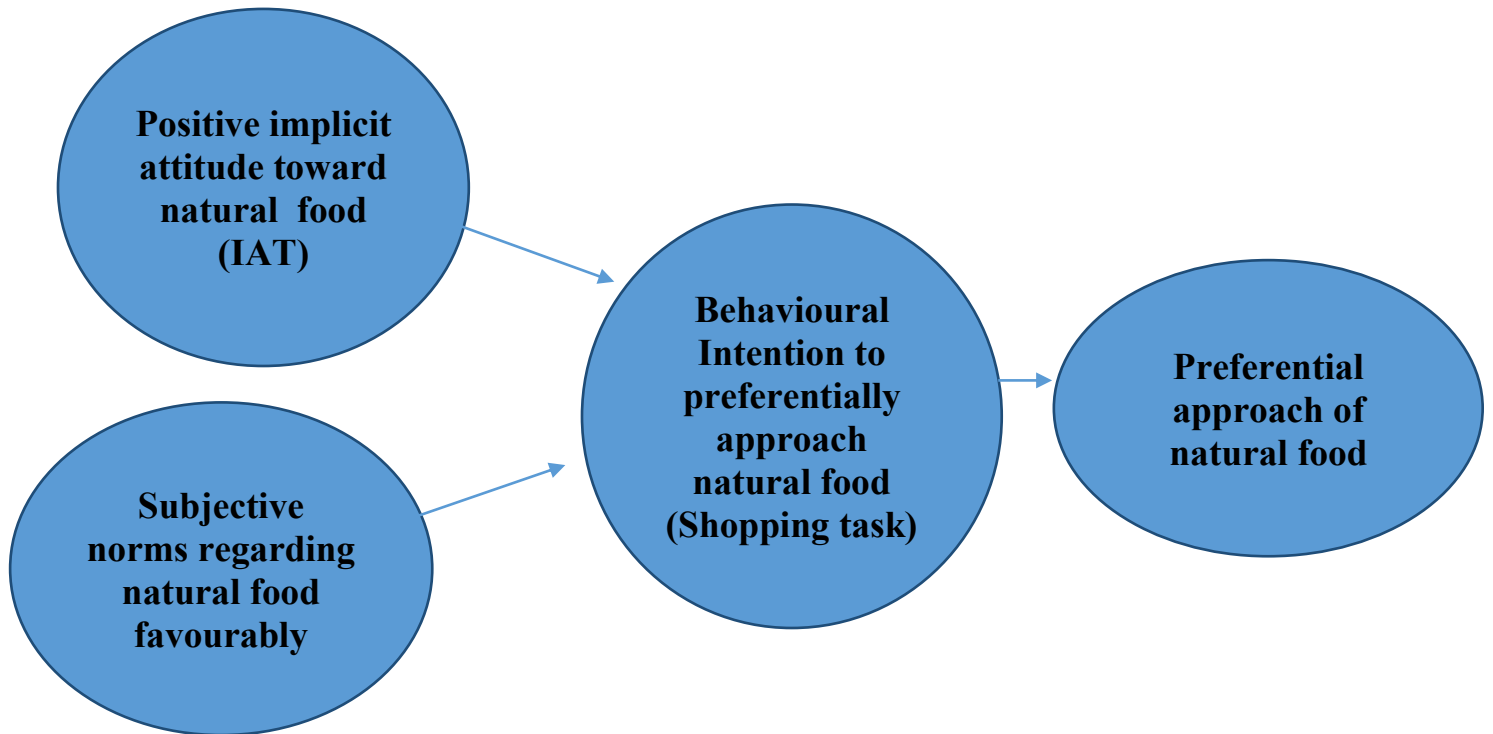


Figure 8. Conceptual diagram of theory of reasoned action applied to the present study.

