The Creation and Testing of a Scale to Measure the Subjective Experiences of Hunger and Satiety

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ABSTRACT

Satiety, in this dissertation, broadly refers to the feeling of fullness and/or inhibition of hunger sensations after a meal resulting from the ingestion of food. The objective of the experiment in Chapter 2 was to gain a better understanding of hunger and fullness from consumers through the use of focus groups. Hunger and fullness sensations were described as having both physical and psychological components. The objectives of Chapter 3 and 4 were to develop and test a questionnaire to assess satiety sensations. Factor analysis of satiety related questions revealed five factors: mental hunger, physical hunger, mental fullness, physical fullness and food liking. These five factors have been named the Five Factor Satiety Questionnaire. In the first validation study, thirty participants evaluated satiety feelings produced by oranges and oatmeal. Food intake from an ad libitum snack offered two hours after breakfast was covertly recorded. The factor scales and traditional single-item scales (hunger, fullness, desire, and prospective consumption) revealed that oatmeal was more satiating than oranges. The factor scales offered enhanced understanding over the traditional scales by showing that oranges produced much more mental hunger and slightly more physical hunger than the oatmeal. The factor scales also had smaller distributions around the means and greater effect sizes than the traditional scales. In a second study, participants evaluated satiety feelings produced by two equal-calorie smoothies that differed only in that one contained cumin to lower acceptability. The more palatable regular smoothie provided greater mental fullness factor sensations than the spiced cumin smoothie. Again, all of the factor scales produced smaller distributions around the means and greater effect sizes. The experiment in Chapter 5 was conducted in response to the interest in understanding satiety that added fibers provide. Hunger and satiety of 10g of oligofructose, inulin, soluble corn fiber, resistant wheat starch and a control with no added fiber in chocolate crisp bars was evaluated. Satiety ratings were made using three satiety scale protocols: (1) Slavin scales of hunger, fullness, satisfaction and prospective consumption, (2) traditional scales of fullness, hunger, amount, and desire and (3) factor scales of mental hunger, physical hunger, mental fullness, physical fullness and food liking. Food intake was measured at
an *ad libitum* lunch served 180min after breakfast and subjects recorded food intake over the remainder of the 24hr study day. Breath hydrogen, breath methane and GI tolerance were assessed. While there were no significant differences in hunger or satiety found using the Slavin scales, traditional scales or factor scales among the fiber treatment bars during the three hour study duration, the factor scales exhibited the least amount of variability indicating higher sensitivity to the differences between the bars than the Slavin or traditional scales. There was also no significant difference found in the *ad libitum* lunch or 24hr calorie consumption among the different fibers. The bar with oligofructose produced the greatest amount of breath hydrogen, bloating and flatulence ratings while the control bar produced the least.
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Chapter 1

LITERATURE REVIEW

Introduction

Satiety, in this dissertation, broadly refers to the feeling of fullness and/or inhibition of hunger sensations after a meal resulting from the ingestion of food (Blundell, 1991; Green et al., 1996; Sorensen et al., 2003). Foods have been shown to vary in their ability to affect feelings of satiety (e.g. Holt et al., 1995; Kissileff et al., 1984; Rolls et al., 1990). Calories, food composition (lipids, carbohydrates, etc.), and food form have all been shown to influence satiety feelings.

Currently, there is no universally accepted measurement for satiety, and sometimes the various methods produce conflicting results. In order to accurately measure the satiety of a food, it is important to have a complete understanding of what it means to be hungry and full. With an improved method to measure satiety, researchers would be able to screen foods for satiety more effectively and be able to gain a better understanding of what factors make a food satiating. Researchers may also be able to gain more insight into the problem of overeating and may be able to better understand ways to help people consume fewer calories. If people consumed foods that provided more satiety per calorie, then their overall calorie intake might be reduced without sacrificing the feelings of satiety and satisfaction from higher calorie foods. Recently, there has been an increasing trend, in both academic and industry settings, to measure the satiety that foods provide. Because of this increase in interest, studies that have investigated the physical and psychological feelings related to hunger and fullness will be described further in this literature review.
Satiety Defined

Over the years, many researchers have shown hunger and satiety to be multi component in nature. Stunkard (1959) asked 200 obese and non-obese subjects what they meant when they said they were hungry. The subjects usually described two components of hunger: (1) the sensations of emptiness in the abdomen, pangs or growls and (2) a desire to eat. In a study with 603 adolescents and adults, Monello and Mayer (1967) asked participants to fill out surveys that were highly structured and consisted of multiple-choice questions. Participants described their feelings of hunger during 6 situations: extreme and ordinary hunger situations (2hr and 0.5hr before a meal), hunger at the beginning of a meal (immediately before eating and after a few bites of food) and hunger at the end of a meal. For each of these eating situations, participants were given a multiple-choice list of sensations and asked to mark all sensations that described their physical sensations, mood, urge to eat, and preoccupation with thoughts of food. No explanation was given for why sensations were included in the list of multiple choice options. Their participants identified many diverse sensation of hunger, yet no one sensation emerged that could solely characterize that hunger. Gastric sensations (emptiness, rumbling, ache, pain, tenseness, nausea) appeared to be the most chosen descriptions of hunger. They also found that the psychological components of urge to eat and preoccupations with thoughts with food were also descriptors of hunger. Their results suggested that hunger may be as much a mental as a physical experience. While many sensations were used to describe hunger, for satiety, participants indicated only vague sensations of gastric bulk and feelings of satisfaction and relaxation as the major sensations experienced. Harris and Wardle (1987) used a revised version of Monello and Mayer’s (1967) hunger/satiety questionnaire and added an additional seven items based on their previous research. They found that neither food deprivation nor reported hunger necessarily implied the perception of bodily sensations (Harris & Wardle, 1987). They were unable to identify a specific hunger symptom or group of hunger symptoms that were commonly experienced by their participants in a hungry state.
(1993) used an open ended questionnaire to ask 83 university students to describe sensations associated with hunger. Participants were also asked to mark on drawings of the human figure where they experienced hunger sensations. Fifteen sensations were listed and were consistent with Mayer et al.’s (1965) work. These fifteen sensations listed in order of the most commonly mentioned were stomach growls, stomach aches, weakness, headaches, pain, dizziness, anxiety, loss of concentration, crave of foods, thoughts of food, mouth waters, uncomfortable, dry mouth, nausea, and thirst. The main area that was reported was the stomach followed by the head region. The neck and chest region were listed by a few as hunger increased. Cardello et al. (2005) compiled a list of 47 phrases (some of which were the same term, just in varying degrees, e.g. extremely full, very full, slightly full) to describe different levels of hunger and fullness. This list was developed from scientific literature on satiety, English dictionaries and from the general psychophysical scaling literature. The words chosen included both physical and psychological components of hunger and fullness (e.g. fullness, hunger, gorged, satiated, satisfied, content, ravenous, neutral, etc.). While many words were initially evaluated, hunger and fullness were the only terms chosen for use on their final Satiety Labeled Intensity Magnitude (SLIM) scale. Zalifah et al. (2008) used the labeled magnitude satiety scale with a linguistically-diverse population to evaluate its suitability for a diverse population. They found additional terms that were ambiguous and not recommended for use (gorged, surfeited, moderately content, slightly satisfied, slightly sated, slightly content, semi-satisfied, semi-hungry, slightly unsatisfied, empty, extreme appetite, voracious, ravenous, least imaginable fullness).

Definitions of hunger and satiety have been discussed over the years. The term satiety has been used in different ways and has been separated, by some, into two functionally different terms. Satiation has been defined as the “with-in meal” satiety (Green et al., 1997; Sorensen et al., 2003). Satiation refers to the process that occurs during a meal and leads to the termination of the meal. Satiety or “between-meal satiety” is most
commonly defined as the state of inhibition from further eating from the end of one meal to the next eating episode (Green et al., 1997; Sorensen et al., 2003). Satiety has also been described as the inhibition of hunger sensations brought on by food consumption (Blundell, 1991). An understanding of satiety cannot be separated from the concept of hunger since hunger and/or the initiation of an eating episode is what is generally thought to be an important aspect of what signals the end of satiety.

Blundell (1979) regarded hunger and satiety as categories of subjective experiences that could not be directly perceived. He believed that hunger and satiety were used as aggregate descriptors of several sensations. Others have agreed that hunger and satiety are multi-component in nature. According to Stubbs et al. (2000) the terms hunger and satiety have objective (unconditioned, or physiological) and subjective (conditioned, or learned) components. Blundell (1991) conceptualized the expression of hunger and satiety in three levels: (1) psychological events (hunger perception, cravings, hedonic sensations) and behavioral operations (meals, snacks, energy and macronutrient intakes); (2) peripheral physiology and metabolic events; and (3) neurotransmitter and metabolic interactions in the brain. Herman and Polivy (1984) described a boundary model for the regulation of eating (Figure 1.1). They used this model to provide an explicit place for both physiological and non-physiological determinants of eating. The idea of the boundary model was that consumption was regulated within boundaries, rather than at a single point. Within the appetitive control zone, various influences such as social factors or food palatability could influence eating. This appetitive control zone was a zone of biological indifference because biological constraints were absent. The physical symptoms of hunger or fullness only occurred once a person passed the boundary out of appetitive control into aversive control. The cognitive and social pressures may spill over into the aversive zones of hunger and satiety such as with a serious dieter who tries to ignore the physiological signs of hunger or such as at a Thanksgiving meal where a person may overeat and be pushed into the satiety aversive control zone.
Oral sensations have been shown to strongly increase the perception of satiety. Jordan (1969) conducted experiments to study if human subjects could control ingestion of a liquid diet orally and/or intragastrically. He found that while food intake could be roughly regulated with the elimination of oropharyngeal factors, there was a separate oral aspect of satiety that was not met. Subjects reported oral cravings after the intragastric meals. Their hunger ratings did not fall as fast as in the studies using the oral feeding method. Likewise, Cecil et al. (1999) found that when a high fat and a high carbohydrate soup of equal calories were consumed intragastrically there were no differences in ratings of hunger and fullness, however when the soups were consumed orally, the high fat soup suppressed hunger and induced fullness more than the high carbohydrate soup. It also tended to be more effective at reducing energy intake from the test meal. These research studies again point towards the multi-component nature of hunger and fullness.

**Common Satiety Descriptors**

Although research supports the multi-component nature of satiety, there does not appear to be any general agreement on terminology that adequately expresses the components of hunger and fullness. In the vast majority of satiety related research only a few select scales, such as hunger and fullness, have been used to measure the satiety that the foods provided. Some researchers have asked subjects to rate only hunger and/or fullness (e.g. Jordan, 1969; Merrill et al., 2004; Teghtsoonian et al., 1981) while others have asked
subjects to rate a group of subjective sensations such as hunger, fullness, satiety, prospective consumption, fullness, desire to eat, satisfaction, nausea, bloatedness, etc. (e.g. Cardello et al., 2005; Holt et al., 1995; Kissileff et al., 1984; Merrill et al., 2002; Rolls et al., 1990). Some researchers asked subjects to rate hunger and satiety/fullness independently, while others ask subjects to rate hunger/fullness on a bipolar scale (indicated by 'hunger/satiety' or 'hunger/fullness' in table 1.1 as opposed to 'hunger, fullness'). Sometimes additional scales, not used in the final data analysis, were evaluated to distract from the primary aim of the study. For example, Cecil et al. (1999) evaluated nausea, dizziness and tiredness in addition to hunger and fullness, Herman et al. (1999) included tiredness and happiness to distract from the aim of the study, and Holt et al. (Holt & Sandona, 2000) asked mood related scales to distract from the importance of the hunger ratings. While many studies did investigate numerous sensations, the sensations were analyzed independently and only the hunger and fullness/satiety sensations were discussed and used to determine the amount of satiety that the treatments provided. For many of the studies that used multiple scales other than hunger and fullness, the authors gave no clear reason for why the additional scales were chosen for evaluation. Table 1.1 includes scales evaluated in 64 articles on hunger and fullness. Because of this vast array of sensations used to measure hunger and satiety, Blundell et al. (2010) recommended that hunger, fullness, satiety, desire, and prospective consumption (How much do you think you could eat right now?) be used to establish a standardized set of scales for the evaluation of hunger and satiety.
Table 1.1: List of scales evaluated in satiety related literature from the past 30 years. Descriptors with a slash between them (e.g. hunger/fullness) indicate use of a bipolar scale.

<table>
<thead>
<tr>
<th>Article</th>
<th>Descriptors evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Louis-Sylvestre et al., 1989)</td>
<td>hunger</td>
</tr>
<tr>
<td>(Teghtsoonian et al., 1981)</td>
<td>fullness</td>
</tr>
<tr>
<td>(Spiegel, 1973)</td>
<td>hunger, fullness</td>
</tr>
<tr>
<td>(McKiernan et al., 2009)</td>
<td>hunger, thirst</td>
</tr>
<tr>
<td>(Brunstrom &amp; Mitchell, 2006)</td>
<td>hunger, fullness, desire to eat</td>
</tr>
<tr>
<td>(Monsivais et al., 2007)</td>
<td>hunger, fullness, thirst, nausea, desire to eat</td>
</tr>
<tr>
<td>(Cooling &amp; Blundell, 1998; Doucet et al., 2003)</td>
<td>hunger, fullness, desire to eat, prospective consumption</td>
</tr>
<tr>
<td>(Herman et al., 1999)</td>
<td>hunger, fullness, tiredness, happiness</td>
</tr>
<tr>
<td>(Rolls, et al., 1994b)</td>
<td>hunger, fullness, thirst, desire to eat, prospective consumption, nausea</td>
</tr>
<tr>
<td>(Bell et al., 1998)</td>
<td>hunger, fullness, thirst, prospective consumption, nausea</td>
</tr>
<tr>
<td>(Stunkard &amp; Koch, 1964)</td>
<td>hunger, emptiness, desire to eat, gastric motility</td>
</tr>
<tr>
<td>(Griggs &amp; Stunkard, 1964)</td>
<td>hunger, gastric motility</td>
</tr>
<tr>
<td>(Stunkard &amp; Fox, 1971)</td>
<td>hunger, stomach contractions</td>
</tr>
<tr>
<td>(Stunkard, 1959)</td>
<td>emptiness, desire to eat, hunger</td>
</tr>
<tr>
<td>(Stubb et al., 1998)</td>
<td>hunger, fullness, appetite, urge to eat, desire to eat, thoughts of food</td>
</tr>
<tr>
<td>(Blundell, 1979)</td>
<td>emptiness, dryness, salivation, unpleasant taste, tightness, headache, dizziness, faintness, spots before the eyes, ringing in ears, emptiness, rumbling, ache, pain, tensioness, nausea, weakness, tiredness, restlessness, cold, warmth, muscular spasms, urge to eat, full stomach, distended, bloated, thoughts of food, self-control required to stop eating</td>
</tr>
<tr>
<td>(Blundell &amp; Rogers, 1980)</td>
<td>hunger, appetite, satiety, arousal, mood scales (happy-sad, lethargic-energetic, tense-relaxed), cerebral, gastric, mouth and throat sensations, desire to eat, prospective consumption, satiety, arousal, alertness, lethargicness/energeticness, attentiveness/dreaminess</td>
</tr>
<tr>
<td>(Kissileff et al., 1996)</td>
<td>hunger, palatability, desire to eat your favorite food, fullness, sickness, strength of feeling like you’ve had enough to eat</td>
</tr>
<tr>
<td>(Parker et al., 2004)</td>
<td>hunger, fullness, nausea, drowsiness, anxiety, satiety, desire to eat, prospective consumption</td>
</tr>
<tr>
<td>(Warwick et al., 1993)</td>
<td>hunger, fullness, alertness</td>
</tr>
<tr>
<td>(De Graaf et al., 1999)</td>
<td>appetite for a meal</td>
</tr>
<tr>
<td>(Hill, Magson et al., 1984)</td>
<td>desire to eat, hunger, fullness, prospective consumption, weakness, irritability, calmness, relaxed, alertness, pleasantness of the food, satisfaction with the food</td>
</tr>
<tr>
<td>(Bobroff &amp; Kissileff, 1986)</td>
<td>palatability, satiety</td>
</tr>
<tr>
<td>(Yeomans, 1996)</td>
<td>hunger, fullness, thirst, food attractiveness, palatability</td>
</tr>
<tr>
<td>(Hetherington et al., 2000)</td>
<td>pleasantness</td>
</tr>
<tr>
<td>(Ward &amp; Mann, 2000)</td>
<td>hunger, mood</td>
</tr>
<tr>
<td>(Wardle &amp; Beales, 1988)</td>
<td>hunger, desire to eat, food appeal</td>
</tr>
<tr>
<td>(Fedoroff et al., 2003)</td>
<td>hunger, fullness, desire to eat, liking, desire to eat for a particular food, craving</td>
</tr>
<tr>
<td>(Sepple &amp; Read, 1989)</td>
<td>anxious, sleepy, desire to eat, hunger, prospective consumption, sickness, fullness, dizziness, indigestion, tummy rumbling, headache, thirst</td>
</tr>
<tr>
<td>(Hulshof et al., 1993)</td>
<td>appetite for a meal, appetite for something sweet, appetite for something savory, satiety, feebleness/weakness with hunger</td>
</tr>
<tr>
<td>(Himaya &amp; Louis-Sylvestre, 1998)</td>
<td>hunger, pleasantness</td>
</tr>
<tr>
<td>(Mattes &amp; Campbell, 2009)</td>
<td>hunger, fullness, desire to eat, thirst, desire to eat something salty, desire to eat something sweet, desire to eat something fatty</td>
</tr>
<tr>
<td>Article</td>
<td>Descriptors evaluated</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------</td>
</tr>
<tr>
<td>(Linne et al., 2002)</td>
<td>motivation to eat, desire to eat, fullness, prospective consumption</td>
</tr>
<tr>
<td>(Stubbs et al., 1995)</td>
<td>hunger, fullness, appetite, pleasantness, and satisfaction of food</td>
</tr>
<tr>
<td>(Burns et al., 2001b)</td>
<td>hunger, fullness, thirst, desire to eat, thoughts of food</td>
</tr>
<tr>
<td>(Yeomans et al., 1997)</td>
<td>desire to continue eating, hunger, fullness, food pleasantness</td>
</tr>
<tr>
<td>(Shide et al., 1995)</td>
<td>hunger, fullness, nausea, cramps, bloating</td>
</tr>
<tr>
<td>(Cecil et al., 1999)</td>
<td>hunger, fullness, nausea, dizziness and tiredness</td>
</tr>
<tr>
<td>(de Castro &amp; Elmore, 1988)</td>
<td>hunger, thirst, mood, energy</td>
</tr>
<tr>
<td>(Burton-Freeman, 2005)</td>
<td>hunger, fullness, desire to eat, prospective consumption, appetite satisfaction</td>
</tr>
<tr>
<td>(Rolls et al., 1990)</td>
<td>thirst, desire to eat, prospective consumption, fullness, satisfaction, nausea, bloatedness, mouth dryness</td>
</tr>
<tr>
<td>(Mattes &amp; Rothacker, 2001)</td>
<td>fullness, hunger, bursting, stuffed, gorged, surfeited, sated, satisfaction, content, famished, neutral, no particular feeling, no appetite, empty, voracious, ravenous</td>
</tr>
<tr>
<td>(Bell et al., 2003)</td>
<td>prospective consumption, hunger, thirst, fullness, nausea, food desired</td>
</tr>
<tr>
<td>(Kissileff et al., 1984)</td>
<td>eagerness to consume the item, prospective consumption, hunger/satiety</td>
</tr>
<tr>
<td>(Rolls et al., 1988)</td>
<td>gastric aching, unpleasant taste, unpleasant oral sensation, weak, warm gastric emptiness, gastric tenseness, alertness, hunger, fullness, desire to eat</td>
</tr>
<tr>
<td>(Rolls et al., 1992)</td>
<td>hunger, thirst, desire to eat, fullness, prospective consumption, bloatedness, desire to binge, desire to purge, guiltiness, fear of becoming fat, depression</td>
</tr>
<tr>
<td>(Holt &amp; Miller, 1994)</td>
<td>hunger, palatability</td>
</tr>
<tr>
<td>(Holt et al., 1995)</td>
<td>Hunger/fullness, prospective consumption, difficulty to eat, sufficiency of serving size, prospective to eat more of the test food, desire to eat something else, desire to eat sweet, desire to eat savory</td>
</tr>
<tr>
<td>(Green et al., 1996)</td>
<td>salty, sweet, pleasant, filling, willingness to eat, thirst, mood, hunger, fullness, perceived qualities of the food</td>
</tr>
<tr>
<td>(Fedoroff et al., 1997)</td>
<td>hunger, fullness, desire to eat, liking, craving, desire to eat a particular food</td>
</tr>
<tr>
<td>(Beridot-Therond et al., 1998)</td>
<td>hunger, satiation, thirst</td>
</tr>
<tr>
<td>(Holt &amp; Delargy, 1999)</td>
<td>alertness, motivation to eat, hunger, desire to eat, fullness, prospective consumption</td>
</tr>
<tr>
<td>(Holt &amp; Sandona, 2000)</td>
<td>alertness, calmness, agitation, hunger, fullness, moods</td>
</tr>
<tr>
<td>(Raben et al., 2003a)</td>
<td>hunger, satiety, fullness, prospective consumption, desire for something salty, desire for sweet, desire for fatty, desire for fish meat</td>
</tr>
<tr>
<td>(Cani et al., 2006)</td>
<td>satiety, hunger, fullness, prospective consumption</td>
</tr>
<tr>
<td>(Flood et al., 2006)</td>
<td>hunger, thirst, fullness, prospective consumption, nausea, sufficiency</td>
</tr>
<tr>
<td>(Mayer et al., 1965)</td>
<td>hunger, fullness, desire to eat, prospective consumption, thirst, enjoyment</td>
</tr>
<tr>
<td>(Friedman et al., 1999)</td>
<td>hunger, desire to eat, amount that could be eaten and fullness, reported body area of hunger sensation</td>
</tr>
<tr>
<td>(Lowe et al., 2000)</td>
<td>hunger, desire to eat, prospective consumption, fullness, stomach growling, headache, thirst, nausea, weakness, dizziness, anxiety, stomach aches, dry mouth</td>
</tr>
<tr>
<td>(Merrill et al., 2002)</td>
<td>hunger, fullness, prospective consumption</td>
</tr>
<tr>
<td>(Hollis &amp; Henry, 2007)</td>
<td>hunger, thirst, pleasantness of appearance, odor, texture, taste and overall palatability</td>
</tr>
<tr>
<td>(Brondel et al., 2007)</td>
<td>hunger, appetite, salivation</td>
</tr>
<tr>
<td>(Mattes, 2007)</td>
<td>appetite, fullness, hunger, desire to eat, and prospective food consumption</td>
</tr>
</tbody>
</table>
Current Methods to Measure Satiety

Line Scales

The most commonly used scale to measure the subjective ratings of hunger, fullness, etc. has been the line scale, called a visual analog scale (VAS) by many researchers. Line scales are usually in the form of a horizontal or vertical line of varying length, with words anchored at each end (the extremes of a question being asked). Participants are usually asked to make a vertical mark across the line corresponding to their feeling at that time. For example, a line scale for hunger may be labeled with “I am not hungry at all” to “I have never been more hungry” (Sorensen et al., 2003). In this example participants would be asked to make a vertical mark across the line corresponding to their hunger at that time. Line scales have been widely used because they are easy and quick to use and simple to interpret. Stubbs et al. (2000) reviewed articles that evaluated the reliability and validity of line scales in terms of the scales’ ability to predict eating behavior, their sensitivity to experimental manipulations, and their reproducibility. Overall, they found that line scales showed a good degree of within subject reliability and validity, because they could predict meal initiation (shown by significant correlations between the hunger rating and the duration of the interval preceding the meal), and the amount eaten (shown by significant correlations between the hunger rating and the amount consumed), were sensitive to test meal manipulations, and resulted in good test-retest reliability. They concluded that line scales were best used in within-subject, repeated measure designs where the effect of different treatments could be compared under similar circumstances. They suggested that the scales were also best used in conjunction with other measures such as eating behavior and changes in plasma metabolites.

There are mixed conclusions as to the ability of line scales to predict food intake. Many studies have used hunger and satiety line scales to predict subsequent food intake (e.g. Kissileff, 1984; Rolls et al., 1990; Rolls et al., 1988), but some researchers argue that line scales do not accurately predict satiety or subsequent food consumption or provide a
sufficient means for food differentiation (e.g. Rolls et al., 1990; Rolls et al., 1988; Wardle, 1987). In a study that investigated foods with varying energy densities, Wardle (1987) found that feelings of fullness and hunger varied for foods with different energy densities, and while not significant, there was a trend towards higher consumption after the low calorie condition than after the high calorie condition. de Castro and Elmore (1988) reported significant correlations between ratings made on a bipolar hunger/fullness scale and the energy content eaten at a subsequent meal. Mattes (1990) found discrepancies in correlations between hunger ratings and energy intake on weekdays versus weekends. No significant correlations were observed for individual subjects. Eating often occurred when hunger ratings were low, and few individuals exhibited a significant correlation between hunger ratings and number of eating occurrences. They concluded that hunger ratings were not a valid index of energy intake computed from food records or the number of eating occurrences. Hill and Blundell (1982) found that the correlation between pre meal hunger rating and the amount of food consumed varied from moderate to weak. They believed that the ratings of hunger and satiety may be unsuccessful predictors of behavior because they require subjects to describe all of their experiences on a single continuum, or to select a single sensation that is assumed to correlate highly with that category of subjective experiences, to the exclusion of other sensations.