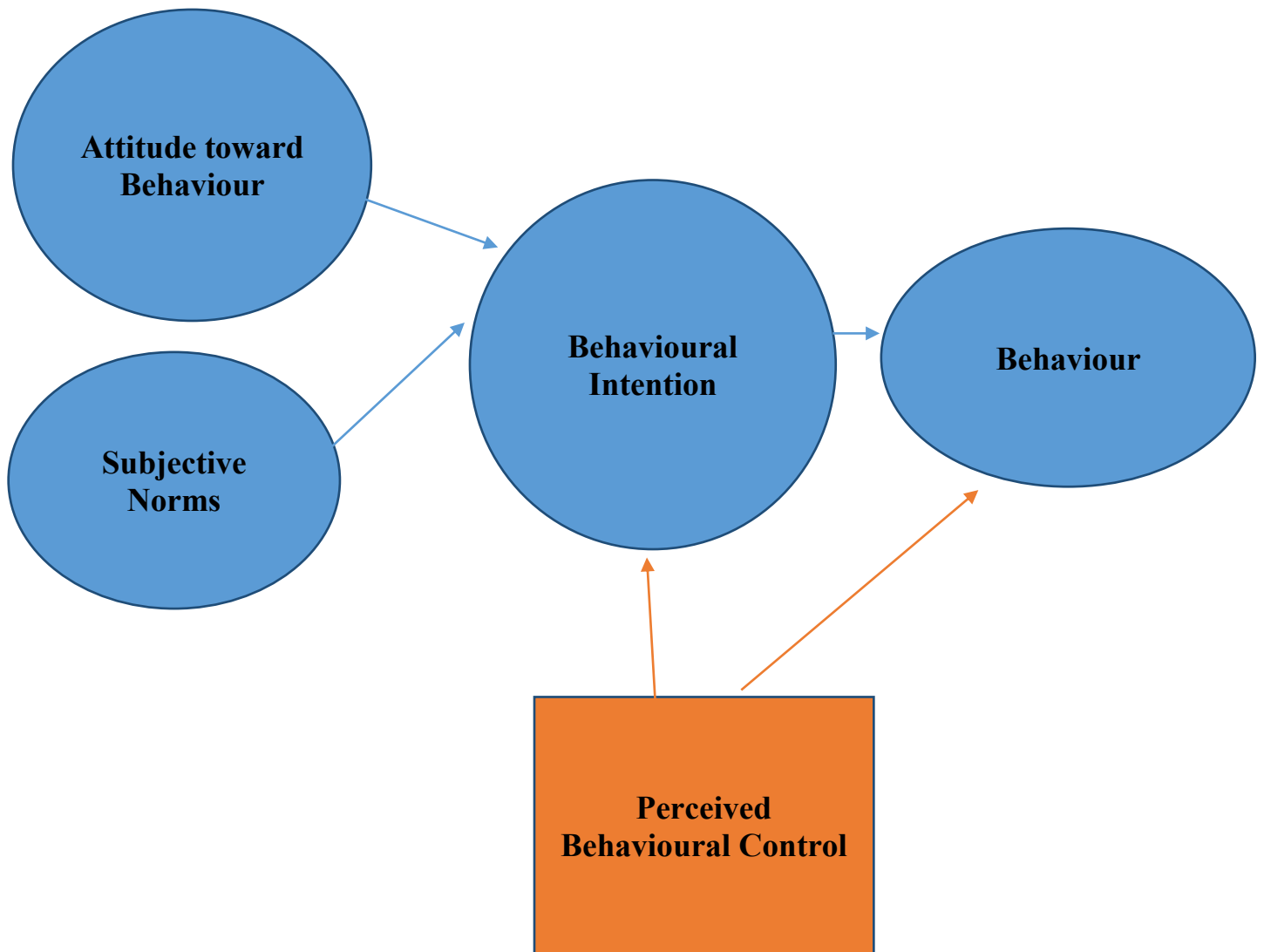


Figure 9. Conceptual diagram of theory of planned behaviour (Madden, Ellen, & Ajzecz, 1992).