Merrill et al. (2002) studied the sensitivity and reliability of four different 100 mm visual analogue scales (scales 1-4 in Figure 1.2) and one fixed point scale (scale 5 in Figure 1.2) for hunger/satiety. An analysis of variance with post hoc tests showed that number of significant mean differences between foods was greatest for the unipolar hunger scale (Scale 2), indicating the highest sensitivity, and was lowest for the unipolar fullness scale (Scale 3), indicating the lowest sensitivity of the scales tested. This also indicated to the researchers that the participants were best able to reliably discriminate among foods through their hunger ratings (scale 2) as opposed to through their fullness ratings (scale
3). Pearson correlation coefficients between the ratings for week 1 and 2 showed that the bi-polar hunger/fullness scale (scale 5) had the highest correlation between the two weeks indicating the highest test-retest reliability. The next highest correlation between the 2 weeks was the unipolar hunger scale (scale 2) followed by the bi-polar hunger/fullness scale (scale 1), the unipolar fullness scale (scale 3) and the amount could eat scale (scale 4). However, the analysis of variance showed no main effect of replication for any of the scales. Taking both sensitivity and reliability into consideration, they concluded that the unipolar hunger scale (scale 2) had the greatest sensitivity and high week to week reliability. These researchers suggested use of a combination of these scales to better understand the subjective aspects of satiety.

**Figure 1.2:** Five scales evaluated in Merrill *et al.* (2002).

Another scale that has been evaluated for its suitability for measuring satiety sensations is the Labeled Magnitude Scale (LMS). The LMS scale is a semantically-labeled scale of sensation intensities that is characterized by a nonlinear spacing of its scale labels. The scale has been shown to be roughly logarithmic in nature (Green *et al.*, 1993). The LMS scale was created based upon the category ratio scale created by Borg in 1982. The LMS
scale has also been shown to yield psychophysical functions similar to magnitude estimation. In a study by Green et al. (1996), taste and smell stimuli were evaluated using the LMS and magnitude estimation methods. They concluded that the LMS produced psychophysical functions equivalent to those produced by magnitude estimation.

A form of a labeled magnitude scale, the Satiety Labeled Intensity Magnitude (SLIM) scale was created to measure hunger and fullness with ratio level responses (Figure 1.3) (Cardello et al., 2005; Zalifah et al., 2008). VAS do not produce ratio results, because they have fixed end-points and subjects are rarely instructed to give their responses in a ratio manner to one another (Cardello et al., 2005). Cardello et al. (2005) showed that the SLIM scale was sensitive, reliable and showed differentiation among their 3 test foods. A couple years later, Zalifah et al. (2008) created a satiety labeled magnitude scale for a linguistically-diverse population that was shown to be very similar to the SLIM scale.

**Figure 1.3:** SLIM scale developed by Cardello et al. (2005)

Some satiety scales, including the SLIM scale, contain both hunger and fullness on the same scale (bipolar scale) (e.g. Cardello et al., 2005; de Castro & Elmore, 1988; Gustaffson et al., 1993; Holt & Miller, 1994; Holt et al., 1995; Holt & Miller, 1995; Lowe et al., 1991; Merrill et al., 2002; Merrill et al., 2004; Spiegel, 1973), while many other researchers use separate scales to measure hunger and fullness (unipolar scale) (e.g. Devitt & Mattes, 2004; Kissileff et al., 1996; Osterholt et al., 2007; Rolls et al., 1990; Rolls et al., 1988; Rolls, 1993). One potential problem with the use of bipolar scales is that the bipolar scales do not allow for times that a person could feel both slightly
hungry and slightly full at the same time. Seeple and Read (1989) investigated the rise and fall of hunger and fullness ratings and found that there were no significant correlations between the time for fullness to decrease to zero and the time that hunger increased. In 3 of their 8 subjects, fullness reached zero at or before hunger feelings returned, while 4 other subjects had hunger feelings begin to increase before fullness had decreased to zero. This revealed that the feelings of hunger and fullness overlapped and decreased or increased at different rates. This is in agreement with research conducted by Read (1992) who found that when hunger and fullness were scored independently, fullness sometimes declined to zero before hunger began to increase.

**Pictorial Methods**

Some researchers have used a pictorial method to measure hunger feelings by asking participants to outline on drawings of the human body where they experience hunger (Friedman et al., 1999; Lowe et al., 2000). In Friedman et al.’s (1999) research, about 55% of subjects indicated the abdominal region when describing imagined slight hunger. This proportion increased as imagined hunger increased. The proportion of subjects indicating additional body sites significantly grew with increasing imagined hunger levels. The size of the abdominal area and the total body area associated with hunger sensation expanded with increasing food deprivation and contracted after eating. This size of the area of hunger sensation did not necessarily correlate with the degree of hunger assessed by use of standard rating scales. Lowe et al. (2000) found that increases in hunger during a fasting period were greater when measured using the pictorial as opposed to the line scales. Correlations between the line hunger scales and the pictorial measures were generally few and small. The correlations did however suggest that the use of scales to measure hunger more adequately reflected the experience of hunger in normal weight than in obese individuals. These research articles provided evidence that pictorial hunger assessment may give information about the experience of hunger that could complement information provided by traditional verbally based hunger scales.
Food intake

The measurement of food intake in combination with measurements of the subjective feelings is commonly used when measuring satiety. Many researchers believe that for satiety to be different among products, the amount consumed ad libitum after a test product should be different. There are however many different ways that researchers measure food intake as well as different units of measurement (e.g. calories, volume, or weight). Some look at daily food logs to determine intake (de Castro & Elmore, 1988; Holt & Delargy, 1999; Mattes, 1990; McKiernan et al., 2009), some measure the food intake of ad libitum test meals (Green et al., 1994; Kissileff, 1984; Leahy et al., 2008; Wansink et al., 2006), some measure ad libitum food intake at a subsequent meal a predetermined number of hours after the standard amount of test food is eaten (Holt & Sandona, 2000; Lowe et al., 1991) and some measure food intake for the remainder of the day. In many of these cases the ad libitum amount of food eaten (calories, weight or volume) is used to assess the amount of satiety that the test meal provided alone or in conjunction with hunger and/or fullness scale ratings. For example, Kissileff et al. (1984) gave subjects an ad libitum meal 15 minutes after subjects were asked to consume a set amount of test food. The researchers measured the difference in intake of the ad libitum meal after the different types of test meal to determine the difference in satiety among the test meals.

Another way food intake has been used to determine satiety differences between foods is by measuring the amount of food eaten to reach a set amount of fullness to determine satiety differences between foods. In a study investigating the differences in the satiety produced by sweet and savory snacks, differences in the amount eaten ad libitum between the snacks was used to measure differences in satiety (Green & Blundell, 1996). The hunger and fullness ratings at the end of eating the snacks were not significantly different among any of the snacks, therefore allowing the amount of snack eaten to indicate the satiety that the snack provided. Stubbs et al. (1998) also used this method to study satiety
with covert alteration in the energy density of diets. Food intake (wet weight of food without non-caloric drinks) decreased as energy density increased although food intake (measured by calories) was lower with the lower energy density food.

While, hunger and satiety ratings have been commonly used in conjunction with food intake, some researchers have found discrepancies between the two (Mattes, 1990; Mayer et al., 1965; Wardle, 1987; Warwick et al., 1993). Mattes (1990) found high correlations between hunger ratings and computed energy intake on weekdays but low correlations between the two on weekends. Eating often occurred when hunger ratings were low or had not increased. They concluded that hunger ratings were not a valid index of energy intake computed from food records. In a study comparing intake and hunger ratings between meals differing in palatability, Warwick et al. (1993) found that hunger ratings went down more, although ad libitum consumption was increased, after a higher palatability meal than after a less palatable meal.

Researchers have found that some adults tend to consume a constant volume regardless of the number of calories in a preload. In Spiegel’s (1973) research, 15 subjects were required to ingest a liquid diet for 10-21 days. The liquid diet was either standard (1.0 kcal/ml) or diluted (0.5 kcal/ml). Nine subjects consumed the same volume of liquid diet regardless of calorie content, while six subjects increased both meal size and meal frequency while on the diluted diet. This regulation took 2-5 days for the six subjects who did show eating regulation. In Bell and Rolls’ (2001) research, while a consistent volume of food was consumed daily across conditions (foods varying in fat content), hunger and fullness ratings did not vary even though energy consumption did vary. Rolls et al. (1998) investigated volume of food and its effects on satiety. Preloads were of equal energy content and similar proportions of fat, carbohydrates and proteins across three volumes (300, 450 and 600ml). Intake was significantly less after the 600ml preload than after the 300ml preload. This effect was still present when energy intake at
dinner (4hrs later) was included. Subjects also reported greater reductions in hunger and prospective consumption and greater increases in fullness after consumption of the 600ml preload than after consumption of the 300ml preload. While the majority of researchers found that participants ate a constant volume, Osterhold et al. (2007) investigated the amount eaten and the satiety feelings evoked by two versions of an extruded snack that were equal in energy density (5.7 kcal/g), but differed in energy per volume (less-aerated snack: 1.00 kcal/ml; more-aerated snack: 0.45 kcal/ml). They found that subjects consumed a 73% greater volume of an aerated snack than a less aerated snack (higher energy per unit volume). However, despite differences in intake, hunger and fullness ratings did not differ across conditions.

Other researchers have found that adults consumed a constant weight of food and not necessarily volume. In Bell et al.’s (1998) research, a consistent weight of food was consumed by normal weight women over a period of up to two weeks despite differences in energy density between their lunch and dinner main entrées. There were no significant differences in hunger or fullness after meals or over the two day study period. Devitt and Mattes (2004) investigated food unit size (small food unit or customary food unit) and energy density (manipulated fat content with a low and high condition) on food consumption and hunger and fullness ratings and found that hunger, fullness, desire to eat and prospective consumption ratings were not significantly different among the different food unit sizes or the different energy densities. They did find that the gram weight of food consumed was constant across all treatments.

Since it is common for researchers to measure food intake from a subsequent meal to assess satiety of a test food, it is important to take into account the influence of that subsequent food on consumption. The food choices that a person is provided with have been shown to influence food consumption. Studies have shown the more varied a meal, the greater the food intake (Rolls et al., 1984; Rolls, 1979; Rolls, 1985). One of the
factors influencing this greater intake with a more varied meal could be sensory-specific satiety. Sensory specific satiety is the changing hedonic response to the sensory properties of a food as it is consumed (Rolls, 1986), and should not be confused with satiety as discussed in this literature review. Sensory specific satiety is rated by asking individuals to rate their subjective liking or pleasantness of the taste, smell, texture, or appearance of a food before and after the consumption of the food. The changes in these subjective ratings with consumption can be compared to those for other foods that are not consumed. Usually, the pleasantness of the sensory properties of the eaten food decreases significantly more than the pleasantness of uneaten foods. When designing a study or when comparing across studies, the food choices provided to participants should be considered since they will influence the amount eaten at the ad libitum snack or meal.

**Combination of food intake and line scale ratings**

A couple researchers have developed calculations combining both subjective sensation ratings and food intake to determine the satiety. With the use of the various hunger or fullness scales, a satiating efficiency can be calculated to determine the ability of a food to induce satiety (Blundell, 1991; Kissileff et al., 1984). The satiating efficiency uses a preloading method with preloads that vary along one dimension (e.g. nutrient composition, energy content, weight, or volume) given on different occasions. The subject is allowed to eat the test meal ad libitum following the preload. The satiating efficiency is the negative of the slope of the equation relating test meal intake to preload size (Kissileff, 1984). A satiating efficiency of 1 represents a reduction in test meal intake of 1 unit per unit of preload, a satiating efficiency of greater than 1 represents a reduction in test meal intake of greater than 1 unit per unit of preload and a satiating efficiency of less than 1 represents a reduction in test meal intake of less than 1 unit per unit of preload.

Green *et al.* (1997) combined food intake with subjective hunger/satiety ratings by calculating a satiety quotient to compare the satiety of different foods. The satiety
quotient was calculated by dividing the difference between ratings of motivation to eat before and after the eating episode by the weight or energy content of intake during the episode. The post eating rating would be made at different times following consumption, thus allowing the creation of a temporal profile of the satiating value of the food consumed.

Lastly, a unique way to assess satiety was used by comparing the latency to request a meal after consuming a test food. Beridot-Therond et al. (1998) evaluated differences in satiety of mineral waters sweetened and flavored in different ways by isolating participants and depriving them of all time cues. During their isolation they were allowed to eat, read, study or listen to music. Hunger and satiety ratings were made throughout the day as well as the time from lunch until the spontaneous request for dinner.

Length of satiety studies
The length of time after eating ends to test foods for satiety is not standardized across the realm of satiety research. Testing lengths ranged from 15 minutes to weeks of food intake measurements. Merrill et al. (2002) found that measuring satiety over a one hour period may underestimate the area under the satiety curve for more satiating foods, such as oatmeal, because rated satiety levels remained above baseline level even after one hour. However, they also found high correlations among ratings at 30 and 60 min (r = 0.88) which suggests that a 30-min testing period may be as predictive of the satiety value of a given food as a 60-min testing period.

The Effectiveness of Current Satiety Screening Methods
Satiety screening methods are under scrutiny due to discrepancies between food intake and subjective ratings, the vast differences found by different researchers and because of differences found between groups of participants with respect to their hunger and satiety feelings. McKiernan et al. (2008) found that in 39 papers reviewed (pertaining to hunger,
fullness, satiety, appetite, and food intake), published between 1995 and 2005, 64% of the papers found no significant associations between any of the appetitive questions and food intake. In only 21% was a significant association reported between a subset of appetitive questions and intake. Only six papers found consistent significant associations (e.g. McKiernan et al., 2008). In McKiernan et al.’s (2009) study, researchers found that hunger ratings were only moderately correlated with energy intake ($r = 0.30$).

McKiernan et al. believed this may reflect a weak association between biological needs and sensations presumed to describe the biological needs, an inability of untrained (or perhaps even trained) individuals to report on such associations, or a low specificity and sensitivity of current measures of appetitive sensations (hunger, fullness, thirst) and intake. Examples of articles that found inconsistencies between hunger and fullness scales and consumption are shown below:

1. Rolls et al. (2004) found no significant difference in satiety ratings between different portion sizes even though there was increased food intake as the portion size increased.

2. Wardle (1987) found differences in hunger ratings of normal weight women between varying energy density preloads. However, the amount consumed at a meal 120 min after pre load consumption was not found to be significantly different.

3. Tournier and Louis-sylvestre (1991) found that subjects consumed more after a liquid food than after the solid version of the food, yet hunger ratings were not different.

4. Green and Blundell (1996) found that while a high fat snack resulted in a higher energy intake than the other snack types, there were no differences in hunger or satiety sensations after 4 test meals (1 protein rich, 1 carbohydrate rich, and one fat rich) or in *ad libitum* intake.

5. Doucet *et al.* (2003) found that no association was observed between measured or reported energy intakes and appetite ratings before weight loss in
either men or women. Reported energy intake was also not associated with appetite sensations after weight loss. In contrast, the postprandial area under the curve for fullness was significantly negatively associated with the measured intake in men after weight loss.

(6) Raben et al. (2003b) found no association between measured or reported energy intake and appetite ratings (hunger, fullness, desire to eat, and prospective food consumption) before weight loss in either men or women. (7) McKiernan et al. (2008) found that patterns of hunger were weakly predictive of energy intake ($r = 0.30$).

(8) Linne et al. (2002) found that when vision was investigated with food consumption and hunger ratings, subjects consumed 22% less food when blindfolded although the feeling of fullness was identical to the fullness reported after the larger meal consumed without blindfolding.

(9) Barkeling et al. (2003) found that obese subjects ate 34% less food when blindfolded and had no significant differences with or without blindfolding in hunger or satiety ratings.

Influence of food liking on satiety

Food liking has been shown to influence hunger and satiety ratings (Sorensen et al., 2003). Sorensen et al. (2003), found that in some studies subjects felt less hunger and more fullness following a more palatable meal (Bobroff & Kissileff, 1986; Warwick et al., 1993), while in other studies the opposite was seen with subjects feeling more hunger and less fullness after a palatable meal compared to a less palatable meal (Hill et al., 1984; Rogers & Schutz, 1992). In Warwick et al.’s (1993) research, subjects had a greater decrease in hunger ratings and greater increase in fullness ratings following a tasty breakfast over a bland breakfast. Rogers and Schutz (1992) also found that hunger and desire to eat were greater during the consumption of a preferred food as compared to an equal caloric meal of less palatability. Yeomans et al. (1997) found that ratings of
hunger increased in the early stages of eating a palatable food and then declined, whereas hunger declined throughout the bland food eating episode. The opposite trend was seen in Hill et al.’s (1984) research; two hours after a highly preferred meal, subjects rated desire to eat and hunger greater over the low preference condition. Holt et al. (1999) found that their least palatable meal was the most filling and was associated with less food intake during the morning and after lunch. Hunger returned at a slower rate after this meal than after the more palatable meal. No effect of palatability on hunger ratings or test meal intake after consuming three standardized soups that differed in palatability has also been seen by several researchers (de Graaf et al., 1999; Holt & Delargy, 1999).

**Participant Differences – Influences on Satiety Ratings**

Differences between participants, such as age, gender, body mass index (BMI), and level of eating restraint, have been studied to determine if feelings of hunger and fullness or the amount consumed differs among the varying categories of participants.

*Gender and Age*

In Monello and Mayer’s (1967) research, males, both adults and adolescents, seemed to experience hunger in a more specific physical way while females experienced hunger in a more diffuse and cerebral manner. During extreme hunger, both men and women generally reported more intense sensations than adolescents. Adolescents described satiety as a more intense gastric sensation than adults and they stated that they continued to feel some mild hunger sensations for longer after the meal than adults (Monello & Mayer, 1967). In other studies that have compared adults to children, researchers found that children adjusted for caloric density by consuming significant more of a lower energy dense food, while adults tended to consume a consistent weight or volume of food even when it varied in energy density (Birch & Deysher, 1985; Leahy et al., 2008).
Eating restraint

Eating restraint level has been shown to influence hunger and fullness ratings and food consumption. Restrained eaters are habitual dieters who restrain their food intake in order to control their body weight (Herman & Polivy, 1980; Ruderman, 1986; Stunkard, 1981). This restrained eating has been measured by various scales over the years. Herman et al. (1978) created the revised Restraint Scale that included ten questions about dieting, weight loss, weight fluctuation, thoughts of food, guilt about eating, and consciousness about what food you eat (Herman & Polivy, 1980; Herman & al, 1978). This scale was developed to identify individuals who were chronically concerned about their weight and who attempted to control or reduce their weight through dieting (Polivy et al., 1988). Stunkard and Messick (1985) created a questionnaire to measure eating restraint, disinhibition, and hunger called the Three-factor Eating Questionnaire/Eating Inventory. They used items from existing questionnaires, Herman and Polivy’s (1980) Revised Restraint Scale, Pudel et al.’s (1975) Latent Obesity Questionnaire and seventeen newly written items based on clinical experience on the authors. Around the same time as the Three Factor Eating Questionnaire was developed, the Dutch Eating Behavior Questionnaire (DEBQ) eating scale was created to measure restraint, emotional and external eating (van Strien et al., 1986).

The restraint scales have been compared in several studies (Allison et al., 1992; Bond et al., 2001; Ricciardelli & Williams, 1997). The Eating Inventory, a subscale of the Dutch Scale and the Herman’s Scale were investigated with 901 participants (Allison et al., 1992). The test-retest reliability was highest for the Herman’s Scale (r = .95) and approximately equal for the Dutch Scale (r = .92) and Eating Inventory (r = .91). Internal consistency was highest for the Dutch Scale (Chronbach’s α = .95), followed by the Eating Inventory (Chronbach’s α = .90) and then by the Herman’s Scale (Chronbach’s α = .82). The Dutch Scale was the most homogeneous scale, shown by a single principal component accounting for 68.2% of the variance. A single factor accounted for only
39.1% and 34.6% of the variance in the Herman’s Scale and The Eating Inventory, respectively. The stability of the factor structure of the Dutch Scale was confirmed by Ricciardelli et al. (1997) and shown to be stable across genders, weight categories, and random samples. A factor analysis of the Restraint Factor of the Eating Inventory was found to contain three principal components: emotional/cognitive concern for dieting, calorie knowledge, and behavioral dieting control (Ricciardelli & Williams, 1997).

When comparing the Restraint factor of the Eating Inventory to Herman’s Scale, only the emotional/cognitive concern for dieting equated with Herman’s Scale. A separate factor analysis of the Eating Inventory factors determined that more specific constructs should be investigated, because the general constructs of the original Eating Inventory questionnaire seem over simplified (Bond et al., 2001).

Restraint has been shown to influence eating behavior and satiety. Ruderman and Christensen (1983) found that non-restrained eaters consumed less after a preload than without it, whereas restrained eaters ate more. In Burley et al.’s (1987) study, high restraint subjects consistently expressed significantly less hunger before, during and after the breakfasts as compared to low restraint subjects. In Ward and Mann’s (2000) research, restrained eaters (Herman’s Scale) consumed more food when under high cognitive load than when under low cognitive load, while non-restrained eaters showed the opposite pattern. Fedoroff et al. (2003) found that restrained eaters ate significantly more cookies or pizza after being cued with cookie or pizza smell than non-restrained eaters. Rogers and Hill (1989) found a similar break down of dietary restraint by subjects induced by food stimuli. Exposure to the sight and smell of palatable foods was sufficient to induce a loss of dieting motivation. Rogers and Hill (1989) suggest that this may account for the increased consumption and inability to adjust for caloric differences seen by restrained eaters. Tomiyama et al. (2009) found that restrained eaters overate after experiencing anxiety, distraction, and the presence of positive or negative moods, but not hunger sensations, while the only factor that triggered eating in non-restrained
eaters was hunger. This loss of control among restrained eaters has been termed a disinhibition phenomenon (Ruderman, 1986). The disinhibition hypothesis proposed that restrained eaters overeat after disruptions in self-control. This difference in eating pattern could also be related to a difference in salivation rate between restrained and non-restrained eaters. Wooley and Wooley (1973) found that salivation positively correlated with hunger and appeal of food stimuli ratings. In a study that measured the salivary response between restrained eaters and non-restrained eaters, researchers found that pre-lunch salivary reactivity was significantly greater in restrained eaters (Brunstrom et al., 2004). However, this was not related to the reported levels of hunger before lunch.

The effect of dieting status on hunger and fullness ratings and eating has shown similar results to that of eating restraint status (Lowe et al., 1991). In stressful situations, researchers have shown that dieters eat significantly more than non-dieters (Wardle & Beales, 1988). This is similar to how restrained eaters react to stress (Tomiyama et al., 2009). Rolls et al. (1988) found that non-dieters, who were also non-restrained eaters, adjusted intake after a preload by significantly decreasing their caloric intake at a subsequent lunch, while dieters were unresponsive to the type of preload (varied by dietary fat) and tended to eat the same number of calories regardless of the preload. The opposite tendency was seen in Lowe et al.’s (1991) study investigating restraint status, dieting status and body mass index. They found that restrained dieters ate much more without a preload than with one, while the two non-dieting groups showed the opposite tendency. They then classified participants according to BMI and found that among normal-weight subjects, non-preloaded dieters overate and among overweight subjects, non-dieters overate (Lowe et al., 1991).

The Herman and Polivy’s (1984) boundary model (Figure 1.1), discussed earlier in this literature review, has been shown to differ for dieters and non-dieters. Dieters seem to act as if they have a larger spread between their hunger and satiety boundaries. This
means that a dieter may have a lower hunger boundary than a non-dieter. However, the researchers have also seen times when a dieter ate considerably more than a non-dieter. This suggests that their upper satiety boundary may be elevated relative to the non-dieter. Herman and Mack (1975) found that non-dieters (non-restrained eaters) followed the boundary model by eating less ice cream following increasing amounts ice cream pre-load, while dieters actually increased the amount eaten with the increasing amount of pre-load.

**Body Mass Index (BMI)**

Body mass index (BMI) among normal weight (BMI = 18.5-24.9), overweight (BMI = 25-29.9) and obese (BMI of 30 or greater) subjects has been shown to affect the amount eaten and the hunger and fullness ratings. Wooley (1971) found that obese subjects’ hunger ratings increased progressively as their experiment progressed (subjects were given a high calorie diet for five consecutive days and then a low calorie diet for five consecutive days), while normal weight subjects’ hunger ratings were consistently low throughout the experiment. Both obese and normal weight subjects showed a similar incomplete caloric adjustment to caloric changes and consumed similar amounts of food regardless of caloric content. The differences in hunger ratings were assumed to be due to differences in the meaning of hunger to obese and normal weight subjects. Wooley (1971) hypothesized that this could be because the obese subjects’ hunger ratings contained appetitive (smelling, seeing, thinking, etc.) factors while the normal weight subjects’ hunger may only have been related to feelings in the viscera and other parts of the body. The appetitive components of hunger that the obese subjects rated were assumed to not have been met or satisfied by the test meal and therefore resulted in higher hunger ratings. Teghtsoonian et al. (1981) found that overweight subjects’ satiety feelings decreased more rapidly after a meal than normal weight subjects using cross-modal matching to scale perceived satiety. Stunkard and Koch (1964) studied obese and non-obese men and women and found that obese subjects seemed prone to either strongly
deny hunger by very low ratings or strongly indicate hunger with very high ratings; 
Women tended to deny hunger and men to exaggeration of hunger. Some obese subjects 
reported hunger all the time while some never reported hunger and some reported hunger 
only sometimes.

Some researchers have hypothesized that differences in level of restraint may underlie 
obese-normal differences in behavior (Herman & Polivy, 1980; Hibscher & Herman, 
1977). It is therefore important to take BMI and restraint level of participants into 
account when designing a satiety screening study. Both restraint and BMI were 
investigated in a study by Rolls et al. (1994b). Study participants were divided into six 
groups: (1) normal-weight non-restrained males, (2) normal-weight, restrained males, (3) 
normal-weight, non-restrained females, (4) normal-weight, restrained females, (5) obese, 
non-restrained females, and (6) obese, restrained females according to the Eating 
Inventory to measure restraint. Only the normal weight non-restrained males accurately 
compensated for the energy in the preloads regardless of the nutrient composition. The 
normal-weight non-restrained females consumed significantly more after consumption of 
the medium-fat yogurt (126kcal) than after the high-carbohydrate yogurt (18kcal). All 
other groups besides the normal-weight non-restrained males and females consumed 
about the same amounts after each preload, regardless of preload type. There were no 
significant differences seen in hunger or fullness ratings between the different preloads 
even though for the normal-weight non-restrained males, a difference in consumption at 
the *ad libitum* lunch was seen.