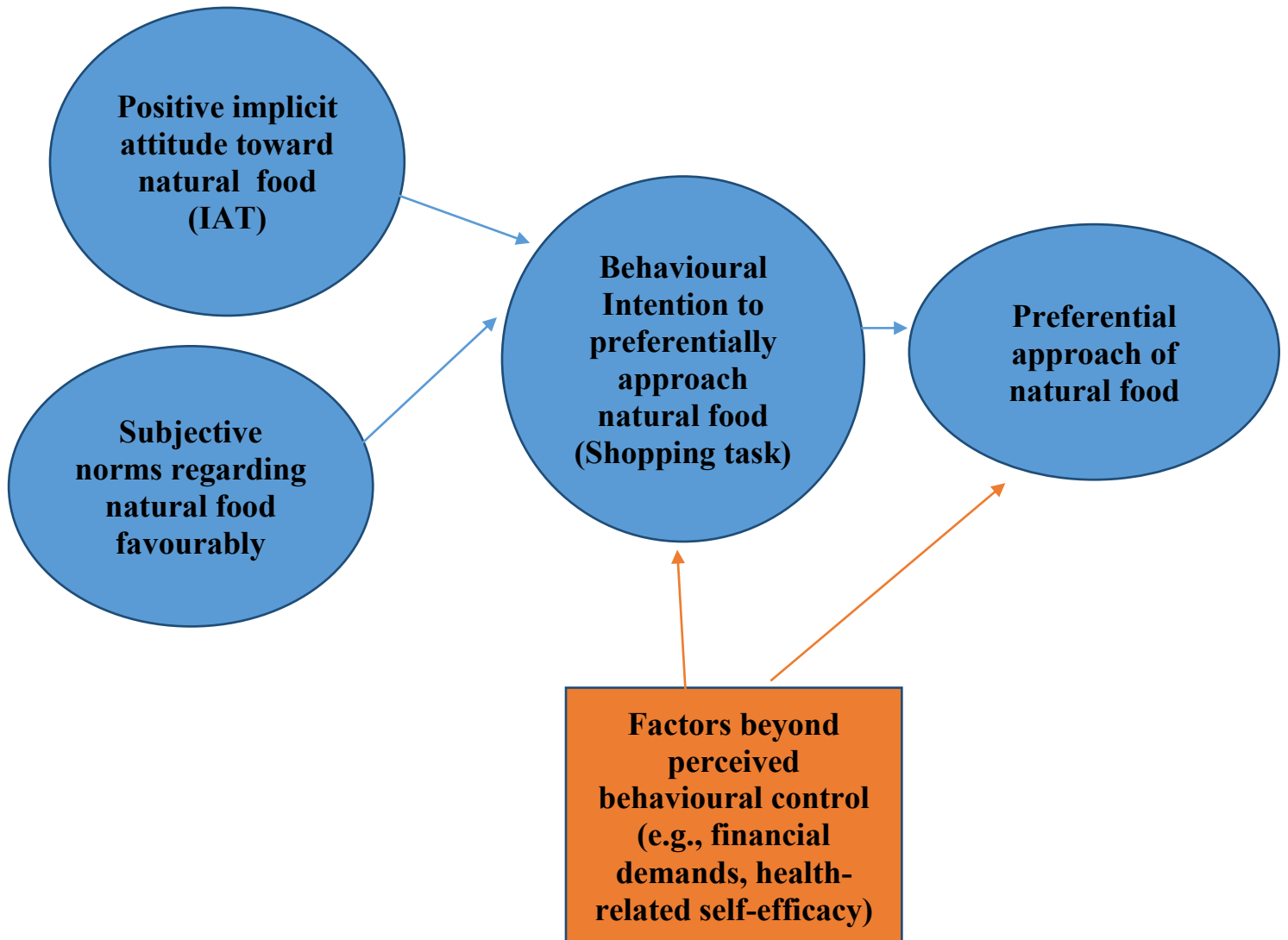


Figure 10. Conceptual diagram of theory of planned behaviour applied to the present study.

Appendix A
Bratman Orthorexia Test (BOT)

1. Do you spend more than three hours a day thinking about healthy food?
2. Do you plan tomorrow's food today?
3. Do you care more about the virtue of what you eat than the pleasure you receive from eating it?
4. Have you found that as the quality of your diet has increased, the quality of your life has correspondingly diminished?
5. Do you keep getting stricter with yourself?
6. Do you sacrifice experiences you once enjoyed to eat the food you believe is right?
7. Do you feel an increased sense of self-esteem when you are eating healthy food? Do you look down on others who don't?
8. Do you feel guilt or self-loathing when you stray from your diet?
9. Does your diet socially isolate you?
10. When you are eating the way you are supposed to, do you feel a peaceful sense of total control?

Appendix B
ORTO-15 Test and Scoring Chart

Test

1. When eating, do you pay attention to the calories of the food?
 - Always
 - Often
 - Sometimes
 - Never

2. When you go in a food shop do you feel confused?
 - Always
 - Often
 - Sometimes
 - Never

3. In the last 3 months, did the thought of food worry you?
 - Always
 - Often
 - Sometimes
 - Never

4. Are your eating choices conditioned by your worry about your health status?
 - Always
 - Often
 - Sometimes
 - Never

5. Is the taste of food more important than the quality when you evaluate food?
 - Always
 - Often
 - Sometimes
 - Never

6. Are you willing to spend more money to have healthier food?
 - Always
 - Often
 - Sometimes
 - Never

7. Does the thought about food worry you for more than three hours a day?
 - Always
 - Often
 - Sometimes
 - Never

8. Do you allow yourself any eating transgressions?
 - Always
 - Often
 - Sometimes
 - Never

9. Do you think your mood affects your eating behaviour?
 - Always
 - Often
 - Sometimes
 - Never

10. Do you think that the conviction to eat only healthy food increases self-esteem?
 - Always
 - Often
 - Sometimes
 - Never

11. Do you think that eating health food changes your lifestyle (frequency of eating out, friends, ...)?
 - Always
 - Often
 - Sometimes
 - Never

12. Do you think that consuming healthy food may improve your appearance?
 - Always
 - Often
 - Sometimes
 - Never

13. Do you feel guilty when transgressing?
 - Always

- Often
- Sometimes
- Never

14. Do you think that on the market there is also unhealthy food?

- Always
- Often
- Sometimes
- Never

15. At present, are you alone when having meals?

- Always
- Often
- Sometimes
- Never

Scoring Chart

Items	Responses			
	Always	Often	Sometimes	Never
2-5-8-9	4	3	2	1
3-4-6-7-10-11-12-14-15	1	2	3	4
1-13	2	4	3	1

Appendix C

Participant Information Letter

Dear Potential Participant:

This study will be of interest to people who:

- are non-smokers;
- are not currently taking any cold, antidepressant, or hypertension medications;
- do not have any nut allergies.