**Satiety of Foods**

Foods have been shown to vary in the amount of satiety they evoke (Holt et al., 1995; 
Kissileff et al., 1984; Merrill et al., 2004). Holt *et al.* (1995) evaluated 38 foods in 
isoenergetic portions (1000kJ, 239kcal) (fruits, bakery products, snack foods, 
carbohydrate-rich foods, protein-rich foods, and breakfast cereals). They found that
boiled potatoes produced the highest satiety score while croissants produced the lowest. Satiety scores correlated positively with the serving weight, protein, fiber and water contents of the foods and negatively with palatability ratings. Merrill et al. (2004) evaluated equal calorie (300 kcal) portions of 17 common military ration items (applesauce, beverages, cookies, power bars, sandwiches, spaghetti, pastry, crackers, turkey and potatoes) and two commercial food items (oatmeal and yogurt). Significant differences in perceived satiety were found with the greatest satiety rating produced by oatmeal. Higher protein content and higher fatty/oily/creamy ratings were associated with greater satiety. Raben et al. (2003a) compared breakfast meals with similar energy density and fiber contents but differing in protein, carbohydrate, fat or alcohol. Satiety and ad libitum food intake were measured for 5h after breakfast and were not found to be significantly different for any of the 4 meals.

Fiber
The majority of studies reviewed indicate that fiber increases satiety. Burley et al. (1987) found a significantly higher fullness rating (taken 2.5 hours after the test breakfast) after participants consumed a high fiber (12g fiber) as compared to a low fiber (3g fiber) breakfast meal of toast, breakfast cereal, milk, butter and orange marmalade. However, there were no significant differences seen for hunger, desire to eat or prospective consumption ratings and no significant difference in energy intake at a lunch 2.5 hours after the breakfast meal. Holt et al. (1999) found that a high fiber, carbohydrate rich breakfast was the least palatable but most filling meal and was associated with less food intake during the morning and at lunch. Hunger returned at a slower rate after this meal than after the low-fiber, carbohydrate-rich meal (Holt & Delargy, 1999). While most researchers have found differences in satiety due to increases in fiber, no significant difference in satiety was found by Gustaffson et al. (1993) who evaluated carrots, peas, Brussels sprouts and spinach by adding them to a lunch meal and evaluating the satiety they produced. The added vegetables contained about 4.4g dietary fiber. The non-significant finding could be due to the relatively small amount of fiber being added to the
large meal. In a review article by Slavin and Green (2007) there were many studies that showed increases in satiety due to fiber; however the form of the fiber also played an important role. Insoluble fiber appeared to increase satiety to a greater extent than soluble fiber.

Effects of fiber on satiety also appear to be dependent on whether the fiber has been added as an isolated fiber supplement or if the fiber is a naturally occurring fiber in the food (Slavin & Green, 2007). In a test with the addition of alginate and guar gum as a fiber source to breakfast bars, Mattes (2007) found no significant differences in satiety ratings. Willis et al. (2009) found that resistant starch and corn bran had the greatest impact on increases in satiety, while polydextrose had very little effect on the satiety and was similar to a low-fiber treatment. Oligofructose significantly increased satiety at breakfast and dinner and significantly reduced hunger and prospective food consumption ratings (Cani et al., 2006). The energy intake at breakfast and lunch was also significantly lower after the oligofructose treatment as compared to a placebo of maltodextrin.

**Fat**

A few articles have found that some types of fat increase satiety by either increasing subjective satiety ratings and/or by decreasing food intake at subsequent meals (Burns et al., 2001a; Cecil et al., 1999; Hulshof et al., 1993; Rolls et al., 1988), while the majority of researchers have either found no differences due to fat or that other food components, such as protein, fiber or carbohydrate are more satiating (Burton-Freeman, 2005; Holt & Delargy, 1999; Rolls, et al., 1994a; Stubbs et al., 1995). Hulshof (1993) investigated three fat levels [0.42MJ (100kcal), 1.67MJ (399kcal), and 3.35MJ (800kcal)] and found no effects in subsequent energy consumption due to the levels of fat. However, the high-fat preloads were subjectively rated as being more satiating than the low-fat preloads. Burns et al. (2001a) evaluated a fat emulsion containing fractionated palm and oat oil in yogurt (5g of the novel fat emulsion + 1g milk fat) versus a control yogurt (6g milk fat).
Mean energy intake was significantly lower after the test yogurt compared with a control yogurt. Burton-Freeman (2005) found that test meal energy intake after preloads containing about 40% walnut or safflower fat or 4% fat did not differ. There were also no significant differences found for the subjective ratings of hunger, fullness, desire to eat, or prospective consumption. However, appetite satisfaction was rated significantly higher for the safflower and walnut oil. Rolls et al. (1988) found mixed results with the consumption of different amounts of medium chain triglycerides (100, 200 and 300kcal). Non-dieters significantly decreased caloric intake at lunch, while dieters did not. Cecil et al. (1999) found that a high fat soup suppressed hunger and induced fullness significantly more than a high carbohydrate soup of equal calories (400kcal in 425ml). On the other hand, carbohydrates were found to be more satiating than fats in research by Rolls et al. (1994b) and Holt et al. (1999) who found that high fat yogurt or breakfast preloads suppressed intake at lunch less than high carbohydrate preloads. This is in agreement with research by Warwick (1993) who found that high carbohydrate meals tended to be more satiating (smaller hunger rating) than high fat meals. Cooling and Blundell (1998) found that subjects who preferred high fat foods consumed significantly more energy from the high fat meals than from the high carbohydrate meals. The subjects who preferred the high fat foods also had higher baseline hunger ratings than the subjects who preferred the low fat foods. The high fat preferring group and the low fat preferring group both rated the high fat and high carbohydrate foods as equally filling.

Carbohydrate
Carbohydrates have been shown to be more satiating than fat by most studies investigating the two food components. In Holt and Delargy’s (1999) research, subjects consumed 2035 kJ/486kcal breakfasts varying in macronutrient content [two fat-rich, two carbohydrate-rich (low and high-fiber)]. While the high fiber carbohydrate rich breakfast was the most filling overall, both the carbohydrate rich breakfasts were more satiating than the fat rich breakfasts. Rolls et al. (1994b) found that high carbohydrate yogurt
preloads were more satiating than high fat preloads by an increase in satiety ratings and an increased suppression of food intake. Although Stubbs’ *et al.* (1995) research, which was discussed in the section on fat, found differences in satiety due to fat content, they hypothesized that the increases in satiety with the decrease in fat content may really be due to the increased amounts of carbohydrates or protein in the test samples. While most studies have found carbohydrates to be more satiating than fats, Cecil *et al.* (1999) found that a high fat soup suppressed hunger and induced fullness significantly more than a high carbohydrate soup of equal calories (400kcal in 425ml).

Two studies that investigated sweeteners in beverage form found no significant differences in satiety between the sweeteners (Holt & Sandona, 2000; Monsivais *et al.*, 2007). Sugar-rich and sugar-free beverages were not found to significantly affect the feelings of hunger and fullness or *ad libitum* consumption of a palatable, fat-rich snack (Holt & Sandona, 2000). When sucrose, HFCS 42, HFCS 55, diet cola, and 1% fat milk were compared, no differences were found among the sucrose, either HFCS sweetened colas or the diet cola for hunger or satiety or in energy intakes at lunch. Only the 1% fat milk suppressed energy intake a lunch (Monsivais *et al.*, 2007).

**Protein**

Halton and Hu (2004) reviewed papers that investigated the satiety of protein and found that of 14 papers examined, 11 found that protein preloads significantly increased the subjective ratings of satiety over other macronutrients such as fats or carbohydrates. Porrini *et al.* (1995) found that meatballs high in protein were more satiating than pasta that was high in carbohydrates. This increase in satiety with the meatballs was shown by increases in fullness, decreases in hunger and also significantly reduced food intake as compared to the pasta meal. Johnson and Vickers (1993) and Hill and Blundell (1986) found that eating a preload high in protein or high in carbohydrate decreased hunger more than eating the high fat preload. In Johnson and Vickers (1993) research, the high protein
preload also decreased the weight of food eaten more than eating the high fat or high carbohydrate preload and decreased the total caloric intake more than eating the high fat preload. Latner and Schwartz (1999) found that a liquid lunch high in protein caused women to consume 31% fewer calories at dinner than after the high carbohydrate lunch. Subjects also reported greater hunger after the carbohydrate lunch and before dinner than after the high protein lunch. Barkeling et al. (1990) found that at a subsequent meal subjects ate 12% less after a high-protein meal compared to the high carbohydrate meal of equal calories. Dunshea et al. (2007) found that high-protein diets, and in particular those that contain whey proteins, may reduce hunger and food intake. While the majority of papers have found protein to be more satiating than other macronutrients such as fat or carbohydrates, a couple articles have found no differences in the subjective feelings of hunger and satiety or in food intake between meals differing in protein, carbohydrates or fat (de Graaf et al., 1992).

**Food Form**
Evidence that liquids have less impact on increasing satiety than do solid foods remains inconclusive (Almiron-Roig et al., 2003). Some researchers have shown solid foods to be more satiating than liquid foods of the same energy and nutrient content (Almiron-Roig et al., 2003; Himaya & Louis-Sylvestre, 1998; Hulshof et al., 1993; Mattes & Campbell, 2009; Mattes, 2005; Rolls et al., 1990). However, when including soup as a liquid food, some studies have found soup to be more satiating than solid foods (Mattes, 2005; Rolls et al., 1990). Hulshof (1993) and Tournier et al. (1991) found that preloads in a liquid form were less satiating (measured by food intake and hunger ratings) than two preloads in a solid form, one made with locust bean gum and one made with gelatin. Solid (apple), semisolid (apple sauce), and beverage (apple juice) were compared for the amount of satiety that they produced at a meal and as a snack (Mattes & Campbell, 2009). Whether consumed with a meal or alone as a snack, the beverage induced the least amount of satiety, while the solid food form produced the greatest satiety. On the
other hand, Flood et al. (2007) found that consuming a soup preload significantly reduced subsequent test meal intake; however, the after lunch hunger, thirst, fullness and prospective consumption ratings were not significantly different between the condition with the soup preload and the condition without. In that study, subjects were allowed to eat the soup *ad libitum* and could have been eating to reach a similar level of satiety. Broth and vegetables served separately, chunky vegetable soup, and chunky-pureed vegetable soup, pureed vegetable soup, or no soup were consumed as a preload (Flood & Rolls, 2007). A test meal was consumed *ad libitum* 15 min after the soup was consumed. The type of soup had no significant effect on test meal intake or total meal energy intake, however, consuming soup, as compared to having no soup, did significantly reduce test meal intake and total meal energy intake. Himaya *et al.* (1998) found a significantly greater suppression of hunger and reduction in subsequent meal intake after consumption of a chunky soup, than after consumption of only vegetables and water. This is in agreement with other researchers who have also found that soups decrease hunger and increase fullness when compared to solid foods (Kissileff, 1984; Mattes, 2005; Rolls *et al.*, 1990). Rolls *et al.* (1990) and Kissileff and Gruss (1984) found that soup reduced second course intake significantly more than other preloads (crackers, cheese, melon, or juice). Kissileff and Gruss (1984) suggested that the difference may relate to nutrient dispersion, orosensory cues, or temperature.

Viscosity may be an important factor in the induction of satiety. In a study by Mattes *et al.* (2001), significantly greater and more prolonged reductions of hunger were observed with a more viscous shake. Moorhead *et al.* (2006) evaluated test lunches (3329kJ, 795 kcal) of boiled rice with sweet and sour sauce, chicken and carrots (whole carrots, blended carrots, or carrot nutrients). Meals with whole carrots and blended carrots resulted in significantly higher satiety ratings and a reduction in food intake for the remainder of the day compared to the meal with only the carrot nutrients (Moorhead *et al.*, 2006). They attributed the differences to both the physical structure and fiber content.
of the carrots. Holt and Miller (1994) found that the processing of cereals (whole grains, cracked grains, coarse and fine whole meal flour) had a significant effect on the level of satiety induced with subjective satiety responses tended to be higher for the less processed foods. The whole grain meal produced the highest satiety response and the fine flour meal produced the lowest response.
RESEARCH OBJECTIVES AND HYPOTHESES

Part I: Consumer views of hunger and fullness: a qualitative approach

Objective: To gain a better understanding of the complex ideas of hunger and fullness from consumers through the use of focus groups.

Hypothesis: Both physical and mental factors for both hunger and satiety will have a significant effect on satiety and will therefore be present in the discussions around hunger and fullness.

Part II: The development of a scale to measure hunger and satiety sensations

Objective: To develop a questionnaire to assess hunger and satiety sensations

Hypothesis: Both physical and mental hunger and satiety constructs will be present in the factors extracted.

Part III: Validation and testing of the hunger and satiety questionnaire

Study 1: Validation and testing of the hunger and satiety questionnaire with breakfast meals of oranges and oatmeal

Objective 1: To assess the sensitivity to detect differences in hunger, fullness and liking between the oranges and the oatmeal (through evaluation of effect sizes and distributions of each of the scales) of the new multi-item factor scales compared to the single-item traditional scales of hunger, fullness, desire, and amount.

Hypothesis 1a: The mental hunger factor scale, physical hunger factor scale, mental fullness factor scale and physical fullness factor scale will have a greater effect size than the single-item traditional scales of hunger, fullness, desire and amount for measurements: (1) immediate rating or rating change due to eating breakfast, (2) rating change over the 2hrs after breakfast, and (3) overall rating assessed by the area under the curve (AUC).
**Hypothesis 1b:** The factor scales will have smaller distributions of scores around the mean than the distributions around the traditional scale means for all three rating measurements.

**Objective 2:** To compare the hunger and satiety sensations produced by the oranges and oatmeal using the factor scales and traditional scales at three rating measurements: (1) immediate rating or rating change due to eating breakfast, (2) rating change over the 2hrs after breakfast, and (3) overall rating assessed by the AUC.

**Hypothesis 2a:** For immediate rating change, there will be a similar change in physical hunger and physical fullness between the oranges and oatmeal and a smaller decrease in mental hunger and a smaller increase in mental fullness for the oranges than for the oatmeal.

**Hypothesis 2b:** For rating change over the 2hrs after breakfast, there will be a greater increase in mental hunger and physical hunger for the oranges than for the oatmeal and a corresponding greater decrease in mental fullness and physical fullness.

**Hypothesis 3b:** The oranges will have a smaller AUC for the mental and physical fullness factors and a greater AUC for the physical and mental hunger factors than the oatmeal breakfast.

**Objective 3:** To compare the amount of calories eaten at the *ad libitum* snack served 2 hours after the breakfast session between the session day with the breakfast of oranges and the session day with the breakfast of oatmeal.

**Hypothesis 3:** More calories will be consumed on the session day with the breakfast of oranges than on the session day with the breakfast of oatmeal.

**Objective 4:** To determine if the factor scales or the traditional scales can be used to predict the amount of calories consumed at the *ad libitum* snack served 2hrs after the breakfast of oranges or oatmeal.
**Hypothesis 4:** The mental hunger factor scale and the physical hunger factor scale will have the highest correlation to the amount of calories eaten at the *ad libitum* snack.

**Study 2: Validation and testing of the hunger and satiety questionnaire with breakfast meals of smoothies differing in liking**

**Objective 1:** To assess the sensitivity to detect differences in hunger, fullness and liking between two smoothies that differ in liking (through evaluation of effect sizes and distributions of each of the scales) of the new multi-item factor scales compared to the single-item traditional scales of hunger, fullness, desire, and amount.

**Hypothesis 1a:** The mental hunger factor and mental fullness factor will have a greater effect size for three rating measurements than the traditional scales of hunger, fullness, desire and amount for measurements: (1) immediate rating or rating change due to eating breakfast, (2) rating change over the 2hrs after breakfast, and (3) overall rating assessed by the AUC.

**Hypothesis 1b:** The factor scales will have smaller distributions of scores around the mean than the distributions around the traditional scale means for all three rating measurements (Use of a mean of multiple questions eliminates extreme values, thus reducing the standard deviation compared to single scale standard deviations).

**Objective 2:** To compare the hunger and satiety sensations produced by the two smoothies using the factor scales and traditional scales and the rating measurements: (1) immediate rating or rating change due to eating breakfast, (2) rating change over the 2hrs after breakfast, and (3) overall rating assessed by the AUC.

**Hypothesis 2a:** For immediate rating change, there will be a similar change in physical hunger and physical fullness between the cumin spiced smoothie and the
regular smoothie and a smaller decrease in mental hunger and smaller increase in mental fullness for the cumin spiced smoothie than the regular smoothie.

*Hypothesis 2b*: For rating change over the 2hrs after breakfast, there will be a greater increase in mental hunger and physical hunger for the cumin spiced smoothie than the regular smoothie and a corresponding greater decrease in mental fullness and physical fullness.

*Hypothesis 3b*: The cumin spiced smoothie will have a smaller AUC for the mental fullness factor and a greater AUC for the mental hunger factor than the regular smoothie.

**Objective 3**: To compare the amount of calories eaten at the *ad libitum* snack served 2 hours after the breakfast session between the session day with the breakfast of regular smoothie and the session day with the breakfast of cumin spiced smoothie.

*Hypothesis 3*: More calories will be consumed on the session day with the breakfast of cumin spiced smoothie than on the session day with the breakfast of regular smoothie.

**Objective 4**: To determine if the factor scales or the traditional scales can be used to predict the amount of calories consumed at the *ad libitum* snack session served 2hrs after the breakfast of regular or cumin spiced smoothie.

*Hypothesis 4*: The mental hunger factor scale and physical hunger scale will have the highest correlation to the amount of calories eaten at the *ad libitum* snack.

**Part IV: Satiety response of oligofructose, inulin, soluble corn fiber and resistant starch in non-restrained normal and overweight women and the relationship to fermentation**

**Objective 1**: To assess the sensitivity to detect differences (through evaluation of distributions of each of the scales and internal consistency reliabilities) in hunger,
fullness and liking among a control bar and 4 fiber bars made with either 10g of oligofructose, 10g inulin, 10g soluble corn fiber, or 10g resistant starch using the factor scales, traditional scales and Slavin scales.

**Hypothesis 1:** The factor scales will have smaller distributions around the means than the distributions around the means for the traditional scales and Slavin scales for all three rating measurements.

**Objective 2:** To compare the hunger and satiety sensations produced by the four fiber bars differing in fiber type and the control fiber bar through three rating measurements: (1) immediate rating or rating change due to eating breakfast, (2) rating change over the 2hrs after breakfast, and (3) overall rating assessed by the AUC, using three rating scales (factor scales, traditional scales and Slavin scales).

**Hypothesis 2:** The control bar will have the smallest fullness immediate rating change due to fiber bar consumption, the smallest 2hr change in fullness, greatest 2hr rating change in hunger, and largest area under the curve for the hunger related factors, traditional hunger scale and Slavin hunger scale.

**Objective 3:** To compare the amount of calories eaten at the ad libitum lunch served 3 hours after the breakfast session among each of the five session days with a different fiber breakfast bar or control bar served on each session day.

**Hypothesis 3:** More calories will be consumed on the session day with the control bar than on the session days with the fiber bars.

**Objective 4:** To compare the amount of calories eaten over the 24 hours after the study session (recorded by food logs) among each of the 4 fiber bars and the control bar with no added fiber.

**Hypothesis 4:** More calories will be consumed on the session day with the control bar than on the session days with the fiber bars.
**Objective 5:** To determine if there are differences in the amount of hydrogen or methane present in the breath at baseline (before breakfast) or at 3 hours after breakfast (right before lunch) among the 4 fiber treatment breakfast bars and the control breakfast bar with no added fiber.

*Hypothesis 5:* The control breakfast bar with no added fiber will produce the lowest breath hydrogen and methane ratings at both baseline and 3 hours after breakfast.

**Objective 6:** To compare the gastrointestinal effects (number of stools, stool consistency, bloating and flatulence) produced by the 4 fiber bars varying on fiber type and the control bar with no added fiber.

*Hypothesis 6:* The control breakfast bar with no added fiber will produce the lowest number of stools, bloating and flatulence ratings.
Chapter 2

CONSUMER VIEWS OF HUNGER AND FULLNESS: A QUALITATIVE APPROACH

The objective of this study was to gain a better understanding of the complex ideas of hunger and fullness from consumers through the use of focus groups. Results of 4 focus group interviews with (1) female normal weight dieters, (2) female normal weight non-dieters, (3) female overweight dieters and non-dieters, and (4) male normal weight dieters and non-dieters, were reported. Hunger and fullness sensations were described as having both physical and psychological components that were divided into two groups: typical and extreme. Overall, hunger was described as the presence of stomach growls, stomach hunger pains, emptiness, focus on eating, loss of energy, and desire to eat. Fullness was described as a feeling of food in the stomach, stomach stretch, satisfaction, contentment, energized, focused, and lack of the desire to eat. Typical fullness was described with many psychological components while typical hunger was primarily physical in nature. Participants described situations where sensations of mental hunger and physical fullness overlapped, which provided evidence that the overall constructs of hunger and fullness may not be simple, polar opposites.

Foreword: The bulk of the narrative presented in this chapter has been previously published (Murray & Vickers, 2009). Some minor revisions and additions are included.
**Introduction**

One strategy for consuming fewer calories and thus helping in the reduction of obesity is to consume foods that give a higher satiety to calorie ratio. Satiety has been broadly defined as the feeling of fullness and/or inhibition of hunger sensations after a meal resulting from the ingestion of food (Blundell, 1991; Green et al., 1997; Sorensen et al., 2003). Foods have been shown to vary in their ability to affect feelings of satiety (Holt et al., 1995; Kissileff et al., 1984; Rolls et al., 1990). These differences in satiety may provide an important insight into obesity and may provide a way to help people consume fewer calories. If people consumed foods that provided more satiety per calorie, then their overall calorie intake might be reduced without sacrificing the feelings of satiety and satisfaction from higher calorie foods. There has been an increasing trend, in both academic and industry settings, to measure the satiety that foods provide.

An understanding of the subjective experiences of hunger and satiety is important to the accurate measurement of the satiety that a food provides. Various researchers and authors have attempted to define hunger and satiety. Blundell (1979) regarded hunger and satiety as categories of subjective experiences that could not be directly perceived. He believed that hunger and satiety were used as aggregate descriptors of several sensations. According to Stubbs et al. (2000) the terms hunger and satiety have objective (unconditioned, or physiological) and subjective (conditioned, or learned) components. A few studies have used surveys or experiments to gain a better understanding of the feelings of hunger and satiety. In a study on obesity and the denial of hunger, Stunkard (1959) asked 200 obese and non-obese subjects what they meant when they said they were hungry. The subjects usually described two components of hunger: (1) the sensations of emptiness in the abdomen, pangs or growls and (2) a desire to eat. In a study with 603 adolescents and adults on descriptors of hunger and satiety, Monello and Mayer (1967) asked participants to fill out surveys that were highly structured and consisted of multiple-choice questions. Participants described their feelings of hunger
during 6 situations: extreme and ordinary hunger situations (2hr and 0.5hr before a meal), hunger at the beginning of a meal (immediately before eating and after a few bites of food) and hunger at the end of a meal. For each of these eating situations, participants were given a multiple-choice list of sensations and asked to mark all sensations that described their physical sensations, mood, urge to eat, and preoccupation with thoughts of food. No explanation was given for why sensations were included in the list of multiple choice options. Their participants identified many diverse sensation of hunger and no clear sensations or traits emerged that could clearly characterize their hunger. For satiety, participants indicated only vague sensations of gastric bulk and feelings of satisfaction and relaxation as the major sensations experienced. Mattes and Friedman (1993) used an open ended questionnaire to ask 83 participants to describe sensations associated with hunger. Participants were also asked to mark on drawings of the human figure where they experienced hunger sensations. Fifteen sensations were listed and were consistent with Mayer et al.’s (1965) work. These fifteen sensations listed in order of the most commonly mentioned were: stomach growls, stomach aches, weakness, headaches, pain, dizziness, anxiety, loss of concentration, crave foods, thought of food, mouth waters, uncomfortable, dry mouth, nausea, and thirst. The main area that was reported was the stomach followed by the head region. The neck and chest region were listed by a few as hunger increased (Mattes & Friedman, 1993). This pictorial method has been used by others (Friedman et al., 1999; Lowe et al., 2000). In Friedman et al.’s (1999) research, approximately 55% of subjects indicated an abdominal locus with slight hunger. The size of the abdominal area and the total body area associated with hunger sensations increased with increasing food deprivation and decreased after eating. When comparing the pictorial method to scale ratings, the size of the area of hunger sensations did not necessarily correlate with the degree of hunger on the rating scale (Friedman et al., 1999). This could indicate that the hunger on the rating scale encompassed more sensations than the physical feelings indicated by the drawings. Cecil et al. (1999) found no differences in ratings of hunger and fullness between the intragastric consumption of a high fat and a
high carbohydrate soup; however, when the soups were consumed orally, the high fat soup suppressed hunger and induced fullness more than the high carbohydrate soup. This indicates that hunger and fullness sensations include more than just the physical sensations felt in the stomach and that the oral stimulation plays a role in those feelings. Based on these thoughts of authors immersed in the subject of hunger and fullness and on the few studies conducted with consumers about the definition of hunger and satiety, hunger and satiety appear to be multi-component in nature.

In spite of the strong support for multiple components of hunger and satiety, the vast majority of research on determining the satiety of a food has used only a few select words to measure the satiety. Some researchers have asked subjects to rate only hunger and/or fullness (Jordan, 1969; Merrill et al., 2004; Teghtsoonian et al., 1981) while others have asked subjects to rate a group of subjective sensations such as hunger, fullness, satiety, prospective consumption, fullness, desire to eat, satisfaction, nausea, bloatedness, etc. (Cardello et al., 2005; Holt et al., 1995; Kissileff et al., 1984; Merrill et al., 2002; Rolls et al., 1990). While these latter studies have looked at multiple sensations to measure the amount of satiety a food provided, only the hunger and fullness/satiety sensations were used. From these articles I could not determine how and why the additional sensations were chosen for evaluation. Cardello et al. (2005) compiled a list of 47 phrases to describe different levels of hunger and fullness. This list was developed from scientific literature on satiety, English dictionaries and from the general psychophysical scaling literature. The words chosen included both physical and psychological components of hunger and fullness e.g. fullness, hunger, gorged, satiated, satisfied, content, ravenous, neutral, etc. While many words were initially evaluated, hunger and fullness were the only terms chosen for use on their final Satiety Labeled Intensity Magnitude (SLIM) scale. Those terms were chosen because of the small variability between the panelist ratings and because they were consistent with other satiety scales. Although research
clearly supports the multi-component nature of satiety, there does not seem to be a general agreement on terminology that adequately expresses the components.

The most commonly used scale to measure the subjective ratings of hunger, fullness, etc. has been the visual analog scale (VAS). Many studies have used these scales to measure hunger and satiety and to try and predict subsequent food intake (e.g. Kissileff et al., 1984; Rolls et al., 1990; Rolls et al., 1988), but some researchers argue that VAS do not accurately predict satiety or subsequent food consumption or provide a sufficient means for food differentiation (e.g. Rolls et al., 1990; Rolls et al., 1988). Rolls et al. (1990) found that while the ratings of hunger, fullness, and desire to eat correlated well with subsequent intake, these ratings did not differentiate between their test foods of soup and melon. This either means that both soup and melon provided the same satiety sensations or that the scales were not sensitive enough to detect differences between the products. Labeled magnitude scales such as the SLIM scale mentioned above, have recently been created to measure hunger and fullness (Cardello et al., 2005; Zalifah et al., 2008). Cardello et al. (2005) showed that the scale was sensitive and reliable and showed differentiation between their 3 test foods. Zalifah et al. (2008) created a labeled magnitude scale for a linguistically diverse population and compared their scale to the SLIM scale. Their scale was very similar to the one developed by Cardello et al. (2005). These labeled magnitude scales have not yet been widely used and tested with food consumption or in actual eating situations and have not been shown to be superior to the VAS or to provide a sufficient means for food differentiation.

This study was undertaken to help better understand, from the perspective of the consumer, the complexity of hunger and satiety. I used a structured focus group method to gain an understanding of what hunger/satiety dimensions should be evaluated when screening foods for satiety (Krueger, 2000; Morgan, 1993; Stewart, 2007).
Methods

Participants

Four focus groups were held at the University of Minnesota Saint Paul Campus in July 2008, with a total of 31 participants. Participants were recruited from a database of students and staff on the Saint Paul campus who had previously indicated an interest in participation in sensory studies for the Sensory Center in the Food Science and Nutrition Department (Appendix A). A recruitment questionnaire was used to screen respondents for demographic information, including gender, age, height, weight, profession, and current weight management effort (currently working on losing weight, currently working on gaining weight, actively working on maintaining current weight, or not currently involved in any weight management effort for weight loss, weight gain or weight maintenance). Respondents were also screened to make sure they had no food allergies, no medical condition that restricted their diet in any way (including diabetes, eating disorder, celiac disease), were breakfast eaters, were native English speakers, and were not working or going to school in areas related to nutrition. Participants received $50.00 for their participation in the study. The protocol was approved by the University of Minnesota Institutional Review Board and all participants gave their informed consent prior to their inclusion in the study.

The focus groups were differentiated by gender, current weight management effort, and body mass index (BMI, Kg/m²). The normal dieters group was comprised of normal weight females with a calculated BMI of less than 25 who were currently working on losing weight or actively working on maintaining their current weight (n=8). The normal non-dieters group was comprised of females with a BMI of less than 25 who were not currently involved in any weight management effort (n=9). The overweight group was comprised of overweight females with a calculated BMI of >25 who were a mix of the four weight management efforts (n=7), and the male group was comprised of males with
a BMI <25 who represented a mix of the four weight management efforts (n=7).
Additional data about the participants are presented in Table 2.1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>BMI</th>
<th>Number in each weight management effort category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal dieters</td>
<td>Female</td>
<td>&lt;25</td>
<td>Currently working on losing weight (3)</td>
</tr>
<tr>
<td>(n=8)</td>
<td></td>
<td></td>
<td>Currently working on gaining weight (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Actively working on maintaining current weight (5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not currently involved in any weight management effort (0)</td>
</tr>
<tr>
<td>Normal non-dieters</td>
<td>Female</td>
<td>&lt;25</td>
<td>Currently working on losing weight (0)</td>
</tr>
<tr>
<td>(n=9)</td>
<td></td>
<td></td>
<td>Currently working on gaining weight (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Actively working on maintaining current weight (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not currently involved in any weight management effort (9)</td>
</tr>
<tr>
<td>Overweight</td>
<td>Female</td>
<td>&gt;25</td>
<td>Currently working on losing weight (3)</td>
</tr>
<tr>
<td>(n=7)</td>
<td></td>
<td></td>
<td>Currently working on gaining weight (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Actively working on maintaining current weight (0)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not currently involved in any weight management effort (4)</td>
</tr>
<tr>
<td>Male</td>
<td>Male</td>
<td>&lt;25</td>
<td>Currently working on losing weight (2)</td>
</tr>
<tr>
<td>(n=7)</td>
<td></td>
<td></td>
<td>Currently working on gaining weight (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Actively working on maintaining current weight (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not currently involved in any weight management effort (1)</td>
</tr>
</tbody>
</table>

**Pre-Focus Group Activities**

Pre-focus group activities were conducted to encourage participants to actively think about their feelings of hunger and fullness before and after eating several different types of breakfast foods (Appendix B). Before coming to the focus group, participants were asked to evaluate 5 breakfast foods or beverages on an empty stomach (Table 2.2) by answering questions regarding their feelings of hunger and fullness (Table 2.3) before and after consuming each food items, and to fill out a one-day food log (Appendix C).
Table 2.2: Five foods that focus group participants were asked to consume and answer questions about before participating in the focus group.

<table>
<thead>
<tr>
<th>Breakfast Item</th>
<th>Manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Bar</td>
<td>Balance Bar Company, East Hanover, NJ 07936</td>
</tr>
<tr>
<td>Balance® Nutrition Energy Bar/High Protein – yogurt honey peanut</td>
<td>Balance Bar Company, East Hanover, NJ 07936</td>
</tr>
<tr>
<td>Breakfast Beverage</td>
<td>Nestlé USA, Inc., Glendale, CA 91203</td>
</tr>
<tr>
<td>Carnation Instant Breakfast® Complete Nutritional Drink – Milk Chocolate</td>
<td>Nestlé USA, Inc., Glendale, CA 91203</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>The Quaker Oats Company, Chicago, IL 60604</td>
</tr>
<tr>
<td>Quaker® Instant Oatmeal Express – Golden Brown Sugar</td>
<td>The Quaker Oats Company, Chicago, IL 60604</td>
</tr>
<tr>
<td>Cereal</td>
<td>General Mills, Minneapolis, MN 55440</td>
</tr>
<tr>
<td>Cheerios® – Toasted Whole Grain Oat Cereal</td>
<td>General Mills, Minneapolis, MN 55440</td>
</tr>
<tr>
<td>Oranges</td>
<td>Wescott, Elgin, MN 55932</td>
</tr>
<tr>
<td>2 Large Naval Oranges (454 g)</td>
<td>Wescott, Elgin, MN 55932</td>
</tr>
</tbody>
</table>

Table 2.3: Pre-focus group activity questions that focus group participants were asked to answer along with each food in Table 2 before participating in the focus groups.

Before Consumption:
1. How do you expect to feel after eating this product? Explain.
2. Do you expect this meal to satisfy your hunger? Explain.

After Consumption:
3. How do you feel after eating the product (Feelings related to hunger, fullness, satisfaction, satiety, etc.)?
4. At about what time do you expect to feel hungry again? Explain why.
5. At what time did you actually begin to feel hungry and/or eat something after consuming the product?

Interview protocol

In the 2-hour focus group sessions, participants were asked questions related to their feelings and sensations of hunger, fullness, satisfaction, satiety, etc. (Appendix D). The focus group discussions followed a protocol based on a semi-structured interview guide developed in accordance with established guidelines (Krueger, 2000). The goals of the project were explained to participants, and assurances of anonymity and confidentiality.
were given. The interview guide consisted of an introduction and a check list of questions/topics that had to be discussed. Each group was moderated by the same interviewer to ensure consistency in interviewing style. Additional assistance was provided by a note taker. Each focus group lasted approximately 120 min and was audio and video-recorded and later transcribed.

The questions asked during the focus groups were designed to raise discussions on all types of feelings and sensations related to hunger and fullness. Table 2.4 shows the line of questioning. Table 2.4 does not give the exact questions as asked during the interviews. The exact way in which the questions were formulated during the interview depended on the progress of the discussion. Some questions were not directly asked because the group discussions addressed the subjects before the question could be asked.

Table 2.4: General Line of Questioning for the four focus group sessions.

| 1. What did you eat for breakfast this morning? |
| 2. Which of the breakfast products was the most/least filling? Lasted the longest/shortest? |
| 3. How do you define hunger? |
| 4. How do you know when you are hungry? |
| 5. Does extreme hunger differ from moderate hunger? |
| 6. Describe the desire you have to eat as candy is passed around the table? |
| 7. How do you define fullness? |
| 8. What makes you stop eating after a meal or a snack? |
| 9. Describe the fullness you feel when you drink a glass of water. |
| 10. Which do you think would fill you up more, a glass of tomato juice or a bowl of tomato soup? |
| 11. Describe the feeling of fullness after a large meal. |
| 12. Is there a difference in the feeling of fullness right after you eat and fullness that lasts over time? |
| 13. Is it possible to be not hungry and not full at the same time? |
| 14. Is it possible to be slightly hungry and slightly full at the same time? |

Data Analysis

A total of 6.6 h of audio recorded verbatim transcripts were created for the four focus groups. Data were analyzed using the long-table approach of cutting, sorting, and arranging (Krueger, 2000). A cut-and-paste technique was used to categorize and group quotes by themes. Transcripts were color coded and lines were numbered to keep track of where quotes originated. Quotes were grouped by theme and then by similarity. A
A descriptive summary from each theme and for each focus group was written. The context in which responses were given was taken into account when analyzing the transcripts. Similarities and differences between each focus group type were analyzed. The frequency (only used in a broad sense such as many, some, few) and extensiveness (how many different people said something) of comments were used to determine the importance of specific topics. Quotes were pulled from the transcript to illustrate the themes. Specific quotes were chosen that captured the essence of what was said.

**Results**

The results have been divided into sections by the main themes that arose from all focus groups: hunger sensations, fullness sensations, and hunger and fullness sensations that overlap. Information on these themes is then followed by comparisons among focus groups.

**Hunger Sensations**

While hunger was described by a few as a continuum, each group also broke the hunger sensations into two groups, typical hunger and extreme hunger (Table 2.5). Growling stomach, empty stomach, and the presence of stomach pain were mentioned by all groups as key identifiers of typical hunger. Extreme hunger was described as having a headache, light headiness, being fixated on food, and feeling irritable.

“When someone says they are hungry they almost always feel something in their stomach that is uncomfortable”

“It [stomach] feels very light and it feels empty. It will growl and I can feel the growling.”

“When my concentration is completely gone because I’m hungry…It’s just how much your focus and your brain’s attention is on getting food and how much it’s thinking about it.”
“Hunger can be sort of a range. There is the bored hunger or the ‘I should eat now’ where I’m not really very hungry but I’m thinking about food. Versus this, where I’m really hungry or I haven’t actually eaten and I need to. That is where I start to get crabby and not feel well in general.”
“Normal hunger is a moderate discomfort in the stomach. Extreme is like whoa, really bad”
“Hunger pains are stabbing. They are sharp.”

In three of the focus groups, the normal dieters, normal non-dieters and overweight groups, participants discussed times where they had hunger sensations that subsided for a time. Stress, sadness, and having a high activity level were three causes of the hunger sensations going away or not being noticed.

“The onset of stress and not even necessarily I have a huge project due or presentation to give or whatever the stress is, but just the normal everyday increase in energy adrenaline from having a, b, c, d and e to get done before a certain amount of time. That stress kind of compensates for your hunger. It sort of takes the place of your hunger. So the focus is completely on what you’re doing and not at all on what your body might be telling you.”
“If I’m bored I tend to eat more, but if I’m busy I don’t think about it.”
“Situations when I’m feeling sorrowful about something I don’t feel like I have the hunger.”
“If I’m not busy, I could have endless, continual hunger all day long.”

The initiation of an eating episode primarily occurred with the presence of hunger sensations (as described in Table 2.5). However, time, routine, the options of food available, and the desire to stop and take a break to eat were also given as reasons to initiate an eating episode.
“For me it’s mostly the time. I expect to eat at a certain time.”
“In my office, we start talking about lunch probably like an hour or an hour and a half before hand and we are just like oh my gosh is it lunch yet just because we are looking for a break.”
“The options…If you know you have good leftovers or something waiting for you at work or at home, then you think about it and I think it triggers you to be more hungry or eat it more often rather than when you just have to go to the fridge and think about what am I going to eat. It’s going to be more work.”

Table 2.5: Sensations used to describe hunger by participants from all four focus groups. Sensations were divided into physical and mental components related to typical and extreme hunger.

<table>
<thead>
<tr>
<th>Typical Hunger</th>
<th>Physical</th>
<th>Mental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty/hollow feeling</td>
<td>Lack of concentration on tasks</td>
<td></td>
</tr>
<tr>
<td>Stomach feels light</td>
<td>Boredom</td>
<td></td>
</tr>
<tr>
<td>Growling stomach noises</td>
<td>Desire to eat</td>
<td></td>
</tr>
<tr>
<td>Stomach movement</td>
<td>Feeling the need to refuel</td>
<td></td>
</tr>
<tr>
<td>Stomach pains</td>
<td>Thoughts toward food</td>
<td></td>
</tr>
<tr>
<td>Drained/loss of energy</td>
<td>Desire to chew something</td>
<td></td>
</tr>
<tr>
<td>Stomach feels the opposite of stretched</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightheaded</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extreme Hunger</th>
<th>Physical</th>
<th>Mental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dizziness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shakiness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle weakness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fullness Sensations

Like the hunger sensations, participants divided the fullness sensations into two groups, typical fullness and extreme fullness sensations (Table 2.6). Typical fullness was
summarized as a lack of hunger sensations, a comfortable, content feeling, having the ability to concentrate on tasks other than food, having an increase in energy, and having a decrease in the desire for food. The term satisfaction and/or the feeling of happiness also came up in each group to describe fullness. Fullness sensations seem to contain a combination of mental and physical components. For all groups, extreme fullness was identified as a negative sensation and could be characterized by a bloated uncomfortable feeling, and a stretched stomach feeling. The three female groups mentioned that a feeling of regret or disgust comes along with extreme fullness.

“My stomach feels like there is something in it, and I don’t have the noises and the hunger pains that I was experiencing earlier.”
“I have a comfortable feeling in my stomach and I’m kind of energized.”
“A feeling of fullness for me isn’t just a feeling for me. A lot of it is am I feeling happy with the variety of tastes and textures.”
“To me fullness means I’m not going to snack. If I’m really full I’m going to go meal to meal and I can skip snacks, but if I’m not full I’m going to need a snack between each meal.”
“[Food is] way more appetizing when you’re hungry than when you’re full.”
“Typical fullness gives me energy to do things like working out, but overly full makes me want to do less. Instead of getting that energy, I feel more sluggish.”
“Feeling of disgust [in reference to extreme fullness].”

The type of food or the method of consuming the food seemed to affect the fullness sensations. The sensation of fullness from drinking water was perceived as a different type of fullness than the fullness felt from a typical meal. Several participants mentioned that the water would not provide the energized feeling that food provides and that the fullness from water did not last as long as the fullness from food. The temperature of a food was also mentioned to affect the feeling of fullness. All focus groups agreed that
warmer foods would make them feel fuller. The feeling of satisfaction was mentioned as being increased with warmer foods. The method of consuming the food was also mentioned to cause a difference in the feeling of fullness. Foods that they have to eat as opposed to drink would provide a fuller sensation. Several people mentioned that they thought the fullness sensation differences felt among the various types of foods could be partly or mostly psychological instead of physical. Satisfaction was again brought up when the various types of fullness were discussed.

“It [water] doesn’t provide the boost.”
“It [water and/or food] is pressing up against your chest kind of feeling when you eat a lot, regardless of what it is, but for water, I think that goes away relatively quickly and you don’t feel that stretch/pressure as much anymore…food is more dense and solid and will last a little bit longer.”
“A different full, but not satisfied [referring to the water].”
“The warmth of the [soup] would probably make me feel satisfied longer just because you have in mind that the soup is a meal and that the juice is a beverage.”
“I think it depends on how fast you eat it. If the soup is hot it would take a lot longer to eat than the juice. You’d eat slower and you’d kind of fill up a little bit better.”

The termination of a meal or snack was described by participants by various typical fullness sensations. Also mentioned as factors of meal termination were when all the food was gone, when the time allotted for eating was over, and when a loss of appetite or loss of desire to eat a particular food occurred. Participants of the normal dieters focus group were very concerned with meeting their nutritional requirements, and they would stop eating when all their nutritional requirements were met.
“When I’m not feeling the hunger pains. When I’ve gotten all my food groups in.”
“My plate is clean.”
“…not wanting anymore food.”
“For me it’s less about an actual feeling. It’s when I think my urgency for these certain foods are satisfied.”
“It’s just a feeling of I’ve had enough.”
“My brain and my stomach kind of tell me when to stop.”
“If I’m not really enjoying the food then I would probably have less than I would normally eat.”

Satisfaction was mentioned at various times throughout the focus groups so the moderator decided to probe further on what it meant to participants to be satisfied. The term satisfaction was found to have various meanings. There were discrepancies over fullness being incorporated into the definition of satisfaction. Some participants felt being full meant they were satisfied, some felt fullness was a part of satisfaction, and some felt that they did not have to be satisfied to be full.

“The most ideal full, the most comfortable.”
“You don’t want anything else.”
“When I think of being satisfied I think of enjoying what I just ate and feeling like I’m not hungry anymore, not necessarily feeling like I’m stuffed…satisfied is a step down for me from being stuffed, but then it also has this qualitative that I just ate something that is going to sustain me and satisfy my hunger.”
“I don’t have to be satisfied to be full.”
“Satisfied is the one thing that defines fullness to me.”
“There are many levels to be satisfied at. Some people, they need something salty or sweet after or a larger quantity.”
The idea that some foods provide fullness sensations that last for a long period of time, while other foods only provide fullness sensations for a very short period of time was discussed. In the pre-activities completed by the focus group members, the oranges and oatmeal were mentioned as the most immediately filling product. Participants expressed that it was a surprise at how filling the oranges were. The fullness sensation associated with drinking a lot of water as opposed to consuming a typical meal provided a shorter fullness sensation. Participants knew that they were immediately full when stomach pains were gone, the stomach was no longer growling, and the feeling of emptiness in the stomach was abated.

“Immediately after consuming [the oranges], it was pretty filling just quantity wise in terms of liquid, but it didn’t keep me full for the rest of the morning.”

“You can drink a lot of water and feel that full sort of stretch right away, but you know you’re going to be hungry once that passes which it usually does pretty quickly.”

The oatmeal product was identified most frequently as the best at reducing hunger throughout the morning. There was a discrepancy among participants about the instant breakfast beverage. Some members from the normal dieters, normal non-dieters and male focus groups thought it was most filling and some thought it was the least filling. Participants noted that the hunger pains were held off the longest by the product that kept them full the longest throughout the morning.

“The oranges lasted an hour and a half before I was hungry and ate something and the oatmeal lasted almost five hours.”

“As far as the [protein] bar and drink [CIB] goes, because they were dense and more calorically there, I think it was better in terms of keeping me full.”
“Dense kind of full not just the sort of stretch you get from eating the oranges…The food just lasts longer, it keeps the stomach full a little bit longer.”

Participants agreed that throughout the day there are times where no hunger or fullness sensations are felt. They agreed that it was possible to be not hungry and not full at the same time. This sensation occurs between meals and at a time where participants feel comfortable and do not have thoughts related to food.

“Comfortably numb.”
“Focus of my attention is not on my hunger or fullness.”
“Absence of appetite. It’s comfortable. You’re not thinking about eating.”
“You don’t crave food…you are okay without eating.”
Table 2.6: Sensations used to describe fullness by participants from all four focus groups. Sensations were divided into physical and mental components related to typical and extreme fullness.

<table>
<thead>
<tr>
<th>Typical Fullness</th>
<th>Physical</th>
<th>Mental</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lack of stomach pain</td>
<td>Satisfaction</td>
</tr>
<tr>
<td></td>
<td>Lack of hunger sensations</td>
<td>Content</td>
</tr>
<tr>
<td></td>
<td>Cessation of appetite</td>
<td>Comfortable</td>
</tr>
<tr>
<td></td>
<td>Not hungry</td>
<td>Happiness</td>
</tr>
<tr>
<td></td>
<td>Feeling of something present in the stomach</td>
<td>Reenergized</td>
</tr>
<tr>
<td></td>
<td>Feeling of something dense in the stomach</td>
<td>Ability to focus on tasks</td>
</tr>
<tr>
<td></td>
<td>Stretch in the stomach</td>
<td>Lack of desire to eat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food not as appealing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extreme Fullness</th>
<th>Physical</th>
<th>Mental</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discomfort</td>
<td>Sick of food</td>
</tr>
<tr>
<td></td>
<td>Roundness of stomach</td>
<td>Feeling of disgust with self</td>
</tr>
<tr>
<td></td>
<td>Tightness of pants</td>
<td>Gluttony</td>
</tr>
<tr>
<td></td>
<td>Loss of mobility</td>
<td>Regret</td>
</tr>
<tr>
<td></td>
<td>Heavy feeling</td>
<td>Feeling of ability to skip the next meal</td>
</tr>
<tr>
<td></td>
<td>Sick feeling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nauseous</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stuffed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sluggish</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard to breath</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need to recline</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bloated</td>
<td></td>
</tr>
</tbody>
</table>

Hunger and Fullness Sensations Overlap

When participants were asked if it were possible to be slightly hungry and slightly full at the same time, they agreed that it would be possible to feel full from one type of food and hungry for another at the same time. They also mentioned times when they were full from eating, but when new food, such as dessert, was available, their hunger would come back and they would continue to eat. Cravings for certain foods, the availability of food, a lack of satisfaction, and boredom were mentioned as times when participants could be hungry and full at the same time.
“The oranges felt really bulky in your stomach, but you still wanted to eat. I mean it is one kind of full and one kind of hunger so it seems like it’s possible.”
“I think that’s where when I’m bored comes in. I could feel really full but still be kind of hungry.”
“I crave something…hungry for something, yet still slightly full.”
“I eat the salad and no longer have hunger pains but I’m not full. I still want to eat a little bit more. So then I’ll eat some pasta”
“It is where I am right now. I don’t need to eat. I don’t feel hungry and I don’t feel full, but you put food in front of me and I’ll eat it.”
“I think it depends on the food. If it’s something that is really sugary like if I just cookies I’d probably be like oh I just had a lot of cookies but I’m still kind of hungry because it wasn’t nutritionally satisfying.”

Comparison among focus groups
All focus groups responded similarly with two notable exceptions. The first exception was with the physical feelings of hunger and fullness. Participants of the normal dieters group were less able to describe their physical feelings of hunger and fullness and were more focused on the amount of food they were consuming as well as the nutritional value of the foods. They seemed to have a hard time even recognizing as many hunger and fullness physical sensations as the other groups. The second exception was in the description of psychological feelings after eating a large meal. The three female groups mentioned feelings of regret and disgust towards themselves for having consumed so much food, while participants of the male group mentioned feelings of achievement and satisfaction from finishing a large meal.
Discussion

Evidences of psychological as well as physical components of hunger and satiety, which were found in my focus groups, are also supported by previous research. For example, in my focus groups, while the oranges reduced the physical hunger, psychological components such as desires or cravings for other foods were still present. Jordan (1969) conducted experiments to study if human subjects could control ingestion of a liquid diet orally and/or intragastrically. He found that while food intake could be roughly regulated with the elimination of oropharyngeal factors, there was a separate oral aspect of satiety that was not met. Subjects reported psychological components, oral cravings, after the intragastric meals and their hunger ratings did not fall as fast as in the studies using the oral feeding method. They argued that satiety as defined by the reduction in food intake and satiety as defined by a hunger or subjective rating did not necessarily directly correlate. Monello and Mayer (1967) found that people described satiety as having psychological components of satisfaction and relaxation and only vague physical sensations of gastric bulk. Read (1992) also defined satiety as a feeling of satisfaction that was associated with the cessation of food intake. This feeling of satisfaction was mentioned and discussed as a part of satiety in my focus groups. Satisfaction appears to be very complex with individuals differing in what it means to be satisfied. For some, satisfaction was described as the main factor that defined fullness and was an indicator of their physical fullness, while others viewed satisfaction as one component of fullness in a more psychological way (feelings related to the pleasantness of the flavor of the food, knowing they met their nutritional requirements for the day, etc.).