Thank you for your interest in participating in our research study being conducted by student researchers Brittany Mascioli and Gabriela Coccimiglio under the supervision of Dr. Ron Davis in the Department of Psychology at Lakehead University. The purpose of this project is to examine changes in heart and visual activity that may occur when people interact with food. There are two parts to this study. The first part is an online questionnaire which will take up to 60 minutes to complete. The online questionnaire will ask you about some of your thoughts and behaviours with respect to eating, body image and personality. After the completion of part 1, you will be able to choose a time to visit our laboratory in the Department of Psychology for the final portion of the study which will take about 75 minutes of your time.

During the laboratory visit, you will be fitted with two electrooculogram (EOG) electrodes above and below your right eye, and three ECG electrodes on your clavicle and lower rib to record heart and visual activity while you interact with food in the following four ways:

- 1) Sort images of different foods and words into categories.
- 2) Plan a hypothetical list of groceries.
- 3) Rank a number of food items in order of preference.
- 4) Sample some of these foods in a taste test, based on your preferences.

All information that you provide will be kept completely confidential. Only Brittany Mascioli, Gabriela Coccimiglio, and Dr. Ron Davis will be permitted to view your information. A potential conflict of interest may arise for participants enrolled in a class taught by Dr. Davis who may feel pressure to participate. However, Dr. Davis is never aware of the identities of those who volunteer to participate in this study and he will not see any information that could be used to identify participants. In addition, your identifying information will be kept completely confidential in reports of results and publications. All of the information that you provide will be assigned a code unattached to your name and securely stored on a password protected computer located in a double-locked research office in the Department of Psychology at Lakehead University Thunder Bay Campus for 5 years as per University regulations. In addition, your identifying information will be kept completely confidential in reports of results and publications.

A benefit associated with participating in this study is the learning experience that may be gained as a result of participating in psychological research. This research may also benefit society by increasing our knowledge about factors that influence eating behaviours with respect to healthy foods. A risk associated with participating in this study is the potential for distressing feelings to come up relating to body image, eating behaviour and/or personality while completing the

questionnaires. This level of distress or discomfort is no more than you would experience in your daily life when thinking about these topics. You may choose not to answer any of the questions without penalty. If at any point during or after this study you would like to speak to a mental health professional, feel free to contact the Student Health and Counseling Centre located in the Prettie Residence in person or by telephone at 807-343-8361.

Your participation in this study is completely voluntary and you may withdraw from it at any time without penalty.

If you are registered in a Psychology undergraduate course that is eligible for bonus points, your participation in both components (online questionnaire and laboratory visit) would lead to 3 bonus points credited to your final grade in that course: 1 for completing the online questionnaire and another 2 for completing the lab visit.

Please feel free to contact Brittany Mascioli and/or Dr. Ron Davis with any questions that you might have about this study. If you wish to receive a summary of the findings of this study, you will have the opportunity to indicate your interest to do so during the completion of the online questionnaire, during the laboratory session, as well as during a final debriefing email that will be sent once all participants have participated. You will be asked to provide an email address to indicate where the summary should be sent. The summary will be sent at the conclusion of the study once all participants have completed their participation and all analyses have been conducted. You will not be identified directly or indirectly through this process or any subsequent process involving publication of the results.

This study has been approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team, please contact Sue Wright at the Research Ethics Board at 807-343-8283 or research@lakeheadu.ca

Sincerely,

Brittany Mascioli bmasciol@lakeheadu.ca (705) 365-0986
Dr. Ron Davis ron.davis@lakeheadu.ca (807) 343-8646

Appendix D Participant Consent Form

By providing my name and signature below, I indicate that I have read the “Participant Information Letter” and that I have had the opportunity to receive satisfactory answers from the researchers concerning any questions that I might have about my participation in **The Clean Eating Study**. I understand and agree to the following:

1. I understand all of the information on the “Participant Information Letter”;
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 this online questionnaire without penalty or consequence;
5. There are no anticipated physical risks associated with participation in this study. I understand that the act of completing the questionnaire about eating behaviour, body image and personality may cause feelings of distress. This distress is no more than would be experienced in daily life when thinking about these topics. Should I experience any personal distress or discomfort during or following my participation, I know that I may personally contact the Student Health and Counseling Centre at Lakehead University (Thunder Bay campus) located in the Prettie Residence in person or by telephone at 807-343-8361 to speak to a mental health professional;
6. My personal information will be securely stored in the Department of Psychology at Lakehead University for 5 years as per University regulations;
7. Dr. Ron Davis is never aware of the identities of those who volunteer to participate in this study;
8. My personal information will remain anonymous should any publications or public presentations come out of this project;
9. I may receive a summary of this research upon completion if I so request;
10. I give my permission to be contacted by telephone and/or email for the purpose of participation in this study; and
11. I understand and agree to this “Consent to Participate”

Full Name (*please print*)

Date

Signature (*please sign*)

Appendix E
Eating Attitudes Test-26

Instructions: Please answer the questions below as accurately, honestly, and completely as possible.