The liking/palatability of a food was discussed in the focus groups as a cause of an increase in hunger sensations due to an increase in desire to eat. Participants discussed that their desire to eat and thoughts towards food increased when they had preferred food. This then caused their hunger sensations to increase. A review of the effect of liking/palatability on food intake, hunger and fullness ratings was written by Sorensen et
In the articles reviewed by Sorensen et al. (2003), diverging results for the subjective hunger and fullness ratings were seen among the articles; for example, in some of the articles subjects either felt more hunger and less fullness after a palatable meal compared to a less palatable meal. In other articles participants felt the opposite, and in some articles there was no difference in subjective hunger and fullness ratings (Yeomans & Symes, 1999). Yeomans et al. (1997) found that hunger ratings were higher after tasting a palatable food (pasta with oregano), but changed little after tasting a less palatable (pasta without oregano). Hill et al. (1984) and Warwick et al. (1993) also found that ratings of the desire to eat and hunger were significantly higher with a preferred food than with a non-preferred food. Warwick et al. (1993) found that fullness was greater after a tasty breakfast than after a bland, less palatable breakfast. However, both Yeomans et al. (1997) and Hill et al. (1984) found that fullness ratings were unaffected by the palatability of the food. Another interesting find by Hill et al. (1984) was that hunger ratings 2 hours after the preferred meal were higher than the ratings from the non-preferred meal at the same time point. They suggested that this difference could be due to the subjects’ willingness to eat more of the food they consumed 2 h before. Bobroff and Kissileff (1986) observed that hunger ratings were significantly greater after a less palatable meal (banana-coloda frozen yogurt drink with added cumin) than after a palatable meal (banana-coloda frozen yogurt drink served plain). No difference was observed between hunger ratings for palatable and less palatable meals in research conducted by Yeomans and Symes (1999), Yeomans (1996), and De Graaf et al. (1999); slight increases in intake with a palatable food were seen, but hunger ratings were not significantly different between the two foods. While Yeomans (1996) saw no difference in hunger ratings between the different meals, he observed an increase in fullness rating for the palatable meal over the unpalatable meal. Since the research related to liking/palatability and satiety feelings shows conflicting results, the effect of palatability on satiety is unclear.
During the focus group sessions, participants compared feelings of satiety produced by liquid versus solid foods and hot versus cold foods, comparisons that may be more psychological (cognitive) in nature and/or differ in the longevity of the satiety produced. In a study by Tournier and Sylvestre (1991) the 24-hour total calorie intake following a liquid meal was higher than following a solid meal even though both meals were of equal calorie content, weight, volume and composition and even though hunger ratings made over 4h following the meal were not significantly different. The researchers attributed the difference in the amount consumed partly to the psychological cues from the form of the food. My focus group participants and participants in Mattes’s (2005) study found that the temperature of the food (overall warmer foods were thought to be more filling) had an effect on satiety. Mattes (2005) found that warm foods (apple soup served at 60°C) reduced hunger and increased fullness ratings to a greater degree than cooler foods (apple juice 10°C). Both Mattes (2005) and my focus group participants attributed these difference in temperature or solid/liquid consistency to psychological factors such as the way the food is viewed (as a meal, snack or beverage) or the expected satiety that product will bring.

Participants in all focus group mentioned that their cognitive activity level increased or decreased the amount of hunger or fullness that they felt. In the focus groups, participants discussed a delay in hunger sensations due to a high level of cognitive activity throughout the day. When participants were bored, they mentioned that their thoughts drifted towards food, and they felt hunger. Abramson and Stinson (1977) showed that subjects participating in a boring cognitive activity (subjects who were asked to write “cd” over and over again) ate more and reported a greater desire to eat than interested subjects (subjects who were asked to write stories about what was happening in particular pictures). While their study did not measure hunger ratings, the amount of food consumed and the subjective rating of desire to eat may be indicative of hunger components.
The presence of food or having thoughts of food increased hunger feelings for focus group participants. When a bowl of candy was passed around the table and each participant was asked to take and eat one piece of candy, some of the participants mentioned that they were more hungry after seeing the bowl of candy and having one piece of candy than before they ever saw the candy. Wansink et al. (2006) found that people ate an average of 2.2 more candies each day when the candies were placed in an area where they were visible. While Wansink’s et al. (2006) study only looked at consumption, it may be possible that subjective feelings of hunger also increased. In Rogers and Hill’s (1989) research, they found that participants who were exposed to palatable foods or asked to imagine any food they would like to eat significantly increased their ratings of hunger, desire to eat and prospective consumption. These participants were not in a state of hunger before starting the experiment because they were required to eat their normal lunch not more than 40 min prior to the study. Therefore, the increase in hunger rating was due to the exposure or imagination of the palatable food.

The female dieters group seemed less in touch with their hunger and satiety feelings compared to the non-dieters group, because they listed fewer hunger and fullness descriptors and seemed to struggle to come up with them. This could be due to the dieters’ regimented dieting practices and focus strongly tied to calorie intake. Herman and Mack (1975) showed that restrained eaters (who are most often dieters) ate more after a preload than after having no preload whereas unrestrained eaters (non-dieters) regulated their eating by consuming less food when a preload was given than without a preload. In research by Fedoroff et al. (2003), restrained eaters ate more cookies and pizza than unrestrained eaters after being cued with cookies and pizza. Ward and Mann (2000) showed that restrained eaters consumed more food when under high cognitive load than when under low cognitive load and unrestrained eaters showed an opposite pattern. This was referred to as a disinhibition effect with the restrained eaters. While
these studies only showed differences in the amount eaten, the increase in consumption after a preload may be due to the dieters being less in touch with their physical feelings of hunger and fullness. Fedoroff et al. (1997) found that ratings for the desire to eat, liking and craving for a particular food were higher for restrained eaters after exposure to the smell and thought of that food than unrestrained eaters. They also found that restrained eaters ate significantly more than unrestrained eaters after pre-eating exposure to smell and thought cues of the same food. The increase in amount eaten again could indicate that the restrained eaters/dieters were less in touch with their feelings of fullness after eating.

The male focus group participants mentioned feelings of achievement after finishing a large meal whereas the female groups mentioned feelings of regret. This finding was similar to that of surveys conducted by Seim’s (1990) with 109 women and 89 men on attitudes toward food. They found that when women thought about overeating they felt guilty twice as often as the men (Seim, 1990). In a study with 421 individuals, Beardsworth et al. (2002) found that women were significantly more likely to say they ‘always’ or ‘often’ felt guilt after eating certain items of food than were men, and women were less likely to say they ‘never’ felt guilt. The feeling of guilt after eating may not be related to eating restraint since the feeling of guilt came up in both female dieters and female non dieters group.

During some parts of the focus group discussions, hunger and fullness seemed to be polar opposites, for example, fullness was described as the absence of the physical hunger sensations of “noises and hunger pains.” In contrast, during the discussion on overlapping hunger and fullness, participants described times they felt both hunger and fullness at the same time. It appears that although the physical components of hunger are the opposite of the physical components of fullness, one may feel physically full and still mentally hungry. For example, participants discussed how their stomach felt physically
full of oranges, yet they were still hungry for other foods. This is in agreement with Read (1992) who found that hunger was not the opposite of satiety, and that hunger and satiety were very likely controlled by different gastrointestinal mechanisms. In some studies, hunger and fullness have been scored on a bipolar scale (Cardello et al., 2005; Merrill et al., 2002; Merrill et al., 2004). A biopolar scale with overall hunger at one end and overall fullness at the other does not allow for someone to feel both mentally hungry and physically full at the same time. Seeple and Read (1989) investigated changes in hunger and fullness over time after eating a meal and found no significant correlations between the time for fullness to decrease to zero and the time for hunger to increase. In 3 of their 8 subjects, fullness reached zero at or before hunger feelings returned, whereas in four subjects, hunger feelings began to increase before fullness had decreased to zero. With a biopolar scale these different rates of changes in hunger and fullness would not be seen.

From this research, I suggest that multiple hunger and satiety descriptors be evaluated to create a satiety profile that includes both the physical and mental components of hunger and fullness to measure the satiety that a product provides. I have selected what I feel is a representative list of hunger and satiety descriptors from my focus groups’ comments to help distinguish differences among the various types of satiety that one feels (Table 2.7). These descriptors need to be evaluated for completeness, usefulness, redundancy, etc. in future research.
**Table 2.7:** Recommended hunger/Satiety descriptors determined from four consumer focus groups on understanding consumer views of hunger and fullness.

<table>
<thead>
<tr>
<th>Hunger Descriptors</th>
<th>Satiety Descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of hunger</td>
<td>Amount of fullness</td>
</tr>
<tr>
<td>Amount of stomach growls</td>
<td>How much food do you feel in your stomach?</td>
</tr>
<tr>
<td>Amount of stomach hunger pains</td>
<td>How stretched is your stomach?</td>
</tr>
<tr>
<td>How empty does your stomach feel?</td>
<td>How satisfied do you feel with the meal?</td>
</tr>
<tr>
<td>How much of your concentration is on eating?</td>
<td>How content do you feel?</td>
</tr>
<tr>
<td>How much energy do you have?</td>
<td>How reenergized do you feel?</td>
</tr>
<tr>
<td>How much do you desire to eat?</td>
<td>How focused are you on your daily tasks?</td>
</tr>
<tr>
<td>How better do you desire to eat something?</td>
<td>How much do you desire to eat something?</td>
</tr>
<tr>
<td>How appealing is the thought of eating food right now?</td>
<td></td>
</tr>
</tbody>
</table>
The objective of this study was to develop a questionnaire to assess hunger and satiety sensations. Ninety-three questions related to satiety feelings were administered to 212 people. Both factor analysis and cluster analysis were completed and compared. Factor analysis produced more comprehensible factor groupings of the questions. Factor analysis of the questions revealed five satiety related factors: (1) mental hunger, (2) physical hunger, (3) mental fullness, (4) physical fullness and (5) food liking.

Introduction

Satiety has been broadly defined as the feeling of fullness and/or inhibition of hunger sensations after a meal resulting from the ingestion of food (Blundell, 1991; Green et al., 1996; Sorensen et al., 2003). Self-reported satiety measures include a range of measures made on line scales related to hunger and fullness feelings, desires to eat, prospective consumption, etc. Review papers published by Stubbs et al. (2000), Merrill et al. (2002), Hill et al. (1995) and Blundell et al. (2010) go into more detail about common self-report scales. Based on these reviews, it is evident that there is no universally accepted measurement for satiety. In my review of the satiety related literature, it was also evident that the lack of a universal measurement tool and universal procedure to screen a food’s satiety has caused much confusion and conflicting reports about the satiety produced by various food components. Blundell et al. (2010) recognized the problem of a lack of a universal satiety measurement tool and recommended the use of visual analogue scales for ‘hunger’, ‘fullness’, ‘satiety’, ‘desire’, and ‘prospective consumption (quantity)’ to determine subjective appetite in adults. Hunger and fullness sensations have both physical and psychological components (Harris & Wardle, 1987; Mattes & Friedman, 1993; Monello & Mayer, 1967). Participants in Murray and Vickers’ (2009) focus
groups described hunger as having physical components such as empty stomach feeling, growling stomach, and stomach pain, and having mental components such as a desire to eat and lack of concentration on tasks. Fullness was described as having physical components such as feeling of something in the stomach, stretch in the stomach and having mental components of satisfaction, comfort, and ability to focus back on tasks and not on hunger feelings.

With an improved universal satiety measurement tool, researchers would be able to gain a better understanding of what makes a food satiating and to more effectively screen foods for satiety. The objective of this experiment was to develop an improved method for measuring hunger and satiety to better reflect the complexity of hunger and satiety using a factor analysis method and to test the sensitivity and validity of the new measurement tool. Based on the focus group research, it is hypothesized that both physical and mental factors for both hunger and fullness would have a significant effect on satiety and would be evident in the new satiety measurement tool.

**Methods**

*Participants*

Two hundred and thirty six people between the ages of 18-65 completed the hunger and fullness survey. Participants were recruited through a note sent out on Facebook® (Appendix E). The protocol was approved by the University of Minnesota Institutional Review Board, and all participants gave their informed consent prior to beginning the questionnaire.

*Procedure*

A questionnaire of hunger and fullness related sensations was compiled from the past 25 years of satiety related research literature as well as from my focus group research on hunger and fullness sensations (Murray and Vickers, 2008) (The full questionnaire is shown in Appendix F).
Participants were e-mailed a link to the questionnaire that was created using SIMS 2000© version 6.0 (Sensory Computer Systems, Morristown, NJ, USA; the full questionnaire is shown in Appendix F). Participants were instructed with the following:

“Welcome to the study to help better understand what it means to be hungry and full! Your participation in this research is greatly appreciated and will help to make an impact on researchers’ and food developers’ knowledge related to the feelings of hunger and fullness.

This questionnaire will take about 15-30 minutes to complete and can be completed at any time of day.

To participate you need to:
- Be between the ages of 18 and 65
- Speak English as your first language
- Have approximately 30 minutes to fill out this online questionnaire

Please DO NOT eat while taking this questionnaire.”

Participants were asked to report their age, gender, height, weight, current dieting status (currently working on losing weight, currently working on gaining weight, actively working on maintaining current weight, or not currently involved in any weight management effort for weight loss, weight gain or weight maintenance), how long it had been since their last meal or snack and if English was their first language (Appendix F).

The majority of questions were presented on a scale that consisted of a line of 20 radio buttons (Figure 3.1). The first radio button (far left end of the scale) was labeled with “none”, the 19th radio button was labeled with “Greatest possible amount” or “Strongest imaginable sensation of any kind” and the 20th radio button (far right end of the sale) was labeled with “unfamiliar with the statement”. For each question, participants were instructed “If you are ever unfamiliar with the statement, click the last circle on the far right end of the scale under the unfamiliar with the statement label”. The five liking
questions were asked on a scale that ranged from ‘Greatest imaginable disliking’ to ‘Greatest imaginable liking’. The full questionnaire can be found in Appendix F.

**Figure 3.1:** An example of the three types of scales used in the scale creation study. The full questionnaire can be found in Appendix F.

<table>
<thead>
<tr>
<th>Rate the extent to which you currently have stomach cramps</th>
<th>None</th>
<th>Slight</th>
<th>Moderate</th>
<th>Great</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate the extent to which your stomach currently feels empty</td>
<td>None</td>
<td>Slight</td>
<td>Moderate</td>
<td>Great</td>
</tr>
<tr>
<td>Rate the amount of food you currently desire</td>
<td>None</td>
<td>Slight</td>
<td>Moderate</td>
<td>Great</td>
</tr>
</tbody>
</table>

Rate your overall liking of the food you last ate
- Greatest imaginable disliking
- Dislike extremely
- Dislike very much
- Dislike moderately
- Dislike slightly
- Neutral
- Like slightly
- Like moderately
- Like very much
- Like extremely
- Greatest imaginable liking

For questions 1-76 of figure 3.2, participants were instructed to “please base your ratings on your feelings right now”. For questions 77-88, participants were instructed to “please make your ratings based on how you felt right after eating your most recent food (meal or snack). They were also asked to describe the food they had last eaten before beginning the questions. For the remaining 5 questions (89-93), participants were told: “you will be making liking ratings on a scale the ranges from greatest imaginable disliking to greatest imaginable liking. Please make your ratings based on how you felt right after eating your most recent food (meal or snack).”
Figure 3.2: Questionnaire for the scale development study

**Part I:**
1. Rate the amount of food you currently desire (None – Greatest possible amount)
2. Rate the current amount of food you could eat (None – Greatest possible amount)
3. Rate your current desire to eat any food
4. Rate your current desire to eat your next meal
5. Rate your current desire to eat something fatty
6. Rate your current desire to eat something salty
7. Rate your current desire to eat something savory
8. Rate your current desire to eat something sweet
9. Rate your current desire to eat your favorite food
10. Rate your current desire to eat a snack
11. Rate your current feeling of satiety
12. Rate the extent to which your stomach currently aches
13. Rate your current feeling of nausea
14. Rate your current feeling of alertness
15. Rate your current amount of energy
16. Rate your current feeling of anxiety
17. Rate your current feeling of anxiousness
18. Rate your current appetite
19. Rate the extent to which you currently have stomach pain
20. Rate your current feeling of calmness
21. Rate your current attentiveness
22. Rate the extent to which your stomach currently feels bloated
23. Rate the extent to which your stomach feels like it is currently bursting
24. Rate your current feeling of coldness
25. Rate your current feeling of depression
26. Rate your current appetite for a meal
27. Rate your current feeling of dizziness
28. Rate your current feeling of fullness
29. Rate your current feeling of dreaminess
30. Rate your current feeling of drowsiness
31. Rate your current feeling of faintness
32. Rate the extent to which you currently feel famished
33. Rate your current feeling of feebleness
34. Rate your current feeling of gastric aching
35. Rate your current feeling of gastric motility
36. Rate your current feeling of gastric tenseness
37. Rate the extent to which you currently feel gorged
38. Rate the guilt you currently have from eating your last meal
39. Rate your current feeling of happiness
40. Rate the extent to which your head currently aches
41. Rate the extent to which your stomach is currently rumbling
42. Rate your current feeling of hunger
43. Rate your current feeling of indigestion
44. Rate your current feeling of irritability
45. Rate your current feeling of lethargy
46. Rate your current motivation to eat
47. Rate the extent to which your mouth currently feels dry
48. Rate your current stomach muscle spasms
49. Rate the extent to which you are currently thinking of food
50. Rate your current feeling of nausea
51. Rate your current non-stomach body aches
52. Rate your current feeling of contentedness
53. Rate the extent to which your stomach currently feels distended
54. Rate your current feeling of ravenousness
55. Rate your current feeling of relaxedness
56. Rate your current feeling of restlessness
57. Rate the extent to which your ears are currently ringing
58. Rate your current feeling of sadness
59. Rate your current rate of salivation
60. Rate your current feeling of sickness
61. Rate your current feeling of sleepiness
62. Rate the extent to which you currently have stomach contractions
63. Rate the extent to which you currently have stomach cramps
64. Rate the extent to which your stomach currently feels empty
65. Rate the extent to which you currently feel stomach pain
66. Rate the extent to which your stomach currently feels stuffed
67. Rate the extent to which your stomach is currently growing
68. Rate your current non-stomach body pains
69. Rate your current level of thirst
70. Rate your current feeling of gastric tightness
71. Rate your current tiredness
72. Rate your current urge to eat
73. Rate your current feeling of warmth
74. Rate your current feeling of weakness
75. Rate your current feeling of weakness with hunger
76. Rate your current willingness to eat

**Part II:**
77. Rate your contentedness with the food you last ate
78. Rate your feeling of fullness from the food you last ate
79. Rate your appetite satisfaction from the food you last ate
80. Rate your desire for more of the food you last ate
81. Rate your desire for more of a different food than you last ate
82. Rate the difficulty to eat the food you last ate
83. Rate the enjoyment you had from the food you last ate
84. Rate the satisfaction with the food you last ate
85. Rate the self-control it required you to stop eating the food you last ate
86. Rate the strength of the feeling that you had enough to eat from the food you last ate
87. Rate the satisfaction with the feeling of fullness form the food you last ate
88. Rate your feeling that the meal or snack was a sufficient size
89. Rate your overall liking of the food you last ate
90. Rate your liking of the appearance of the food you last ate
91. Rate your liking of the odor of the food you last ate
92. Rate your liking of the flavor of the food you last ate
93. Rate you liking of the texture of the food you last ate
Data Analysis

Participants who did not mark English as their first language or who marked a majority of the statements as ‘unfamiliar with the statement’ or who took longer than 45 minutes to complete the questionnaire (assumption was that the participant did not follow the instructions and complete the questionnaire at one sitting) were removed from the data set. Questions with 3 or more people marking ‘unfamiliar with the statement’ were also removed from the data set before cluster or factor analyses were performed.

Both McQuitty’s Elementary Linkage Analysis and Factor Analysis were conducted and compared to determine the underlying structure of the questions (Crocker & Algina, 2008; McQuitty, 1957). Scores for each of the questions ranged from 0-18 with the left most radio button with a value of 0 and the right most radio button with a value of 18. A subject’s score for a given question corresponded to the radio button chosen.

For McQuitty’s Elementary Linkage Analysis, a Pearson correlation matrix of the 94 items was computed using XLStat version 2009.2.01. Missing data were handled by pairwise deletion by removing observations with missing data only when the variables involved in the calculations had missing data instead of deleting an observation entirely from all analysis if any data point was missing. McQuitty’s Elementary Linkage Analysis was completed using the correlation matrix to create clusters of the items (McQuitty, 1957). Each cluster that was created was a subset of variables that each had its highest correlation with another variable in the cluster. Variables within a cluster had higher intercorrelations among themselves than they did with variables in other clusters. The steps taken in McQuitty’s Elementary Linkage Analysis were:

1. I began with the absolute values of a full correlation matrix, including both the upper and lower triangles. The correlations of an item with itself were removed from the matrix.
2. For each variable (each column in the matrix), the highest correlation with the other variables was identified and circled.

3. The highest correlation in the matrix was found. These two variables began the first cluster.

4. For each of the variables, I determined if there were other variables that had their highest correlation with the variable in the cluster (i.e., I looked across the row to see if there were any circled values).

5. If so, I added that variable to the cluster, and repeated step 4 for each new variable added to the cluster.

6. If not, that cluster was complete and I began a new cluster by repeating step 3 for all variables that have not been previously clustered (i.e., I found the highest correlation in the reduced correlation matrix, eliminating variables that were already in clusters).

7. I terminated when all variables have been assigned to clusters.

After the cluster analysis was complete, the correlation matrix was re-ordered by cluster membership. This allowed the intra-cluster correlations and the cross-correlations between each set of clusters to be easily seen. Cross-correlations were relatively low compared to correlations within a cluster. Clusters that were determined to have little relevance to hunger and fullness were deleted for purposes of this study (details in the results). All 2-item clusters that did seem relevant to the hunger and fullness questionnaire were examined to see what other cluster each of the items would fit best into based on the next highest correlation. These items were placed into the cluster that contained the items next highest correlation.

Factor Analysis was completed using SAS version 9.2 on a Pearson Correlation matrix of the data set using a principal factor analysis extraction method (Complete SAS code is shown in Appendix G). Data from participants with missing values were not analyzed.
Initial communalities were computed using squared multiple correlations, and a varimax rotation was used for clearer interpretation. The number of factors to extract were determined through parallel analysis using principal axis/common factor analysis and using permutations of the raw data set to preserve the exact number of variables, number of cases, and exact range for each variable (O'Connor, 2000). One-thousand parallel data sets were computed and averaged. The eigenvalues derived from the actual data were compared to the eigenvalues derived from the random data. Factors were retained as long as the eigenvalue for a particular factor was greater than the respective mean eigenvalue from the random data. After the factors were extracted, only the factors pertaining to mental hunger, mental fullness, physical hunger, physical fullness and food liking were retained for the remaining analysis. Scores for these five factors along with scores for the traditional scales of fullness, hunger, desire, and prospective consumption (amount) were computed by averaging the rating from each question in a given factor for each participant at each time point (the inverse of the fullness rating was used in the mental hunger factor score calculation since fullness was negatively associated with the other questions in the factor). To compare the factor scales with the single-item traditional scales of hunger, fullness, desire and prospective consumption that had been part of the questionnaire, a Pearson correlation matrix of the mean factor scores and traditional scale scores was computed and analyzed to determine the highest correlation for each traditional scale to each factor scale.

SAS code for the Pearson correlation matrix:

```sas
proc corr data = one OUTP = pearsoncorrelationmatrixone;
var traditionalfullness traditionalhunger traditionalamount traditionaldesire traditionalsatifsaction factor1MH factor2PH factor5MF factor6L factor8PF;
run;
```

The internal consistency reliability, a measure of the degree to which each item of a rating scale measured the same construct, for each of the factors was measured using
Cronbach’s α, a measure of the average correlation of items within a scale (Cronbach, 1951; Dmitrienko et al., 2007). Cronbach’s α was computed using the proc corr procedure in SAS version 9.2. Cronbach’s α ranges from 0-1, with higher scores indicating good internal consistency. If α is very low, the scale is either too short or the items have very little in common. Cronbach’s α was computed using the proc corr procedure in SAS version 9.2.

SAS code for Cronbach’s alpha calculation:

```sas
proc corr data=satietyraw alpha;
title 'cronbach alpha for factor 1';
var desireamountfood amountfoodeat desireanyfood desiretoeatnextmeal desirefatty desiresalty desiresavory desiresweet desirefavoritefood desiresnack appetite appetiteforameal fullness hunger motivation foodthoughts urge willingness desiremoresamebreakfast desiredifferentbreakfast;
run;

proc corr data=satietyraw alpha;
title 'cronbach alpha for factor 2';
var stomachaches stomachpain famished rumbling stomachcramps empty growling;
run;

proc corr data=satietyraw alpha;
title 'cronbach alpha for factor 5';
var breakfastcontentedness breakfastfullness breakfastappetitesatisfaction breakfastfullnesssatisfaction breakfastsufficiency breakfastsatisfaction;
run;

proc corr data=satietyraw alpha;
title 'cronbach alpha for factor 6';
var overallliking flavorliking appearanceliking textureliking breakfastodorliking;
run;

proc corr data=satietyraw alpha;
title 'cronbach alpha for factor 8';
var bloated bursting stuffed;
run;
```
Results

Participants Characteristics

Six participants who did not mark English as their first language were removed from the data set. One participant was removed because she marked ‘unfamiliar with the statement’ for most of the questionnaire. This left a total of 229 participants (66 males and 164 females; age ranged from 18 to 70 years old). Body mass index (BMI), based on self-reported height and weight, ranged from 15.8 to 43.2 kg/m². Based on United States Department of Health and Human Services breakdown of BMI categories, thirteen were underweight, 133 normal weight, 51 overweight and 33 obese. One hundred and eleven people reported that they were currently working on losing weight, 12 reported they were working on gaining weight, 40 reported they were working on maintaining their current weight, and 67 reported they were not currently involved in any weight management effort. Thirty nine percent of the participants had eaten within the hour before filling out the survey, 27% one to two hours before, 12% two to three hours before, 5.6% three to five hours before and 4.3% had not eaten for more than 10 hours before filling out the questionnaire (Figure 3.3).

Figure 3.3: Distribution of the number of participants in each of the categories of hours since food was last eaten.
**Reduction of unclear items**

Twenty items, with 3 or more people marking ‘unfamiliar with the statement’, were removed from the data set before factor analysis or cluster analysis were performed: satiety, dreaminess, feebleness, gastric aching, gastric motility, gastric tenseness, gorged, indigestion, lethargy, stomach muscle spasms, distended, ravenousness, salivation, contractions, tightness, hunger weakness, food self-control, food enjoyment, contentedness and food had enough (Appendix H). For each of the questions deleted, there appeared to be at least one other question with similar meaning that was less ambiguous to the participants.