Check a response for each of the following statements:

1. I am terrified about being overweight.
 - Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never

2. I avoid eating when I am hungry.
 - Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never

3. I find myself preoccupied with food.
 - Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never

4. I have gone on eating binges where I feel that I may not be able to stop.
 - Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never

5. I cut my food into small pieces.

- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never
6. I am aware of the calorie content of foods that I eat.
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never
7. I particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.)
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never
8. I feel that others would prefer if I ate more.
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never
9. I vomit after I have eaten.
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never

10. I feel extremely guilty after eating.
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never
11. I am preoccupied with a desire to be thinner.
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never
12. I think about burning up calories when I exercise.
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never
13. Other people think that I am too thin.
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely
 - Never
14. I am preoccupied with the thought of having fat on my body.
- Always
 - Usually
 - Often
 - Sometimes
 - Rarely

Never

15. I take longer than others to eat my meals.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

16. I avoid foods with sugar in them.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

17. I eat diet foods.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

18. I feel that food controls my life.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

19. I display self-control around food.

- Always
- Usually
- Often
- Sometimes

- Rarely
- Never

20. I feel that others pressure me to eat.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

21. I give too much time and thought to food.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

22. I feel uncomfortable after eating sweets.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

23. I engage in dieting behaviour.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

24. I like my stomach to be empty.

- Always
- Usually
- Often

- Sometimes
- Rarely
- Never

25. I have the impulse to vomit after meals.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

26. I enjoy trying new rich foods.

- Always
- Usually
- Often
- Sometimes
- Rarely
- Never

Appendix F Body Image States Scale

For each of the items below, check the box beside the one statement that best describes how you feel **RIGHT NOW, AT THIS VERY MOMENT**. Read the items carefully to be sure the statement you choose accurately and honestly describes how you feel right now.

1. Right now I feel...

- Extremely dissatisfied with my physical appearance
- Mostly dissatisfied with my physical appearance
- Moderately dissatisfied with my physical appearance
- Slightly dissatisfied with my physical appearance
- Neither dissatisfied nor satisfied with my physical appearance
- Slightly satisfied with my physical appearance
- Moderately satisfied with my physical appearance
- Mostly satisfied with my physical appearance
- Extremely satisfied with my physical appearance

2. Right now I feel...

- Extremely satisfied with my body size and shape
- Mostly satisfied with my body size and shape
- Moderately satisfied with my body size and shape
- Slightly satisfied with my body size and shape
- Neither dissatisfied nor satisfied with my body size and shape
- Slightly dissatisfied with my body size and shape
- Moderately dissatisfied with my body size and shape
- Mostly dissatisfied with my body size and shape
- Extremely dissatisfied with my body size and shape

3. Right now I feel...

- Extremely dissatisfied with my weight
- Mostly dissatisfied with my weight
- Moderately dissatisfied with my weight
- Slightly dissatisfied with my weight
- Neither dissatisfied nor satisfied with my weight
- Slightly satisfied with my weight
- Moderately satisfied with my weight
- Mostly satisfied with my weight

- Extremely satisfied with my weight

4. Right now I feel...

- Extremely physically attractive
- Very physically attractive
- Moderately physically attractive
- Slightly physically attractive
- Neither attractive nor unattractive
- Slightly physically unattractive
- Moderately physically unattractive
- Very physically unattractive
- Extremely physically unattractive

5. Right now I feel...

- A great deal worse about my looks than I usually feel
- Much worse about my looks than I usually feel
- Somewhat worse about my looks than I usually feel
- Just slightly worse about my looks than I usually feel
- About the same about my looks as usual
- Just slightly better about my looks than I usually feel
- Somewhat better about my looks than I usually feel
- Much better about my looks than I usually feel
- A great deal better about my looks than I usually feel

6. Right now I feel that I look...

- A great deal better than the average person looks
- Much better than the average person looks
- Somewhat better than the average person looks
- Just slightly better than the average person looks
- About the same as the average person looks
- Just slightly worse than the average person looks
- Somewhat worse than the average person looks
- Much worse than the average person looks
- A great deal worse than the average person looks

Appendix G
Health Anxiety Inventory (Short Version)

Each question in this section consists of a group of four statements. Please read each group of statements carefully and then select the one which best describes your feelings, over the past six months.

1.

- I do not worry about my health.
- I occasionally worry about my health.
- I spend much of my time worrying about my health.
- I spend most of my time worrying about my health.

2.

- I notice aches/pains less than most other people (of my age).
- I notice aches/pains as much as most other people (of my age).
- I notice aches/pains more than most other people (of my age).
- I am aware of aches/pains in my body all the time.

3.

- As a rule, I am not aware of bodily sensations or changes.
- Sometimes I am aware of bodily sensations or changes.
- I am often aware of bodily sensations or changes.
- I am constantly aware of bodily sensations or changes.

4.

- Resisting thoughts of illness is never a problem.
- Most of the time I can resist thoughts of illness.
- I try to resist thoughts of illness but am often unable to do so.
- Thoughts of illness are so strong that I no longer even try to resist them.