**McQuitty’s Elementary Linkage Analysis**

Six clusters related to hunger, satiety and food liking were extracted through McQuitty’s elementary linkage analysis. These included a mental hunger cluster, a physical hunger cluster, an extreme physical hunger cluster, a mental fullness cluster, an extreme physical fullness cluster and a food liking cluster. Although the food liking cluster may not be directly related to hunger and satiety, I choose to keep this cluster since it seemed to have relevance for my future studies. The complete correlation matrix ordered by cluster groupings is shown in Appendix I.

While going through the process to extract the final six clusters, the following clusters were deleted because they seemed to lack relevance for a hunger and fullness questionnaire: cluster 1 (anxiety and anxiousness), cluster 3 (non-stomach body aches, non-stomach body pains), cluster 5 (sleepiness, tiredness, drowsiness), cluster 10 (depression, sadness, happiness, guilt), cluster 11 (dizziness, faintness, headaches, sickness, weakness), cluster 14 (alertness, energy, attentiveness), cluster 17 (agitation, irritability, restlessness, ringing), cluster 19 (dry mouth, thirst), cluster 20 (calmness, relaxedness), and cluster 21 (coldness, warmth). It was assumed that since these items
did not cluster with the items with obvious hunger and fullness connotations, they were not relevant for the purpose of this scale creation.

After the initial deletion of irrelevant clusters, I was left with the following 11 clusters (cluster average inter-item correlation shown in parentheses):

<table>
<thead>
<tr>
<th>Cluster 2 (0.64)</th>
<th>Cluster 7 (0.83)</th>
<th>Cluster 13 (0.38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation to eat</td>
<td>Stomach aches</td>
<td>Food fullness</td>
</tr>
<tr>
<td>Urge to eat</td>
<td>Stomach pain 1</td>
<td>Appetite satisfaction</td>
</tr>
<tr>
<td>Appetite for a meal</td>
<td>Cluster 8 (0.60)</td>
<td>Food contentedness</td>
</tr>
<tr>
<td>Food thoughts</td>
<td>Food flavor liking</td>
<td>Food satisfaction</td>
</tr>
<tr>
<td>Willingness</td>
<td>Food overall liking</td>
<td>Food desire</td>
</tr>
<tr>
<td>Desire to eat your next meal</td>
<td>Food texture liking</td>
<td></td>
</tr>
<tr>
<td>Fullness</td>
<td>Food odor liking</td>
<td></td>
</tr>
<tr>
<td>Desire different food</td>
<td>Cluster 9 (0.80)</td>
<td></td>
</tr>
<tr>
<td>Desire to eat something savory</td>
<td>Rumbling</td>
<td></td>
</tr>
<tr>
<td>Desire to eat your favorite food</td>
<td>Growling</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cluster 4 (0.74)</th>
<th>Cluster 12 (0.65)</th>
<th>Cluster 15 (0.72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appetite</td>
<td>Desire to eat something fatty</td>
<td>Food fullness satisfaction</td>
</tr>
<tr>
<td>Hunger</td>
<td>Desire to eat something salty</td>
<td></td>
</tr>
<tr>
<td>Famished</td>
<td>Desire to eat something sweet</td>
<td></td>
</tr>
<tr>
<td>Empty</td>
<td></td>
<td>Food sufficiency</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cluster 6 (0.68)</th>
<th>Cluster 16 (0.44)</th>
<th>Cluster 18 (0.58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount food desired</td>
<td>Cramps</td>
<td>Bloat</td>
</tr>
<tr>
<td>Amount of food you could eat</td>
<td>Stomach pain 2</td>
<td>Bursting</td>
</tr>
<tr>
<td>Desire to eat a snack</td>
<td>Nausea</td>
<td>Stuffed</td>
</tr>
<tr>
<td>Desire to eat any food</td>
<td>Food difficulty</td>
<td></td>
</tr>
</tbody>
</table>

To reduce the number of clusters and group the 2-item and 3-item clusters with larger groupings, the 2 and 3-item clusters were evaluated to see which other cluster they correlated most highly. For cluster 7, both ‘stomach aches’ and ‘stomach pain 1’ correlated most highly with ‘stomach pain 2’ in cluster 16. For cluster 9, ‘rumbling’ and ‘growling’ correlated most highly with ‘hunger’ and ‘empty’, respectively, in cluster 4.
For cluster 15, both ‘food fullness satisfaction’ and ‘food sufficiency’ correlated most highly with ‘Food fullness’ in cluster 13. For cluster 12, ‘desire to eat something fatty’ and ‘desire to eat something salty’ correlated most highly with ‘desire to eat something savory’ in cluster 2 and ‘desire to eat something sweet’ correlated most highly with ‘desire to eat any food’ in cluster 6. However, since ‘desire to eat something sweet’ had its original highest correlation with ‘desire to eat something fatty’, it was placed in cluster 2 along with ‘desire to eat something fatty’. These new groupings are shown below along with their adjusted average inter-item correlations.

<table>
<thead>
<tr>
<th>Cluster 2 (0.59)</th>
<th>Cluster 6 (0.68)</th>
<th>Cluster 8 (0.60)</th>
<th>Cluster 13 (0.41)</th>
<th>Cluster 16 (0.45)</th>
<th>Cluster 18 (0.58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation to eat</td>
<td>Amount food desired</td>
<td>Food flavor liking</td>
<td>Food fullness</td>
<td>Cramps</td>
<td></td>
</tr>
<tr>
<td>Urge to eat</td>
<td>Amount of food you could eat</td>
<td>Food overall liking</td>
<td>Appetite satisfaction</td>
<td>Nausea</td>
<td></td>
</tr>
<tr>
<td>Appetite for a meal</td>
<td>Desire to eat a snack</td>
<td>Food texture liking</td>
<td>Food contentedness</td>
<td>Food difficulty</td>
<td></td>
</tr>
<tr>
<td>Food thoughts</td>
<td>Desire to eat any food</td>
<td>Food odor liking</td>
<td>Food saturation</td>
<td>Stomach aches</td>
<td></td>
</tr>
<tr>
<td>Willingness</td>
<td></td>
<td></td>
<td>Food desire</td>
<td>Stomach pain 1</td>
<td></td>
</tr>
<tr>
<td>Desire to eat your next meal</td>
<td></td>
<td></td>
<td>Food fullness</td>
<td>Cluster 18</td>
<td></td>
</tr>
<tr>
<td>Fullness</td>
<td></td>
<td></td>
<td>Appetite satisfaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire different food</td>
<td></td>
<td></td>
<td>Food contentedness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire to eat something savory</td>
<td></td>
<td></td>
<td>Food satisfaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire to eat your favorite food</td>
<td></td>
<td></td>
<td>Food desire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire to eat something fatty</td>
<td></td>
<td></td>
<td>Food fullness satisfaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire to eat something sweet</td>
<td></td>
<td></td>
<td>Food desire satisfaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire to eat something salty</td>
<td></td>
<td></td>
<td>Food sufficiency</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Cluster 4 (0.67) | |
|-----------------| |
| Appetite | |
| Hunger | |
| Famished | |
| Empty | |
| Rumbling | |
| Growling | |

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Since cluster 6 appears to have similar meaning to cluster 2, cluster 6 items were investigated to determine where they would fall if they were combined with other clusters. ‘Amount of food desired’ and ‘Amount of food you could eat’ had their next highest correlation with ‘appetite’ in cluster 4. ‘Desire to eat any food’ and ‘desire to eat a snack’ have their next highest correlation with ‘desire to eat something savory’ and ‘desire to eat your favorite food’ respectively in cluster 2. These new groupings are shown below along with their average inter-item correlations.

<table>
<thead>
<tr>
<th>Cluster 2 (0.59)</th>
<th>Cluster 4 (0.60)</th>
<th>Cluster 8 (0.60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation to eat</td>
<td>Appetite</td>
<td>Food flavor liking</td>
</tr>
<tr>
<td>Urge to eat</td>
<td>Food thoughts</td>
<td>Food overall liking</td>
</tr>
<tr>
<td>Appetite for a meal</td>
<td>Willingness</td>
<td>Food texture liking</td>
</tr>
<tr>
<td>Food thoughts</td>
<td>Desire to eat your next meal</td>
<td>Food odor liking</td>
</tr>
<tr>
<td>Willingness</td>
<td>Fullness</td>
<td>Cluster 13 (0.41)</td>
</tr>
<tr>
<td>Desire to eat your next meal</td>
<td>Desire different food</td>
<td>Food fullness</td>
</tr>
<tr>
<td>Fullness</td>
<td>Desire to eat something savory</td>
<td>Appetite satisfaction</td>
</tr>
<tr>
<td>Desire different food</td>
<td>Desire to eat your favorite food</td>
<td>Food contentedness</td>
</tr>
<tr>
<td>Desire to eat something fatty</td>
<td>Desire to eat something sweet</td>
<td>Food satisfaction</td>
</tr>
<tr>
<td>Desire to eat something sweet</td>
<td>Desire to eat something salty</td>
<td>Food desire</td>
</tr>
<tr>
<td>Desire to eat something salty</td>
<td>Desire to eat a snack</td>
<td>Food fullness satisfaction</td>
</tr>
<tr>
<td>Desire to eat a snack</td>
<td>Desire to eat any food</td>
<td>Food sufficiency</td>
</tr>
<tr>
<td>Desire to eat any food</td>
<td></td>
<td>Cluster 16 (0.45)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cluster 16 (0.45)</th>
<th>Cluster 18 (0.58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cramps</td>
<td>Food difficulty</td>
</tr>
<tr>
<td>Stomach pain 2</td>
<td>Food dificulty</td>
</tr>
<tr>
<td>Nausea</td>
<td>Stomach aches</td>
</tr>
<tr>
<td>Food difficulty</td>
<td>Stomach pain 1</td>
</tr>
<tr>
<td>Food difficulty</td>
<td>Food difficulty</td>
</tr>
<tr>
<td>Food dificulty</td>
<td>Food dificulty</td>
</tr>
<tr>
<td>Stomach aches</td>
<td>Food dificulty</td>
</tr>
<tr>
<td>Stomach pain 1</td>
<td>Food dificulty</td>
</tr>
</tbody>
</table>

If cluster 18 (bloated, bursting, and stuffed) were combined with another cluster, it would be combined with cluster 2 because it has its next highest correlation with Cluster 2. The
new inter-item correlation with cluster 18 combined with cluster 2 is 0.46. Cluster 18 was not grouped into other clusters since it seemed to be measuring a separate unique construct of extreme physical fullness feelings while cluster 2 seems to be measuring the construct of mental hunger feelings.

A mental hunger, physical hunger, food liking, mental fullness, extreme physical hunger and extreme physical hunger cluster were created. These final cluster groupings are shown in Figure 3.4.
Figure 3.4: Clusters created through McQuitty’s Elementary Linkage Analysis. Unless otherwise marked ratings were made on a scale that ranged from ‘none’ to ‘Strongest imaginable sensation of any kind’. Cluster average inter-item correlations are shown in parentheses following the cluster name.

<table>
<thead>
<tr>
<th>Mental hunger cluster (0.59)</th>
<th>Food liking cluster (0.60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate your current motivation to eat</td>
<td>1. Rate your overall liking of the food you last ate</td>
</tr>
<tr>
<td>2. Rate your current urge to eat</td>
<td>2. Rate your liking of the flavor of the food you last ate</td>
</tr>
<tr>
<td>3. Rate your current appetite for a meal</td>
<td>3. Rate your liking of the appearance of the food you last ate</td>
</tr>
<tr>
<td>4. Rate the extent to which you are currently thinking of food</td>
<td>4. Rate your liking of the texture of the food you last ate</td>
</tr>
<tr>
<td>5. Rate your current willingness to eat</td>
<td>5. Rate your liking of the odor of the food you last ate</td>
</tr>
<tr>
<td>6. Rate your current desire to eat your next meal</td>
<td></td>
</tr>
<tr>
<td>7. Rate your current feeling of fullness</td>
<td></td>
</tr>
<tr>
<td>8. Rate your current desire for a different food than you last ate 1</td>
<td></td>
</tr>
<tr>
<td>9. Rate your current desire to eat something savory</td>
<td></td>
</tr>
<tr>
<td>10. Rate your current desire to eat your favorite food</td>
<td></td>
</tr>
<tr>
<td>11. Rate your current desire to eat something fatty</td>
<td></td>
</tr>
<tr>
<td>12. Rate your current desire to eat something salty</td>
<td></td>
</tr>
<tr>
<td>13. Rate your current desire to eat any food</td>
<td></td>
</tr>
<tr>
<td>14. Rate your current desire to eat something sweet</td>
<td></td>
</tr>
<tr>
<td>15. Rate your current desire to eat a snack</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical hunger cluster (0.60)</th>
<th>Food liking cluster (0.60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate your current appetite</td>
<td>1. Rate your overall liking of the food you last ate</td>
</tr>
<tr>
<td>2. Rate your current feeling of hunger</td>
<td>2. Rate your liking of the flavor of the food you last ate</td>
</tr>
<tr>
<td>3. Rate the extent to which you currently feel famished</td>
<td>3. Rate your liking of the appearance of the food you last ate</td>
</tr>
<tr>
<td>4. Rate the extent to which your stomach currently feels empty</td>
<td>4. Rate your liking of the texture of the food you last ate</td>
</tr>
<tr>
<td>5. Rate the extent to which your stomach is currently rumbling</td>
<td>5. Rate your liking of the odor of the food you last ate</td>
</tr>
<tr>
<td>6. Rate the extent to which your stomach is currently growling</td>
<td></td>
</tr>
<tr>
<td>7. Rate the amount of food you currently desire 2</td>
<td></td>
</tr>
<tr>
<td>8. Rate the current amount of food you could eat 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mental fullness cluster (0.41)</th>
<th>Physical hunger cluster (0.60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate your feeling of fullness from the food you last ate 1</td>
<td>1. Rate the extent to which you currently have stomach cramps</td>
</tr>
<tr>
<td>2. Rate your appetite satisfaction from the food you last ate 1</td>
<td>2. Rate the extent to which you currently feel stomach pain</td>
</tr>
<tr>
<td>3. Rate your contentedness with the food you last ate 1</td>
<td>3. Rate your current feeling of nausea</td>
</tr>
<tr>
<td>4. Rate your satisfaction with the food you last ate 1</td>
<td>4. Rate the difficulty to eat the food you last ate 1</td>
</tr>
<tr>
<td>5. Rate your satisfaction with your feeling of fullness from the food you last ate 1</td>
<td>5. Rate the extent to which your stomach currently aches</td>
</tr>
<tr>
<td>6. Rate your desire for more of the food you last ate 1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extreme Physical hunger cluster (0.45)</th>
<th>Physical fullness cluster (0.58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate the extent to which you currently have stomach cramps</td>
<td>1. Rate the extent to which your stomach currently feels bloated</td>
</tr>
<tr>
<td>2. Rate the extent to which you currently feel stomach pain</td>
<td>2. Rate the extent to which your stomach feels like it is currently bursting</td>
</tr>
<tr>
<td>3. Rate your current feeling of nausea</td>
<td>3. Rate the extent to which your stomach currently feels stuffed</td>
</tr>
<tr>
<td>4. Rate the difficulty to eat the food you last ate 1</td>
<td></td>
</tr>
</tbody>
</table>

Rating made based on how the judges felt right after eating their most recent food (meal or snack)

Rating made on a scale that ranged from ‘none’ to ‘greatest possible amount’

Ratings made on a scale that ranged from “Greatest imaginable disliking” to ‘Greatest imaginable liking’.
Factor Analysis

Since participants had the option to mark ‘unfamiliar with the statement’, thus creating a missing data point, those participants (17) were not analyzed in the factor analysis. This left a total of 212 participants for the factor analysis.

The 10 extracted factors, which accounted for 84% of the common variance, related to mental hunger, physical hunger, moods, non-stomach body pains, mental fullness, food liking, thirst and tiredness, extreme physical fullness, attentiveness, temperature, guilt and nausea.

Parallel analysis indicated that the first 10 factors should be extracted (Table 3.1). These 10 retained factors accounted for 84% of the common variance. These factors were related to mental hunger, physical hunger, moods, non-stomach body pains, mental fullness, food liking, thirst and tiredness, extreme physical fullness, attentiveness, temperature, guilt and nausea (Figure 3.5). ‘Rate the difficulty to eat the food you last ate’ was deleted because it had a factor contribution below 0.3 to all 10 factors. The full factor contribution matrix after the varimax rotation is shown in appendix J.
Table 3.1: Eigenvalues for the first 15 factors from the factor analysis on the actual data before varimax rotation and mean eigenvalues extracted from the random data through parallel analysis.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Before Rotation Eigenvalue</th>
<th>Random Data Eigenvalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18.483266</td>
<td>1.756272</td>
</tr>
<tr>
<td>2</td>
<td>9.831047</td>
<td>1.635092</td>
</tr>
<tr>
<td>3</td>
<td>4.563165</td>
<td>1.544935</td>
</tr>
<tr>
<td>4</td>
<td>2.944808</td>
<td>1.466948</td>
</tr>
<tr>
<td>5</td>
<td>2.775663</td>
<td>1.397701</td>
</tr>
<tr>
<td>6</td>
<td>2.320070</td>
<td>1.335673</td>
</tr>
<tr>
<td>7</td>
<td>2.016806</td>
<td>1.276700</td>
</tr>
<tr>
<td>8</td>
<td>1.843239</td>
<td>1.222129</td>
</tr>
<tr>
<td>9</td>
<td>1.431670</td>
<td>1.170325</td>
</tr>
<tr>
<td>10</td>
<td>1.221095</td>
<td>1.121138</td>
</tr>
<tr>
<td>11</td>
<td>1.059706</td>
<td>1.074929</td>
</tr>
<tr>
<td>12</td>
<td>0.988768</td>
<td>1.029300</td>
</tr>
<tr>
<td>13</td>
<td>0.900526</td>
<td>0.983708</td>
</tr>
<tr>
<td>14</td>
<td>0.839263</td>
<td>0.941578</td>
</tr>
<tr>
<td>15</td>
<td>0.698962</td>
<td>0.900198</td>
</tr>
</tbody>
</table>
Figure 3.5: Factors created through factor analysis after varimax rotation. In parenthesis next to each factor name is the percentage common variance that each factor contributes. The individual item factor loadings are shown in parentheses following each item. The full factor matrix is shown in Appendix J.

<table>
<thead>
<tr>
<th>Factor 1 – Mental hunger (22.8%)</th>
<th>Factor 3 – Mood (4%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate the amount of food you currently desire1(.83)</td>
<td>1. Rate your current feeling of agitation (.58)</td>
</tr>
<tr>
<td>2. Rate the current amount of food you could eat2(.72)</td>
<td>2. Rate your current feeling of anxiety (.79)</td>
</tr>
<tr>
<td>3. Rate your current desire to eat any food (.88)</td>
<td>3. Rate your current feeling of anxiousness (.76)</td>
</tr>
<tr>
<td>4. Rate your current desire to eat your next meal (.82)</td>
<td>4. Rate your current feeling of calmness (.67)</td>
</tr>
<tr>
<td>5. Rate your current desire to eat something fatty(.81)</td>
<td>5. Rate your current feeling of depression (.55)</td>
</tr>
<tr>
<td>6. Rate your current desire to eat something salty (.78)</td>
<td>6. Rate your current feeling of happiness (.49)</td>
</tr>
<tr>
<td>7. Rate your current desire to eat something savory (.85)</td>
<td>7. Rate your current feeling of irritability (.51)</td>
</tr>
<tr>
<td>8. Rate your current desire to eat something sweet (.69)</td>
<td>8. Rate your current feeling of relaxedness (.60)</td>
</tr>
<tr>
<td>9. Rate your current desire to eat your favorite food (.84)</td>
<td>9. Rate your current feeling of restlessness (.53)</td>
</tr>
<tr>
<td>10. Rate your current desire to eat a snack (.76)</td>
<td>10. Rate your current feeling of sadness (.51)</td>
</tr>
<tr>
<td>11. Rate your current appetite (.80)</td>
<td>Factor 4 – Non-stomach body pains (7.7%)</td>
</tr>
<tr>
<td>12. Rate your current appetite for a meal (.80)</td>
<td>1. Rate your current feeling of dizziness (.58)</td>
</tr>
<tr>
<td>13. Rate your current feeling of fullness (.50)</td>
<td>2. Rate your current feeling of faintness (.49)</td>
</tr>
<tr>
<td>14. Rate your current feeling of hunger (.71)</td>
<td>3. Rate the extent to which your head currently aches (.62)</td>
</tr>
<tr>
<td>15. Rate your current motivation to eat (.81)</td>
<td>4. Rate your current non-stomach body aches (.76)</td>
</tr>
<tr>
<td>16. Rate the extent to which you are currently thinking of food (.59)</td>
<td>5. Rate the extent to which your ears are currently ringing (.38)</td>
</tr>
<tr>
<td>17. Rate your current urge to eat (.80)</td>
<td>6. Rate your current feeling of sickness (.57)</td>
</tr>
<tr>
<td>18. Rate your current willingness to eat (.79)</td>
<td>7. Rate your current non-stomach body pains (.75)</td>
</tr>
<tr>
<td>19. Rate your desire for more of the food you last ate (.43)</td>
<td>Factor 5 – Mental Fullness (7.5%)</td>
</tr>
<tr>
<td>20. Rate your current desire for a different food than you last ate1(.66)</td>
<td>1. Rate your contentedness with the food you last ate1(.76)</td>
</tr>
</tbody>
</table>

Factor 2 – Physical hunger (9.2%)

| 1. Rate the extent to which your stomach currently aches (.71) | 2. Rate your feeling of fullness from the food you last ate1 (.72) |
| 2. Rate the extent to which you currently feel stomach pain (.69) | 3. Rate your appetite satisfaction from the food you last ate1 (.81) |
| 3. Rate the extent to which you currently feel famished (.61) | 4. Rate your satisfaction with the food you last ate1 (.63) |
| 4. Rate the extent to which your stomach is currently rumbling (.68) | 5. Rate your satisfaction with your feeling of fullness from the food you last ate1 (.76) |
| 5. Rate the extent to which you currently have stomach cramps (.42) | 6. Rate your feeling that the meal or snack was a sufficient size1 (.68) |
| 6. Rate the extent to which your stomach currently feels empty (.58) | Factor 6 – Food Liking (7.2%) |
| 7. Rate the extent to which your stomach is currently growling (.66) | 1. Rate your overall liking of the food you last ate3 (.83) |

1Rating made based on how the judges felt right after eating their most recent food (meal or snack)
2Rating made on a scale that ranged from ‘none’ to ‘greatest possible amount’
3Ratings made on a scale that ranged from ‘Greatest imaginable disliking’ to ‘Greatest imaginable liking’. 

Figure continued on next page
Figure 3.5 continued:

<table>
<thead>
<tr>
<th>Factor 7 – Thirst and Tiredness (6.4%)</th>
<th>Factor 8 – Physical Fullness (5.5%)</th>
<th>Factor 9 – Attentiveness (5.4%)</th>
<th>Factor 10 – Temperature, guilt and nausea (4.0%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate your current feeling of drowsiness (.63)</td>
<td>1. Rate the extent to which your stomach currently feels bloated (.73)</td>
<td>1. Rate your current feeling of alertness (.78)</td>
<td>1. Rate your current feeling of coldness (.49)</td>
</tr>
<tr>
<td>2. Rate the extent to which your mouth currently feels dry (.42)</td>
<td>2. Rate the extent to which your stomach feels like it is currently bursting (.73)</td>
<td>2. Rate your current amount of energy (.76)</td>
<td>2. Rate the guilt you currently have from eating your last meal (.40)</td>
</tr>
<tr>
<td>3. Rate your current feeling of sleepiness (.77)</td>
<td>3. Rate the extent to which your stomach currently feels stuffed (.68)</td>
<td>3. Rate your current tiredness (.78)</td>
<td>3. Rate your current feeling of nausea (.49)</td>
</tr>
<tr>
<td>4. Rate your current level of thirst (.42)</td>
<td></td>
<td>4. Rate your current feeling of weakness (.45)</td>
<td>4. Rate your current feeling of warmth (-.44)</td>
</tr>
</tbody>
</table>

1. Rating made based on how the judges felt right after eating their most recent food (meal or snack)
2. Rating made on a scale that ranged from ‘none’ to ‘greatest possible amount’
3. Ratings made on a scale that ranged from “Greatest imaginable disliking” to ‘Greatest imaginable liking’.

Since the primary interest of this research was the evaluation of hunger and fullness feelings, the mental hunger factor, physical hunger factor, mental fullness factor, and physical fullness factor were investigated further. Because of the potential influence of food liking and evidence of the potential importance of liking on hunger and satiety feelings, I maintained a food liking factor in addition to the hunger and satiety related factors. Blundell (1991) conceptualized the expression of hunger and satiety in three levels, one of which included psychological events such as hunger perception, cravings, and hedonic sensations. Herman and Polivy (1984) described a boundary model for the regulation of eating that contained physiological and non-physiological determinants of eating. They acknowledged the influence of social factors and food palatability on eating. Jordan (1969) conducted experiments to study if human subjects could control ingestion of a liquid diet orally and/or intragastrically. He found that while food intake could be roughly regulated with the elimination of oropharyngeal factors, there was a separate oral aspect of satiety that was not met. Subjects reported oral cravings after the intragastric meals. Their hunger ratings did not fall as fast as in the studies using the oral feeding method indicating the influence of the palatability of the food on their hunger feelings. Because of these findings, the food liking factor was retained.
The factors related to mood, non-stomach body pains, thirst, tiredness, temperature, guilt and nausea were deleted because they most likely served as distractor questions in the previous satiety research and were not related to the primary aim of assessing hunger and satiety. For example, Cecil et al. (1999) evaluated nausea, dizziness and tiredness in addition to hunger and fullness, Herman et al. (1999) included tiredness and happiness to distract from the aim of the study, and Holt et al. (2000) asked mood related scales to distract from the importance of the hunger ratings.

*Score calculation for the factor and traditional scales*

Scores for the mental hunger factor, mental fullness factor, physical hunger factor, physical fullness factor and food liking factor along with scores for the traditional scales of fullness, hunger, desire, and prospective consumption (amount) were computed by averaging the rating from each question in a given factor for each participant (the inverse of the fullness rating was used in the mental hunger factor score calculation since fullness was negatively associated with the other questions in the factor).

*Internal consistency reliability of the five hunger, fullness and acceptance factors*

The mental hunger factor had the highest Cronbach’s α of 0.95, followed by the physical hunger factor and mental fullness factor with Cronbach’s α’s of 0.90 (Table 3.2). The food liking factor and physical fullness factor had Cronbach’s α’s of 0.89 and 0.80, respectively.

**Table 3.2:** Raw and standardized (items standardized to have a standard deviation of 1.0) Cronbach’s α’s for the factors (Mental Hunger, Physical Hunger, Mental Fullness, Food Liking, Extreme Physical Fullness) (N=212).

<table>
<thead>
<tr>
<th></th>
<th>Raw Cronbach’s α</th>
<th>Standardized Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Hunger Factor</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>Food Liking Factor</td>
<td>0.89</td>
<td>0.89</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>0.80</td>
<td>0.82</td>
</tr>
</tbody>
</table>
Correlation of the new multi-item factor scales to traditional single-item scales
Each of the traditional measures of ‘fullness’, ‘hunger’, ‘amount’, and ‘desire’ had its highest correlation with mental hunger factor, -0.61, 0.83, 0.74, 0.85, respectively (Figure 3.6). Traditional ‘hunger’ and ‘desire’ were also moderately correlated with the physical hunger factor, 0.76 and 0.55 respectively. Based on these correlations, in the following 2 experiments in Chapter 4, each of the traditional scales was compared to the mental hunger factor scale and the traditional hunger and traditional desire scales were also compared to the physical hunger factor scale.

The correlations among the factor scales were generally low (-0.01 to 0.60). The only moderate correlations were with the physical hunger factor to the mental hunger factor (0.60) and with the food liking factor to the mental fullness factor (0.50).

Figure 3.6: Pearson correlation matrix over all participants (N = 212) between the factor scales and the traditional scales. Correlations above 0.5 between each traditional measure and each factor are bolded and underlined.
Discussion

Comparison of McQuitty’s cluster analysis to principal factor analysis

McQuitty’s cluster analysis handled missing data by using pair-wise deletion instead of complete deletion of the observation as occurred in factor analysis. Seventeen participants’ data could not be analyzed with the factor analysis procedure leaving 212 participants for the factor analysis. Since the deleted participants represented only 7% of the total participants, it was assumed to not have an important impact on the factors extracted.

While there were many similarities between the cluster and factor groupings, overall, the comprehensibility of the item groupings from factor analysis seemed clearer than those produced through the cluster analysis. A side-by-side comparison of the factor analysis results to the cluster analysis results is shown in Figure 3.7. The food liking cluster and physical fullness cluster were identical to the food liking factor, and physical fullness factor created through principal factor analysis (Figure 3.7). The mental hunger factor contained 4 items (‘amount of food desired’, ‘amount of food you could eat’, ‘appetite’, and ‘hunger’) that were in the physical hunger cluster instead of the mental hunger cluster. It seems to make more intuitive sense that these items would be grouped with the other food related desires and feelings in the mental hunger factor as opposed to the physical hunger feelings of ‘rumbling’ and ‘growling’. The physical hunger factor differed from the physical hunger cluster in the 4 items just discussed, as well as the physical hunger factors contains 3 items (‘stomach cramps’, ‘stomach pain’, and ‘stomach aches’) that are in a separate cluster grouping that seemed to be related to extreme physical hunger sensations. ‘Nausea’ and ‘difficulty’ were not found in the factor groupings because they had not grouped with the hunger and fullness related factors. Again, it seems to make sense that ‘cramps’, ‘pain’, and ‘aches’ would be grouped with the ‘rumbling’ and ‘growling’ together in one factor related to physical hunger. The mental fullness factor and mental fullness cluster were identical with the
exception of ‘desire for more of the food you last ate’ was grouped with the mental hunger factor instead of in the mental fullness factor. Again, it seems logical that ‘desire for more of the food you last ate’ fits well into factor 1 mental hunger.
Figure 3.7: Comparison of cluster analysis to factor analysis results. Cluster items in parentheses are not present in the factor groupings. Items with an asterisk before them are in different groups between the cluster and factor analysis results.

<table>
<thead>
<tr>
<th>Factor Analysis Results</th>
<th>Cluster Analysis Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor – Mental hunger</td>
<td>Cluster – Mental hunger</td>
</tr>
<tr>
<td>1. Rate your current motivation to eat</td>
<td>1. Rate your current motivation to eat</td>
</tr>
<tr>
<td>2. Rate your current urge to eat</td>
<td>2. Rate your current urge to eat</td>
</tr>
<tr>
<td>3. Rate your current appetite for a meal</td>
<td>3. Rate your current appetite for a meal</td>
</tr>
<tr>
<td>4. Rate the extent to which you are currently thinking of food</td>
<td>4. Rate the extent to which you are currently thinking of food</td>
</tr>
<tr>
<td>5. Rate your current willingness to eat</td>
<td>5. Rate your current willingness to eat</td>
</tr>
<tr>
<td>6. Rate your current desire to eat your next meal</td>
<td>6. Rate your current desire to eat your next meal</td>
</tr>
<tr>
<td>7. Rate your current feeling of fullness</td>
<td>7. Rate your current feeling of fullness</td>
</tr>
<tr>
<td>8. Rate your current desire for a different food than you last ate</td>
<td>8. Rate your current desire for a different food than you last ate</td>
</tr>
<tr>
<td>9. Rate your current desire to eat something savory</td>
<td>9. Rate your current desire to eat something savory</td>
</tr>
<tr>
<td>10. Rate your current desire to eat your favorite food</td>
<td>10. Rate your current desire to eat your favorite food</td>
</tr>
<tr>
<td>11. Rate your current desire to eat something fatty</td>
<td>11. Rate your current desire to eat something fatty</td>
</tr>
<tr>
<td>12. Rate your current desire to eat something salty</td>
<td>12. Rate your current desire to eat something salty</td>
</tr>
<tr>
<td>13. Rate your current desire to eat any food</td>
<td>13. Rate your current desire to eat any food</td>
</tr>
<tr>
<td>14. Rate your current desire to eat something sweet</td>
<td>14. Rate your current desire to eat something sweet</td>
</tr>
<tr>
<td>15. Rate your current desire to eat a snack</td>
<td>15. Rate your current desire to eat a snack</td>
</tr>
<tr>
<td>16. *Rate the amount of food you currently desire</td>
<td>16. *Rate the amount of food you currently desire</td>
</tr>
<tr>
<td>17. *Rate the current amount of food you could eat</td>
<td>17. *Rate the current amount of food you could eat</td>
</tr>
<tr>
<td>18. *Rate your current appetite</td>
<td>18. *Rate your current appetite</td>
</tr>
<tr>
<td>19. *Rate your current feeling of hunger</td>
<td>19. *Rate your current feeling of hunger</td>
</tr>
<tr>
<td>20. *Rate your desire for more of the food you last ate</td>
<td>20. *Rate your desire for more of the food you last ate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor – Physical hunger</th>
<th>Cluster – Physical hunger</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate the extent to which you currently feel famished</td>
<td>1. Rate the extent to which you currently have stomach cramps</td>
</tr>
<tr>
<td>2. Rate the extent to which your stomach currently feels empty</td>
<td>2. Rate the extent to which you currently feel stomach pain</td>
</tr>
<tr>
<td>3. Rate the extent to which your stomach is currently rumbling</td>
<td>3. Rate the extent to which your stomach currently feels empty</td>
</tr>
<tr>
<td>4. Rate the extent to which your stomach is currently growling</td>
<td>4. (Rate your current feeling of nausea)</td>
</tr>
<tr>
<td>5. *Rate the extent to which you currently have stomach cramps</td>
<td>5. (Rate the difficulty to eat the food you last ate)</td>
</tr>
<tr>
<td>6. *Rate the extent to which you currently feel stomach pain</td>
<td>6. Rate the extent to which your stomach currently feels empty</td>
</tr>
<tr>
<td>7. *Rate the extent to which your stomach currently aches</td>
<td>7. Rate the extent to which you currently feel stomach pain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor – Mental Fullness</th>
<th>Cluster – Mental Fullness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate your feeling of fullness from the food you last ate</td>
<td>1. Rate your feeling of fullness from the food you last ate</td>
</tr>
<tr>
<td>2. Rate your appetite satisfaction from the food you last ate</td>
<td>2. Rate your appetite satisfaction from the food you last ate</td>
</tr>
<tr>
<td>3. Rate your contentedness with the food you last ate</td>
<td>3. Rate your contentedness with the food you last ate</td>
</tr>
<tr>
<td>4. Rate your satisfaction with the food you last ate</td>
<td>4. Rate your satisfaction with the food you last ate</td>
</tr>
<tr>
<td>5. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>5. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
</tr>
<tr>
<td>6. Rate your feeling that the meal or snack was a sufficient size</td>
<td>6. Rate your feeling that the meal or snack was a sufficient size</td>
</tr>
<tr>
<td>7. *Rate your desire for more of the food you last ate</td>
<td>7. *Rate your desire for more of the food you last ate</td>
</tr>
</tbody>
</table>

1 Rating made on a scale that ranged from ‘Greatest imaginable disliking’ to ‘Greatest imaginable liking’.
2 Rating made based on how the judges felt right after eating their most recent food (meal or snack)
3 Rating made on a scale that ranged from ‘none’ to ‘greatest possible amount’
4 Ratings made on a scale that ranged from ‘Greatest imaginable disliking’ to ‘Greatest imaginable liking’.

Figure continued on next page
**Figure 3.8 continued:**

<table>
<thead>
<tr>
<th><strong>Factor – Food Liking</strong></th>
<th><strong>Cluster - Food liking</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate your overall liking of the food you last ate(^1)</td>
<td>1. Rate your overall liking of the food you last ate(^1)</td>
</tr>
<tr>
<td>2. Rate your liking of the flavor of the food you last ate(^1)</td>
<td>2. Rate your liking of the flavor of the food you last ate(^3)</td>
</tr>
<tr>
<td>3. Rate your liking of the appearance of the food you last ate(^3)</td>
<td>3. Rate your liking of the appearance of the food you last ate(^3)</td>
</tr>
<tr>
<td>4. Rate your liking of the texture of the food you last ate(^3)</td>
<td>4. Rate your liking of the texture of the food you last ate(^3)</td>
</tr>
<tr>
<td>5. Rate your liking of the odor of the food you last ate(^3)</td>
<td>5. Rate your liking of the odor of the food you last ate(^3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Factor – Physical fullness</strong></th>
<th><strong>Cluster - Physical fullness</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate the extent to which your stomach currently feels bloated</td>
<td>1. Rate the extent to which your stomach currently feels bloated</td>
</tr>
<tr>
<td>2. Rate the extent to which your stomach feels like it is currently bursting</td>
<td>2. Rate the extent to which your stomach feels like it is currently bursting</td>
</tr>
<tr>
<td>3. Rate the extent to which your stomach currently feels stuffed</td>
<td>3. Rate the extent to which your stomach currently feels stuffed</td>
</tr>
</tbody>
</table>

\(^1\)Rating made based on how the judges felt right after eating their most recent food (meal or snack)

\(^2\)Rating made on a scale that ranged from ‘none’ to ‘greatest possible amount’

\(^3\)Ratings made on a scale that ranged from “Greatest imaginable disliking’ to ‘Greatest imaginable liking’.
Chapter 4

**TESTING AND VALIDATION OF THE FACTOR HUNGER AND SATIETY SCALES**

The objective of this study was to test the five factor scales of the hunger and satiety factor questionnaire created in chapter 3 [(1) mental hunger, (2) physical hunger, (3) mental fullness, (4) physical fullness and (5) food liking]. In the first validation study, thirty participants evaluated satiety feelings produced by oranges and oatmeal at 0min, 60min and 120min after consumption. Food intake from an *ad libitum* snack offered two hours after breakfast was covertly recorded. The factor scales and traditional single-item scales (hunger, fullness, desire, and prospective consumption) revealed that oatmeal was more satiating than oranges. The factor scales offered enhanced understanding over the traditional scales by showing that oranges produced much more mental hunger and slightly more physical hunger than the oatmeal. The factor scales also had smaller distributions around the means and greater effect sizes than the traditional scales. In a second study, participants evaluated satiety feelings produced by two equal-calorie smoothies that differed only in that one contained cumin to lower acceptability. The more palatable regular smoothie provided greater mental fullness factor sensations than the spiced cumin smoothie. Again, all of the factor scales produced smaller distributions around the means and greater effect sizes. The multi-item hunger and fullness factor scales offer enhanced sensitivity and understanding of satiety produced by foods.
Introduction

Blundell et al. (2010) described scientific procedures to evaluate psychological and behavioral expressions of appetite, one of these being feelings of satiety. Blundell’s review recommends the use of visual analogue scales for ‘hunger’, ‘fullness’, ‘satiety’, ‘desire’, and ‘prospective consumption (quantity)’ to determine subjective appetite in adults (Blundell et al., 2010). In the studies reported in this chapter, these five measures suggested by Blundell (2010) were evaluated independently as ‘traditional’ measures of satiety and were compared to the newly created factor hunger and fullness measures developed by my previous research reported in Chapter 3.

Food liking has been shown to influence hunger and satiety ratings (Sorensen et al., 2003). Sorensen et al. (2003), found that in some studies subjects felt less hunger and more fullness following a more palatable meal (Bobroff & Kissileff, 1986; Warwick et al., 1993), while in others subjects felt more hunger and less fullness after a palatable meal compared to a less palatable meal (Hill et al., 1984; Rogers & Schutz, 1992). Inconsistency of the relationships among liking, hunger and fullness seen in the literature may be made clearer by use of a more comprehensive multi-item questionnaire, because a greater number of items allows for documentation of more complexity.

The objectives of the experiment in Part I of this chapter were (1) to determine if the factor scales created in chapter 3 were more sensitive to differences in hunger, fullness and liking produced by oranges and oatmeal than the four ‘traditional’ scales of hunger, fullness, desire and amount and (2) to compare the hunger and satiety sensations produced by the oranges and oatmeal using the factor scales and traditional scales. It is hypothesized that the oranges and oatmeal would produce similar physical hunger/fullness ratings, and different mental hunger/fullness ratings, with the oranges producing fewer mental fullness feelings and greater mental hunger sensations than the oatmeal. This hypothesis was based on focus group discussions of oranges providing physical bulk in the stomach yet creating a desire for more food, and oatmeal providing a
satisfied fullness feeling that would last throughout the morning (Murray & Vickers, 2009).

The objectives of the experiment in Part II of this chapter were (1) to determine if the factor scales created in chapter 3 were more sensitive to differences in hunger, fullness and liking produced by two smoothies differing in liking than the four traditional scales of hunger, fullness, desire, and amount and (2) to compare the hunger and satiety sensations produced by the two smoothies using the factor scales and traditional scales. I hypothesized that the smoothie with the greater liking factor score would produce greater mental fullness feelings and fewer mental hunger feelings than the smoothie that was less liked, yet would be equal in physical fullness/hunger feelings.

In both Part I and Part II, the factor scales were compared to the traditional scales recommended by Blundell (2010) for sensitivity to detect differences between the pairs of breakfast meals (oranges and oatmeal or the regular and spiced smoothie). Cohen’s d effect sizes and distributions around each of the factor scale and traditional scale means were used to measure each scale’s sensitivity. Cronbach’s α was used to measure each scale’s internal consistency reliability.
PART I: THE TESTING AND VALIDATION OF THE HUNGER AND SATIETY
QUESTONNAIRE WITH ORANGES AND OATMEAL

Methods

Participants
Thirty participants were recruited from a database of students and staff on the Saint Paul campus who had previously indicated an interest in participation in sensory studies for the Sensory Center in the Food Science and Nutrition Department. To my knowledge, none of the participants had taken part in the experiment in Chapter 3. A recruitment questionnaire was used to screen respondents to make sure they had no food allergies, no medical condition that restricted their diet in any way (including diabetes, eating disorder, celiac disease), were breakfast eaters, liked and were willing to consume oatmeal and oranges and were native English speakers (Appendix K). Participants received $13.00 for their participation in the study. The protocol was approved by the University of Minnesota Institutional Review Board, and all participants gave their informed consent prior to their inclusion in the study.

Foods
Participants came for two separate breakfast sessions, at least 1 week apart, and received cinnamon and sugar flavored Quaker® Instant Oatmeal (The Quaker Oats Company, Chicago, IL) and navel oranges (purchased in bulk from a local grocery store). The oatmeal (66g dry mix with 1 cup of water; 245 kcal) was heated in the microwave for 2 minutes on high immediately before serving for one of the breakfast sessions and the navel oranges (410g, 201 kcal) were peeled, sliced and placed in a bowl before serving for the other session (Appendix L). Both the oatmeal and the oranges were served in identical bowls, and participants were required to eat the entire breakfast. The amounts of oatmeal and oranges were chosen to match each other in appearance volume. Participants were required to drink 200ml of water (Kandiyohi premium filtered water,
Minneapolis, MN) with the breakfast meals. Half the participants received the oatmeal and half received the oranges at their first session.

Participants were offered a tray of snacks when they returned for the follow up session two hours after the breakfast session (Table 4.1) (Appendix L). All snacks were removed from the commercial packaging and placed in glasses, bowls or on plates. The snacks were offered as an appreciation for participating in the breakfast study and participants were told they could eat as much or little as they would like. The snacks were covertly weighed before and after being offered to measure each participant’s intake.

Table 4.1: Snack items and weight (g) served to participants at the snack session for the orange and oatmeal study.

<table>
<thead>
<tr>
<th>Snack Item</th>
<th>Amount Served</th>
<th>Company Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium filtered water</td>
<td>290g</td>
<td>Kandiyohi premium water, Minneapolis, MN</td>
</tr>
<tr>
<td>Yoplait® original creamy smooth</td>
<td>150g</td>
<td>Yoplait USA Inc., Minneapolis, MN</td>
</tr>
<tr>
<td>style strawberry yogurt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Athenos® roasted red pepper</td>
<td>80g</td>
<td>Churny Company Inc., Weyauwega, WI</td>
</tr>
<tr>
<td>hummus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmstand® baby carrots</td>
<td>110g</td>
<td>Supervalue Inc., Eden Prairie, MN</td>
</tr>
<tr>
<td>Red seedless grapes</td>
<td>170g</td>
<td>Purchased from the local Cub Foods,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supervalue Inc., Eden Prairie, MN</td>
</tr>
<tr>
<td>Triscuits® original</td>
<td>6 crackers (26g)</td>
<td>Kraft Foods Global, Inc., Northfield, IL</td>
</tr>
<tr>
<td>Sargento® medium Cheddar cheese</td>
<td>1 slice cut into quarters (20g)</td>
<td>Sargento Foods Inc., Plymouth, WI</td>
</tr>
<tr>
<td>sliced</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culinary Circle® sliced genoa</td>
<td>1 slice cut into quarters (6g)</td>
<td>Supervalue Inc., Eden Prairie, MN</td>
</tr>
<tr>
<td>salami</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Debby® blueberry muffin</td>
<td>1 muffin (52g)</td>
<td>McKee Foods, Collegedale, TN</td>
</tr>
<tr>
<td>Thomas® plain bagels</td>
<td>½ bagel cut into 8 bite size pieces (35g)</td>
<td>Orograin Bakeries Products Inc., Horsham, PA</td>
</tr>
<tr>
<td>Land O’Lakes® salted butter</td>
<td>1 tablespoon (14g)</td>
<td>Land O’Lakes Inc., Arden Hills, MN</td>
</tr>
</tbody>
</table>

**Breakfast Session**

Participants were asked to fast (no food or drink except for water) for 10 hours prior to coming to the study. If they were coffee drinkers, they were allowed to have their morning coffee. If they did consume coffee, they were asked to keep the same routine between the 2 breakfast sessions by having coffee both times. Participants came between 7am and 8:30am to consume their breakfast. Each participant attended his/her sessions at the same time for both sessions.
All questionnaires and instructions were given using SIMS 2000© (Sensory Computer Systems, Morristown, NJ, USA). The scales evaluated were from the factors created in experiment 1 (Figure 4.1) (Appendix M). The majority of the questions in Figure 4.1 were presented on 150mm labeled magnitude scales (scale 1 in figure 4.2). The labeled magnitude scales were anchored with ‘none’ at 0mm, ‘barely detectable’ at 2mm, ‘weak’ at 9mm, ‘moderate’ at 26mm, ‘strong’ at 53mm, ‘very strong’ at 80mm and ‘strongest imaginable’ at 150mm. Slight modifications in the end anchors were made to make sense with the questions (see superscripted numbers of Figure 4.1 for end anchor modifications). The first two questions of the mental hunger factor were presented using a 150mm visual analog scale with ‘none’ at 0mm and ‘greatest possible amount’ at 150mm (scale 3 in figure 4.2). The food liking factor questions were asked using a 120mm scale with anchors labeled ‘Greatest imaginable disliking’ at 0mm, ‘dislike extremely’ at 13mm, ‘dislike very much’ at 25mm, ‘dislike moderately’ at 40mm, ‘dislike slightly’ at 53mm, ‘neutral’ at 60mm, ‘like slightly’ at 67mm, ‘like moderately’ at 81mm, ‘like very much’ at 93mm, ‘like extremely’ at 104mm, and ‘greatest imaginable liking’ at 120mm (scale 2 in figure 4.2). After receiving instructions on how to make ratings on the scales, the participants completed the before breakfast questionnaire (0min, Figure 4.1) and were told to “remember to please base your ratings on your feelings right now.” Once they finished the first questionnaire, they were served a breakfast, either oranges or oatmeal. They were instructed “after being served your breakfast, but before beginning to consume your breakfast, please answer the following question.” This question was “Rate how full you expect to be (Please look at the breakfast to determine your answer)”. Brunstrom and colleagues have shown that foods vary widely in expected satiety and that expected satiety was a significant predictor of portion size chosen by participants and a significant predictor of actual hunger and fullness feelings (Brunstrom et al., 2008; Brunstrom & Shakeshaft, 2009). Because of these findings, I included an expected satiety question in both experiments in this chapter. I hypothesized that with higher expectations of satiety ratings I would see higher actual ratings of satiety. After the
expected satiety questions, participants were instructed to “please take the next 10 minutes to consume the entire breakfast that you have been served. Try to pace your meal to fill the 10 minutes.” After the breakfast meal, participants were asked to complete the hunger and fullness questionnaire for the second time (10min, Figure 4.1). After the second questionnaire, participants were allowed to leave the lab. They were reminded to not eat or drink anything besides water or their normal amount of coffee until they returned to the lab in 2 hours. They were also told that “we realize you may still be hungry, so you will be provided with snacks when you return to the lab”. This was done to help motivate participants to refrain from eating between the breakfast and the follow-up session. Participants were given a notebook containing the third hunger and fullness questionnaire that would be filled out 1 hour after breakfast consumption (70min, Figure 4.1). A multi-channel timer was provided with one channel set for 1 hour after the participant’s breakfast consumption to remind them to fill out the questionnaire and a second channel set for 2 hours to remind them to return for the follow-up session.
Figure 4.1: Hunger, fullness and liking related factors retained. All ratings were made on the general labeled magnitude scale ranging from ‘none’ to ‘strongest imaginable’ unless otherwise noted by the superscripted number. The traditional scales are shown by a superscripted letter following the question.

<table>
<thead>
<tr>
<th>Mental hunger factor</th>
<th>Mental fullness factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate the amount of food you currently desire(^{1,a})</td>
<td>1. Rate your contentedness with the food you last ate</td>
</tr>
<tr>
<td>2. Rate the current amount of food you could eat(^{1,b})</td>
<td>2. Rate your feeling of fullness from the food you last ate(^{2})</td>
</tr>
<tr>
<td>3. Rate your current desire to eat any food</td>
<td>3. Rate your appetite satisfaction from the food you last ate</td>
</tr>
<tr>
<td>4. Rate your current desire to eat your next meal(^2)</td>
<td>4. Rate your satisfaction with the food you last ate</td>
</tr>
<tr>
<td>5. Rate your current desire to eat something fatty</td>
<td>5. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
</tr>
<tr>
<td>6. Rate your current desire to eat something salty</td>
<td>6. Rate your feeling that the meal or snack was a sufficient size</td>
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<tr>
<td>7. Rate your current desire to eat something savory</td>
<td></td>
</tr>
<tr>
<td>8. Rate your current desire to eat something sweet</td>
<td></td>
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<tr>
<td>9. Rate your current desire to eat your favorite food</td>
<td></td>
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<tr>
<td>10. Rate your current desire to eat a snack</td>
<td></td>
</tr>
<tr>
<td>11. Rate your current appetite</td>
<td></td>
</tr>
<tr>
<td>12. Rate your current appetite for a meal</td>
<td></td>
</tr>
<tr>
<td>13. Rate your current feeling of fullness(^2,d)</td>
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</tr>
<tr>
<td>14. Rate your current feeling of hunger(^2,d)</td>
<td></td>
</tr>
<tr>
<td>15. Rate your current motivation to eat</td>
<td></td>
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<tr>
<td>16. Rate the extent to which you are currently thinking of food(^3)</td>
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<tr>
<td>17. Rate your current urge to eat(^2)</td>
<td></td>
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<tr>
<td>18. Rate your current willingness to eat</td>
<td></td>
</tr>
<tr>
<td>19. Rate your desire for more of the food you last ate</td>
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</tr>
<tr>
<td>20. Rate your current desire for a different food than you last ate (^1)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical hunger factor</th>
<th>Physical fullness factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate the extent to which your stomach currently aches(^3)</td>
<td>1. Rate the extent to which your stomach currently feels bloated</td>
</tr>
<tr>
<td>2. Rate the extent to which you currently feel stomach pain(^3)</td>
<td>2. Rate the extent to which your stomach feels like it is currently bursting(^3)</td>
</tr>
<tr>
<td>3. Rate the extent to which you currently feel famished(^3)</td>
<td>3. Rate the extent to which your stomach currently feels stuffed(^3)</td>
</tr>
<tr>
<td>4. Rate the extent to which your stomach is currently rumbling(^3)</td>
<td></td>
</tr>
<tr>
<td>5. Rate the extent to which you currently have stomach cramps(^3)</td>
<td></td>
</tr>
<tr>
<td>6. Rate the extent to which your stomach currently feels empty(^4)</td>
<td></td>
</tr>
<tr>
<td>7. Rate the extent to which your stomach is currently growling(^3)</td>
<td></td>
</tr>
</tbody>
</table>

\(^{1}\)Rating made on a scale that ranged from 'none' to 'greatest possible amount'

\(^{2}\)Rating made on a scale that ranged from 'no sensation' to 'strongest imaginable'

\(^{3}\)Rating made on a scale that ranged from 'not at all' to 'strongest imaginable'

\(^{4}\)Ratings made on a scale that ranged from ‘Greatest imaginable disliking’ to ‘Greatest imaginable liking’.