5.

- As a rule, I am not afraid that I have a serious illness.
- I am sometimes afraid that I have a serious illness.
- I am often afraid that I have a serious illness.
- I am always afraid that I have a serious illness.

6.

- I do not have images (mental pictures) of myself being ill.
- I occasionally have images of myself being ill.

- I frequently have images of myself being ill.
- I constantly have images of myself being ill.

7.

- I do not have any difficulty taking my mind off thoughts about my health.
- I sometimes have difficulty taking my mind off thoughts about my health.
- I often have difficulty in taking my mind off thoughts about my health.
- Nothing can take my mind off thoughts about my health.

8.

- I am lastingly relieved if my doctor tells me there is nothing wrong.
- I am initially relieved but the worries sometimes return later.
- I am initially relieved but the worries always return later.
- I am not relieved if my doctor tells me there is nothing wrong.

9.

- If I hear about an illness, I never think I have it myself.
- If I hear about an illness, I sometimes think I have it myself.
- If I hear about an illness, I often think I have it myself.
- If I hear about an illness, I always think I have it myself.

10.

- If I have a bodily sensation or change, I rarely wonder what it means.
- If I have a bodily sensation or change I often wonder what it means.
- If I have a bodily sensation or change I always wonder what it means.
- If I have a bodily sensation or change I must know what it means.

11.

- I usually feel at very low risk for developing a serious illness.
- I usually feel at fairly low risk for developing a serious illness.
- I usually feel at moderate risk for developing a serious illness.
- I usually feel at high risk for developing a serious illness.

12.

- I never think I have a serious illness.
- I sometimes think I have a serious illness.
- I often think I have a serious illness.
- I usually think I have a serious illness.

13.

- If I notice an unexplained bodily sensation, I don't find it difficult to think about other things.
- If I notice an unexplained bodily sensation, I sometimes find it difficult to think about other things.
- If I notice an unexplained bodily sensation, I often find it difficult to think about other things.
- If I notice an unexplained bodily sensation, I always find it difficult to think about other things.

14.

- My family/friends would say I do not worry enough about my health.
- My family/friends would say I have a normal attitude to my health.
- My family/friends would say I worry too much about my health.
- My family/friends would say I am a hypochondriac.

For the following questions, please think about what it might be like if you had a serious illness of a type which particularly concerns you (such as heart disease, cancer, multiple sclerosis and so on). Obviously you cannot know for definite what it would be like; please give your best estimate of what you think might happen, basing your estimate on what you know about yourself and serious illness in general.

15.

- If I had a serious illness, I would still be able to enjoy things in my life quite a lot.
- If I had a serious illness, I would still be able to enjoy things in my life a little.
- If I had a serious illness, I would be almost completely unable to enjoy things in my life.
- If I had a serious illness, I would be complete unable to enjoy life at all.

16.

- If I developed a serious illness, there is a good chance that modern medicine would be able to cure me.
- If I developed a serious illness, there is a moderate chance that modern medicine would be able to cure me.
- If I developed a serious illness, there is a very small chance that modern medicine would be able to cure me.
- If I developed a serious illness, there is no chance that modern medicine would be able to cure me.

17.

- A serious illness would ruin some aspects of my life.
- A serious illness would ruin many aspects of my life.

- A serious illness would ruin almost every aspect of my life.
- A serious illness would ruin every aspect of my life.

18.

- If I had a serious illness, I would not feel that I had lost my dignity.
- If I had a serious illness, I would feel that I had lost a little of my dignity.
- If I had a serious illness, I would feel that I had lost quite a lot of my dignity.
- If I had a serious illness, I would feel that I had totally lost my dignity.

Appendix H
Balanced Inventory of Desirable Responding

Please indicate how much you agree with each statement.

1. My first impressions of people usually turn out to be right.
 - 1 – Very True
 - 2
 - 3
 - 4 – Somewhat True
 - 5
 - 6
 - 7 – Not True

2. It would be hard for me to break any of my bad habits.
 - 1 – Very True
 - 2
 - 3
 - 4 – Somewhat True
 - 5
 - 6
 - 7 – Not True

3. I don't care to know what other people really think of me.
 - 1 – Very True
 - 2
 - 3
 - 4 – Somewhat True
 - 5
 - 6
 - 7 – Not True

4. I have not always been honest with myself.
 - 1 – Very True
 - 2
 - 3
 - 4 – Somewhat True
 - 5
 - 6

- 7 – Not True
5. I always know why I like things.
- 1 – Very True
 - 2
 - 3
 - 4 – Somewhat True
 - 5
 - 6
 - 7 – Not True
6. When my emotions are aroused, it biases my thinking.
- 1 – Very True
 - 2
 - 3
 - 4 – Somewhat True
 - 5
 - 6
 - 7 – Not True
7. Once I've made up my mind, other people can seldom change my opinion.
- 1 – Very True
 - 2
 - 3
 - 4 – Somewhat True
 - 5
 - 6
 - 7 – Not True
8. I am not a safe driver when I exceed the speed limit.
- 1 – Very True
 - 2
 - 3
 - 4 – Somewhat True
 - 5
 - 6
 - 7 – Not True
9. I am fully in control of my own fate.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

10. It's hard for me to shut off a disturbing thought.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

11. I never regret my decisions.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

12. I sometimes lose out on things because I can't make up my mind soon enough.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

13. The reason I vote is because my vote can make a difference.

- 1 – Very True
- 2

- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

14. My parents were not always fair when they punished me.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

15. I am a completely rational person.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

16. I rarely appreciate criticism.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

17. I am very confident of my judgments.

- 1 – Very True
- 2
- 3

- 4 – Somewhat True
- 5
- 6
- 7 – Not True

18. I have sometimes doubted my ability as a lover.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

19. It's all right with me if some people happen to dislike me.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

20. I don't always know the reasons why I do the things I do.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

21. I sometimes tell lies if I have to.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5

- 6
- 7 – Not True

22. I never cover up my mistakes.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

23. There have been occasions when I have taken advantage of someone.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

24. I never swear.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

25. I sometimes try to get even rather than forgive and forget.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

26. I always obey laws, even if I'm unlikely to get caught.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

27. I have said something bad about a friend behind his or her back.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

28. When I hear people talking privately, I avoid listening.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

29. I have received too much change from a salesperson without telling him or her.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

30. I always declare everything at customs.

- 1 – Very True

- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

31. When I was young I sometimes stole things.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

32. I have never dropped litter on the street.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

33. I sometimes drive faster than the speed limit.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

34. I never read sexy books or magazines.

- 1 – Very True
- 2
- 3

- 4 – Somewhat True
- 5
- 6
- 7 – Not True

35. I have done things that I don't tell other people about.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

36. I never take things that don't belong to me.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

37. I have taken sick-leave from work or school even though I wasn't really sick.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

38. I have never damaged a library book or store merchandise without reporting it.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5

- 6
- 7 – Not True

39. I have some pretty awful habits.

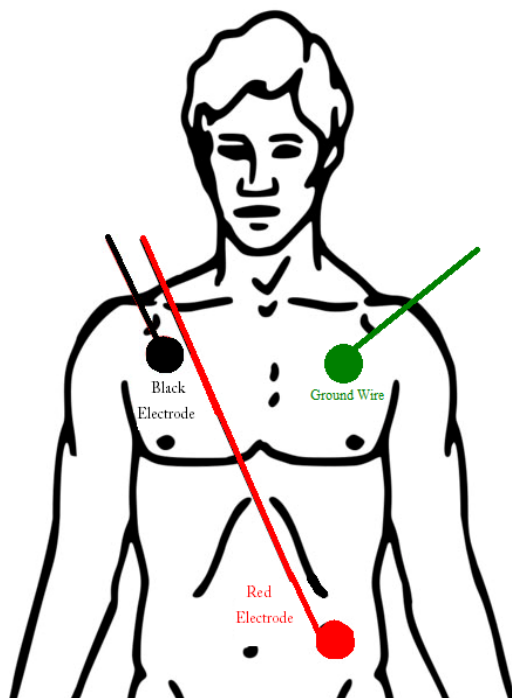
- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

40. I don't gossip about other people's business.

- 1 – Very True
- 2
- 3
- 4 – Somewhat True
- 5
- 6
- 7 – Not True

Appendix I Heart Rate Electrode Placement

As part of this experiment we are interested in collecting information on your heart rate. In order to do this, we will be asking you place electrodes on your skin in the locations below. For your privacy, we will be in the other room while you are applying these electrodes. However, there should be no need for you to remove any of your clothing in order to apply the electrodes.



Please Follow These Steps:

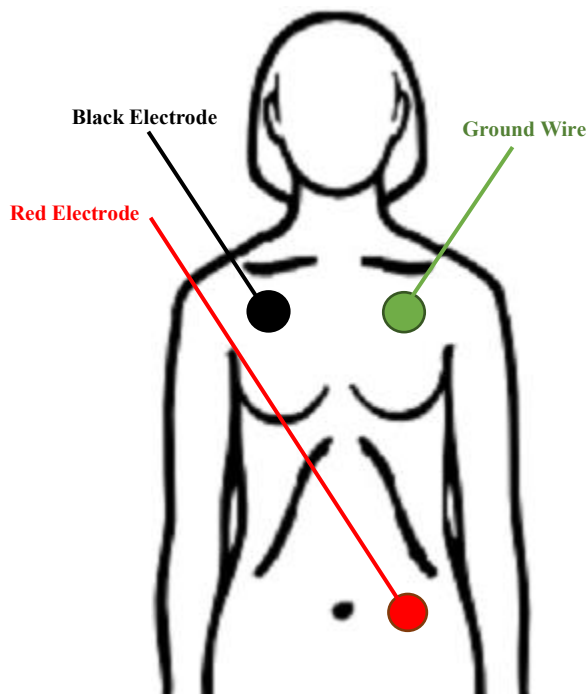
1. Use the alcohol napkin to clean the areas that you will be placing the electrodes.
2. Peel back the protective covering from the black electrode. The surface will now be very sticky, so try not to catch it on your clothes. Place the electrode approximately 1 inch below your collarbone and 2 inches from your right armpit.
3. Peel back the protective covering on the red electrode. Place the electrode below your left ribcage. It sometimes helps to find your lowest left rib with your fingers and then place the electrode approximate 1 inch below this.
4. Peel back the protective covering on the green ground electrode. Place the electrode directly opposite the black electrode on the left side of the body.



This line is 1 inch long

Heart Rate Electrode Placement

As part of this experiment we are interested in collecting information on your heart rate. In order to do this, we will be asking you place electrodes on your skin in the locations below. For your privacy, we will be in the other room while you are applying these electrodes. However, there should be no need for you to remove any of your clothing in order to apply the electrodes.



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3. Peel back the protective covering on the red electrode. Place the electrode below your left ribcage. It sometimes helps to find your lowest left rib with your fingers and then place the electrode approximate 1 inch below this.
4. Peel back the protective covering on the green ground electrode. Place the electrode directly opposite the black electrode on the left side of the body.



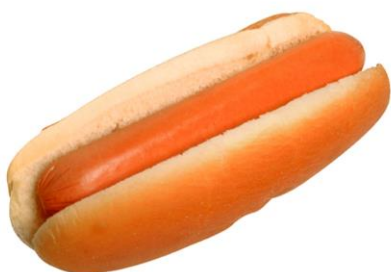
This line is 1 inch long

Appendix J IAT Target Concept Images

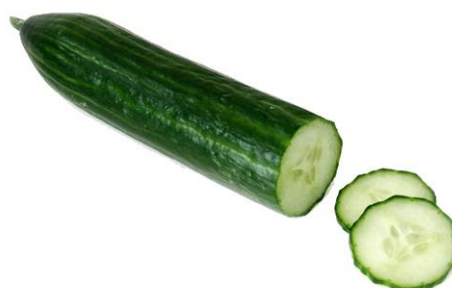
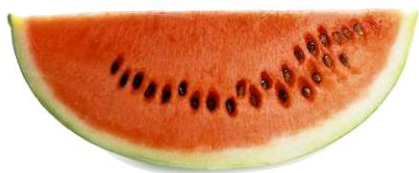
Natural Images



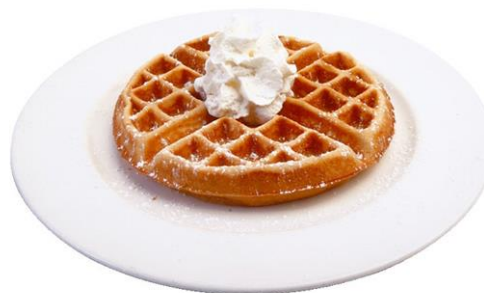
Nonnatural Images



Low-Calorie Images



High Calorie







Appendix K Selected Screenshots of the Shopping Task









Grocery Flyer









Click "Add to cart" to select an item. Click again to unselect it.
The total dollar amount that you have spent is calculated at the bottom of the page.
Pay close attention to the descriptions of the items.
Select items as if you were shopping for groceries for only yourself, to last two weeks.
All prices indicate the total price of the item.
You cannot spend more than one hundred dollars (\$100.00).
Once you are done shopping and have verified that your total does not exceed one hundred dollars (\$100.00),
click "Submit" at the bottom of the page

Produce

			
Avocados—4 for \$4.00!	Romaine Lettuce \$0.99 each	Potatoes \$0.99/lb	Tomatoes \$1.29/lb

Organic Produce

			
Organic Avocados—4 for \$6.99!	Organic Romaine Lettuce \$3.54	Organic Potatoes \$1.49/lb	Organic Tomatoes \$1.75/lb
<input type="checkbox"/> Add to Cart	<input type="checkbox"/> Add to Cart	<input type="checkbox"/> Add to Cart	<input type="checkbox"/> Add to Cart
			
Organic Bell Pepper \$4.99/lb	Organic Carrots \$4.00/lb	Organic Asparagus \$5.99/lb	Organic Zucchini \$1.75/lb

			
Gluten-Free Cookies \$7.29	Organic Gluten-Free Crackers \$7.99	Organic Dried Fruit \$4.99	Gluten & Dairy-Free Ice Cream \$5.99
<input type="checkbox"/> Add to Cart	<input type="checkbox"/> Add to Cart	<input type="checkbox"/> Add to Cart	<input type="checkbox"/> Add to Cart
			
All Natural Organic Juice \$9.29	All Natural Organic Peanut Butter \$6.99	Organic Popcorn \$8.49	Gluten-Free Tortilla Chips \$4.99