\(^{a}\)Traditional desire scale

\(^{b}\)Traditional amount scale (prospective consumption)

\(^{d}\)Traditional fullness scale

\(^{b}\)Traditional hunger scale
**Figure 4.2:** An example of the three types of scales used in the orange and oatmeal study. The full questionnaire can be found in Appendix M.

<table>
<thead>
<tr>
<th>Scale Type 1: General labeled magnitude scale used for the majority of questions in Fig 4.1 (Modifications in end anchors were made to match the question asked)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate your appetite satisfaction from the food you last ate</td>
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<table>
<thead>
<tr>
<th>Scale Type 2: Used for the factor food liking questions in Fig 4.1</th>
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<tbody>
<tr>
<td>Rate your overall liking of the food you last ate</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale Type 3: Used for the mental hunger factor questions 1-2 in Fig 4.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate the current amount of food you could eat</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Follow-up Session**

When participants returned for the follow-up session it was verified that they had not consumed anything besides water or their normal amount of coffee between the breakfast and the follow-up session. If they had consumed coffee, they were reminded to keep the same routine for their second breakfast session. Participants filled out the hunger and fullness questionnaire for the fourth time (130 min, Figure 4.1) and were then offered the snack tray (Appendix L). With the snack tray they were told “We realize that you may not have had enough to eat for breakfast, so please feel free to eat as much or as little as you would like from the snacks we have provided on the tray in front of you. It will be 15 minutes until it’s time for you to answer your last set of questions for the study. Please feel free to read from one of the magazines or newspapers provided and enjoy the snacks while you wait.” After a 15 minute snack period, the participants filled out the hunger and fullness questionnaire for the fifth time (150min, Figure 4.1).
At the end of the second follow-up session, participants were asked to answer questions from the Eating Inventory (Westenhoefer, Stunkar, and Pudel, 1999) and the Dutch Eating Behaviour Questionnaire (Van Strein et al., 1986) to measure the participants’ level of eating restraint. Participants were also asked questions from the recruitment questionnaire again to verify their responses (Appendix M).

**Data Analysis**

The data analysis was conducted using SAS version 9.2. Scores for these five factors along with scores for the traditional scales of fullness, hunger, desire, and prospective consumption (amount) were computed by averaging the rating in millimeters from each question in a given factor for each participant at each time point (the inverse of the fullness rating was used in the mental hunger factor score calculation since fullness was negatively associated with the other questions in the factor).

*Check for baseline differences*

Baseline factor scale and traditional scale ratings, made before breakfast (T₁ in Figure 4.3) between the two session days were analyzed using a repeated measures mixed model analysis of variance with the baseline ratings for each factor scale (except the food liking factor scale) and each traditional scale set as the response and food, day and judge set as the predictors. A food-by-day interaction was initially included in the models, but was deleted from the final model since it was never significant ($\alpha=0.05$). A Kenwardroger correction for cross-over and repeated measure studies was used to correct the covariance matrix of the fixed-effect parameter estimates and denominator degrees of freedom (Kenward & Roger, 1997).

Example SAS code for baseline check:

```sas
proc mixed data = satietyauc;
title 'Baseline Factor 1 Mental Hunger';
class judge day food;
model basefac1 = food day / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
```
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**lsmeans day food/diff;**
**ods select tests3 lsmeans diffs;**
**run;**

**Figure 4.3:** Hypothetical curve showing scale rating change over time. Breakfast was consumed between time 1 (T₁) and time 2 (T₂). The scale ratings were made right before breakfast (T₁), right after breakfast (T₂), 1 hour after breakfast (T₃) and 2 hours after breakfast (T₄). The rating curve was evaluated in three ways: (1) immediate rating change due to breakfast consumption (rating at T₂ – rating at T₁) (the food liking factor immediate rating change was the rating at T₂), (2) change in rating over the 2 hours after breakfast (rating at T₄ – rating at T₂), and (3) the overall session rating [shown as the area under the curve (AUC) from T₁ to T₄ (the food liking factor AUC calculation was the area from T₂ to T₄)].

![Hypothetical curve showing scale rating change over time.](image)

**Expected satiety**

A repeated measures mixed model analysis of variance procedure with a random subject effect and Kenwardroger correction was run to determine if the expected satiety differed between the oatmeal and the oranges. The expected satiety rating was set as the response, and food, day and a food by day interaction were predictors. The food-by-day interaction was removed from the final model since it was not significant (α = 0.05).

Example SAS code for expected satiety question:

```sas
proc mixed data = satietyauc;
title 'Rate how full you expect to be (looking at the food to make the judgment before eating)';
```

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Comparison of the foods

Each of the factor scales and traditional scales was evaluated using three rating measurements (Figure 4.3). The first rating measurement, the immediate change due to breakfast consumption, was used to compare immediate hunger and fullness change due to breakfast consumption. This immediate change was calculated by subtracting the rating made immediately before breakfast \( (T_1) \) from the rating made immediately after breakfast \( (T_2) \). The immediate rating change was not computed for the liking factor. Instead, the liking factor rating made immediately after breakfast \( (T_2) \) was used to measure the effect of eating the breakfast on liking. The second rating measurement, the change in rating over the 2 hour session time after breakfast, was calculated by subtracting the rating made right after breakfast \( (T_3) \) from the rating made 2 hours after breakfast \( (T_4) \). The third rating measurement, the area under the curve starting from the before breakfast rating \( (T_1) \) to the 2 hours after breakfast rating \( (T_4) \), was calculated to assess the overall effect from the breakfast over the entire session. The AUC for the liking factor only included area from the immediately after breakfast rating \( (T_2) \) to the 2 hours after breakfast rating \( (T_4) \). SAS version 9.2 was used to calculate the area under the curve \((\text{AUC})\) using the trapezoidal rule [area under the curve = \( \frac{1}{2} \{ (t_2 - t_1)(m_1+m_2)+(t_3-t_2)(m_2+m_3)+(t_4-t_3)(m_3+m_4) \} \); \( t = \) time; \( m = \) mean rating].

Repeated measures mixed model analysis of variance procedures, with Kenwardroger correction and a random subject effect, were used to determine if the ratings from each of the factor scales and each of the traditional scales differed significantly between oranges and oatmeal. Separate mixed procedures were run for each of the three rating measurements (immediate rating change, 2hr rating change or area under the curve) and
for each of the factor scales and traditional scales. The particular scale for a particular rating measurement was set as the response, and food, day and a food-by-day interaction were set as the predictors. Since none of the food by day interactions were significant ($\alpha=0.05$), the interaction was removed from the final models.

Example SAS code for the scale investigations:

```sas
proc mixed data = auc0;
title 'Does food or day influence fac1_AUC?';
class judge day food;
model fac1_AUC = food day / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans food/pdiff;
ods select tests3 lsmeans diffs;
run;
```

```sas
proc mixed data = auc0;
title 'Does food or day influence fac1_immediateratingchange?';
class judge day food;
model fac1_immediateratingchange = food day/ ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans food/pdiff;
ods select tests3 lsmeans diffs;
run;
```

```sas
proc mixed data = auc0;
title 'Does food or day influence fac1_2hrratingchange?';
class judge day food;
model fac1_2hrratingchange = food day / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans food/pdiff;
ods select tests3 lsmeans diffs;
run;
```

Analysis of the amount of calories consumed at the follow-up snack session

A repeated measures mixed analysis of variance procedure, with the Kenwardroger correction and a random subject effect, was used to determine if there was a significant difference in the amount of snack calories consumed at the ad libitum snack session between the oranges and oatmeal or between the two session days. Calories consumed were set as the response, and food, day and a food by day interaction were set as the
predictors. Again, the food-by-day interaction was removed from the final model since it was not significant (α = 0.05).

Example SAS code for analysis of calories eaten at the snack:

```sas
proc mixed data = weights;
title 'Does the test food, day, or food*day predict calorie intake?';
class day food judge;
model calories = food day / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans food/pdiff;
ods select tests3 lsmeans diffs;
run;
```

The ability of the scales to predict snack calorie consumption

A repeated measures mixed analysis of variance procedure, with the Kenwardroger correction and a random subject effect, was run separately for each factor scale and traditional scale to determine if the amount of snack calories consumed at the ad libitum snack session could be predicted by the factor scales or the traditional scales. Calories consumed was set as the response and day and area under the curve, immediate rating change or 2hr rating change were set as the predictors. Day by AUC, day by immediate rating change and day by 2hr rating change interactions were investigated. The interactions were never significant (α = 0.05) so they were removed from the final models.

Example SAS code for analysis of calories eaten at the snack:

```sas
proc mixed data = xxx.satietyplus;
title 'Does the AUC for each factor or traditional scale predict calorie intake?';
by scale;
class day food judge;
model calories = AUC day / s ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
ods select tests3 lsmeans diffs;
ods output solution;
run;
```
proc mixed data = xxx.satietyplus;
title 'Does the diffbase_15 for each scale predict calorie intake?';
by scale;
class day food judge;
model calories = diffbase_15 day / s ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
ods select tests3 lsmeans diffs;
ods output solution;
run;

proc mixed data = xxx.satietyplus;
title 'Does the diff15_135 for each scale predict calorie intake?';
by scale;
class day food gender judge restraint_cat;
model calories = diff15_135 day / s ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
ods select tests3 lsmeans diffs;
ods output solution;
run;

Comparison of the sensitivity of the factor scales to the traditional scales

Sensitivity of the scales is the ability of the scales to discriminate among food samples. A scale rating with smaller variability would be more sensitive for determining differences between the food samples.

Scale Distribution Comparisons: To compare the distribution of scores for each factor scale and traditional scale, standard deviations around the means over both foods for each scale for immediate rating change (exception: T2 rating for the food liking factor was used instead of an immediate rating change), 2hr rating change, and area under the curve were investigated. Each factor scale was renamed to ‘factor’ and each of the traditional scales to ‘traditional’ so they would be evaluated as separate groups before the t-test was completed. The data file contained a column for the scale (factor, traditional or basic), a column for rating method (immediate, 3hr, or AUC) and a column for the standard deviation. Differences in the size of the standard deviations between the factor scales and the traditional scales over the two foods were tested using a pooled t-test procedure for each rating measurement (immediate rating change, 2hr rating change and area under the curve) separately.
Example SAS model for scale distribution comparisons:

```sas
proc sort data = sd;
  by rating_measurement;
run;

proc print data = sd;
run;

proc ttest data = sd ci = none;
  by rating_measurement;
  class scale;
  var score;
run;
```

**Effect Size Comparisons:** Cohen’s d effect sizes for each of the factor scales and traditional scales were calculated and used as a gauge of the sensitivity of each of the scales for determining the differences in each of the factor and traditional scales between the oranges and oatmeal. Cohen’s d effect size was calculated as the difference between the mean ratings (over all 30 participants) of the foods (oranges and oatmeal) divided by the standard deviation of the differences. The larger the effect size, the more sensitive the measurement tool was for determining differences between the two foods. The difference in means used for the calculation came from the difference in least squares means from a repeated measures mixed model analysis of variance with the scale rating set as the response and food and day set as predictors. The standard deviation used in the calculation was computed by taking the square root of the variance obtained from the estimated V matrix (sum of the covariance estimate for intercept and residual).

Example SAS code for effect size comparisons:

```sas
proc mixed data = auc0;
  title 'diff15_135amount';
  class judge day food;
  model diffmin15_135amount = food day / ddfm=kenwardroger;
  random intercept / subject = judge v vcorr;
  lsmeans food/pdiff;
run;
```
**Internal consistency reliability comparisons:** The internal consistency reliability of the factor scales, a measure of the degree to which each item of a rating scale measured the same construct, was calculated using Cronbach’s $\alpha$, a measure of the average correlation of items within a scale (Cronbach, 1951; Dmitrienko et al., 2007). Cronbach’s $\alpha$ was computed using the proc corr procedure in SAS version 9.2.

Example SAS code for internal consistency reliability calculation:

```sas
proc corr data=satietyraw alpha;
title 'cronbach alpha for mental hunger factor';
var desireamountfood amountfoodeat desireanyfood desiretoeatnextmeal desirefatty desiresalty desiresavory desiresweet desirefavoritefood desiresnack appetite appetiteforameal fullness hunger motivation foodthoughts urge willingness desiremoresamebreakfast desiredifferentbreakfast;
run;

proc corr data=satietyraw alpha;
title 'cronbach alpha for physical hunger factor';
var stomachaches stomachpain famished rumbling stomachcramps empty growling;
run;

proc corr data=satietyraw alpha;
title 'cronbach alpha for mental fullness factor';
var breakfastcontentedness breakfastfullness breakfastappetitesatisfaction breakfastfullnesssatisfaction breakfastsufficiency breakfastsatisfaction;
run;

proc corr data=satietyraw alpha;
title 'cronbach alpha for food liking factor';
var overallliking flavorliking appearanceliking textureliking breakfastodorliking;
run;

proc corr data=satietyraw alpha;
title 'cronbach alpha for physical fullness factor';
var bloated bursting stuffed;
run;
```
Results

Participant Characteristics

The 30 participants, 6 males and 24 females, ranged in age from 18-53 years of age with a mean age of 28.4 years (Table 4.2). They had an average body mass index of 22.5 kg/m\(^2\) with a range of 18.9-28.3 kg/m\(^2\). Eleven indicated they were currently working on losing weight, 2 were currently working on gaining weight, 12 were currently working on maintaining their weight, and 5 were not currently involved in any weight management effort. For the 3 eating restraint measurements that were made, scores for the Flexible Control portion of the Eating Inventory ranged from 2 to 11 with a mean of 5.9; scores for the Rigid Control portion of the Eating Inventory ranged from 1-12 with a mean of 5.6; scores for the Dutch Eating Restraint Scale ranged from 14 to 35 with a mean of 26.2.

Table 4.2: Participant characteristic means or counts for the orange and oatmeal study. Participants in the ‘oat-orange’ group received the oatmeal at their first session and oranges at their second session. Those in the ‘orange-oat’ group received oranges first and oatmeal at their second session.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>oat-orange</th>
<th>orange-oat</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects (count)</td>
<td>16</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>Dutch restraint score (mean)</td>
<td>25.8</td>
<td>26.7</td>
<td>26.2</td>
</tr>
<tr>
<td>Eating Inventory Flexible Control Score (mean)</td>
<td>5.4</td>
<td>6.6</td>
<td>5.9</td>
</tr>
<tr>
<td>Eating Inventory Rigid Control Score (mean)</td>
<td>5.4</td>
<td>5.8</td>
<td>5.6</td>
</tr>
<tr>
<td>Dieting Status – working on losing weight (count)</td>
<td>5</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Dieting Status – working on gaining weight (count)</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Dieting Status – working on maintaining weight (count)</td>
<td>7</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Dieting Status – no weight management effort (count)</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Age (mean)</td>
<td>31.3</td>
<td>25.1</td>
<td>28.4</td>
</tr>
<tr>
<td>Gender (number of males)</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Body mass index kg/m(^2) (mean)</td>
<td>22.4</td>
<td>22.6</td>
<td>22.5</td>
</tr>
</tbody>
</table>
Check for baseline differences and sequence effect

There were no significant differences for any of the factors or traditional satiety questions at baseline (T₁) ratings taken immediately before breakfast (0min) between session day 1 and session day 2. There was also no significant difference in sequence.

Expected satiety

When participants were asked to ‘rate how full you expect to be (looking at the food to make the judgment before eating), they expected to be more full after eating the oatmeal than after eating oranges (oatmeal mean = 70mm, orange mean = 48mm; F-value = 8.3, p-value = 0.008).

Comparison of the foods

Immediate rating change: The oatmeal produced a greater drop in the mental hunger factor feelings than did the oranges (Table 4.3; Figure 4.4 and 4.5). No traditional scales showed significant differences between the oranges and oatmeal for the immediate rating change due to breakfast consumption. The oranges had a significantly higher liking factor rating at the T₂ rating 0min after breakfast (83mm) than the oatmeal (Table 4.3; Figure 4.4) (72mm) (F-value = 6.1, p-value = 0.02).

Two hour rating change: Oatmeal had a smaller increase in mental hunger factor and traditional hunger, and a smaller decrease in mental fullness factor and traditional fullness scale rating than the oranges (Table 4.3; Figure 4.4 and 4.5).

Area under the curve: Oatmeal had a significantly smaller area under the curve for mental hunger factor, physical hunger factor, traditional amount, traditional desire, and traditional hunger than the oranges (Table 4.3; Figure 4.4 and 4.5). The oranges had a significantly larger area under the curve rating (167mm h) than the oatmeal (146mm h) (F-value = 5.6, p-value = 0.02).
Day effects

For immediate rating change, traditional fullness was rated larger on day 1 than on session day 2 (Table 4.4). For 2hr rating change, traditional hunger increased more on day 2 than on day 1. For AUC, there were higher mental hunger, physical hunger traditional amount, traditional desire and traditional hunger ratings on day 2 than day 1 and lower physical fullness and traditional fullness on day 2 than on day 1. There were no significant food-by-day interactions.
Table 4.3: Mean (N=30) immediate rating change, 2hr rating change and area under the curve (AUC) for each factor scale and traditional scale for oatmeal and oranges. Mean scores could range from 0-120mm for the food liking factor and 0-150mm for all other factors and traditional scales. Means within a row within a specific rating measurement type followed by a different letter were significantly different [α=0.05; df (1, 28)].

<table>
<thead>
<tr>
<th>Scale</th>
<th>Immediate Rating Change (mm)</th>
<th>2hr Rating Change (mm)</th>
<th>Area Under the Curve (mm h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>oatmeal</td>
<td>oranges</td>
<td>F</td>
</tr>
<tr>
<td>Mental Hunger Factor</td>
<td>-49a</td>
<td>-40b</td>
<td>7.2</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>-27</td>
<td>-24</td>
<td>0.9</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>-3</td>
<td>-3</td>
<td>0.0</td>
</tr>
<tr>
<td>Food Liking Factor*</td>
<td>72b*</td>
<td>83a*</td>
<td>6.1</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>19</td>
<td>20</td>
<td>0.3</td>
</tr>
<tr>
<td>Traditional amount</td>
<td>-60</td>
<td>-50</td>
<td>3.0</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>-66</td>
<td>-59</td>
<td>1.8</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>-51</td>
<td>57</td>
<td>1.3</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>-65</td>
<td>-65</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0min after breakfast (T2) and the area under the curve calculation is the area from 0min after breakfast (T2) to 3hrs after breakfast (T4).
Table 4.4: Mean ratings for session day over both foods (oatmeal and oranges) and all participants (N=30) and F and p values for the main effect of day from a mixed procedure for the immediate rating change, 2hr rating change and area under the curve (AUC). Mean scores could range from 0-120mm for the food liking factor and 0-150mm for all other factors and traditional scales. Means within a row within a specific rating measurement type followed by a different letter were significantly different \( \alpha=0.05; \text{df}(1, 28) \).

<table>
<thead>
<tr>
<th>Scale</th>
<th>Immediate Rating Change (mm)</th>
<th>2hr Rating Change (mm)</th>
<th>Area Under the Curve (mm h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>day 1</td>
<td>day 2</td>
<td>F</td>
</tr>
<tr>
<td>Mental hunger factor</td>
<td>-47</td>
<td>-43</td>
<td>1.7</td>
</tr>
<tr>
<td>Physical hunger factor</td>
<td>-26</td>
<td>-25</td>
<td>0.2</td>
</tr>
<tr>
<td>Food liking factor</td>
<td>79</td>
<td>77</td>
<td>0.3</td>
</tr>
<tr>
<td>Mental fullness factor</td>
<td>-4</td>
<td>-2</td>
<td>0.0</td>
</tr>
<tr>
<td>Physical fullness factor</td>
<td>22</td>
<td>18</td>
<td>3.3</td>
</tr>
<tr>
<td>Traditional amount</td>
<td>-61</td>
<td>-61</td>
<td>4.7</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>-64</td>
<td>-64</td>
<td>4.7</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>61a</td>
<td>48b</td>
<td>5.3</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>-64</td>
<td>-66</td>
<td>0.1</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0min after breakfast \( T_2 \) and the area under the curve calculation is the area from 0min after breakfast \( T_2 \) to 3hrs after breakfast \( T_4 \).*
**Figure 4.4:** Plots of the mean (mm) (N=30) factor scale ratings (Mental Hunger, Physical Hunger, Mental Fullness, Food Liking and Physical Fullness) at each of the time points (baseline before breakfast 0hr, immediately after breakfast 0.25hr, one hour after breakfast 1.25hr, and two hours after breakfast 2.25hr) for oranges and oatmeal. Mean scores could range from 0-150mm for the mental hunger, physical hunger, mental fullness, and physical fullness factors and from 0-120mm for the food liking factor. Standard error bars represent plus and minus the standard error of the mean.
Figure 4.5: Plots of the mean (mm) (N=30) traditional ratings (Traditional amount, traditional fullness, traditional hunger, traditional desire and traditional satisfaction) at each of the time points (baseline before breakfast 0hr, immediately after breakfast 0.25hr, one hour after breakfast 1.25hr, and two hours after breakfast 2.25hr) for oranges and oatmeal. Mean scores could range from 0-150mm. Mean Standard error bars represent plus and minus the standard error of the mean.
Analysis of the amount of calories consumed at the follow-up snack session
Significantly more calories of food were consumed at the *ad libitum* snack session on session day 2 (591 kcal) than session day 1 (496 kcal) (df(1, 28); F-value = 17.1; p-value = <0.001). A significantly greater number of calories were consumed at the *ad libitum* snack after the oranges (575 kcal) than the oatmeal (512 kcal) (df(1, 28); F-value = 6.7; p-value = 0.015).

The ability of the scales to predict snack calorie consumption
Decreased calorie consumption at the *ad libitum* snack was associated with a larger decrease in the immediate rating change for the mental hunger factor scores (Table 4.5; Figure 4.6). Increased calorie consumption was associated with larger 2hr rating changes for the physical hunger factor scores and traditional hunger scores. Increased calorie consumption was also associated with higher area under the curve mental hunger factor scale scores, higher traditional amount, traditional desire, and traditional hunger scale scores, and lower ratings of area under the curve mental fullness factor scale scores and traditional fullness scale scores.
Table 4.5: Orange and oatmeal study β, F and p-values from the model with calories as the response and immediate rating change, 2hr rating change or area under the curve as the predictor. β represents the increase/decrease in calories consumed for every 1 point increase in scale rating. Scores could range from 0-120mm for the food liking factor and 0-150mm for all other factors and traditional scales. Each factor scale and traditional scale was analyzed separately. P-values marked with an asterisk were significant [df(1, 28); α=0.05].

<table>
<thead>
<tr>
<th>Scale</th>
<th>β</th>
<th>F value</th>
<th>P value</th>
<th>β</th>
<th>F value</th>
<th>P Value</th>
<th>β</th>
<th>F value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor Scales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental Hunger Factor</td>
<td>2.1</td>
<td>4.3</td>
<td>0.045*</td>
<td>1.5</td>
<td>2.5</td>
<td>0.127</td>
<td>1.3</td>
<td>10.2</td>
<td>0.003*</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>-0.5</td>
<td>0.1</td>
<td>0.748</td>
<td>3.0</td>
<td>5.1</td>
<td>0.029*</td>
<td>1.1</td>
<td>1.6</td>
<td>0.219</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>-0.7</td>
<td>1.8</td>
<td>0.184</td>
<td>0.4</td>
<td>0.1</td>
<td>0.718</td>
<td>-1.3</td>
<td>12.5</td>
<td>0.001*</td>
</tr>
<tr>
<td>Food Liking Factor&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.4</td>
<td>0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.685&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-1.3</td>
<td>0.2</td>
<td>0.646</td>
<td>-0.2</td>
<td>0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.659&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>-0.9</td>
<td>0.4</td>
<td>0.544</td>
<td>0.5</td>
<td>0.1</td>
<td>0.713</td>
<td>-0.8</td>
<td>0.6</td>
<td>0.454</td>
</tr>
<tr>
<td><strong>Traditional scales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional amount</td>
<td>0.8</td>
<td>1.1</td>
<td>0.297</td>
<td>0.7</td>
<td>1.5</td>
<td>0.236</td>
<td>0.7</td>
<td>5.4</td>
<td>0.025*</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>0.5</td>
<td>0.6</td>
<td>0.457</td>
<td>1.1</td>
<td>2.9</td>
<td>0.097</td>
<td>1.1</td>
<td>10.6</td>
<td>0.002*</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>-1.2</td>
<td>3.5</td>
<td>0.068</td>
<td>-0.1</td>
<td>0.0</td>
<td>0.868</td>
<td>-0.8</td>
<td>4.0</td>
<td>0.051*</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>0.3</td>
<td>0.2</td>
<td>0.656</td>
<td>1.4</td>
<td>4.0</td>
<td>0.052*</td>
<td>0.8</td>
<td>4.5</td>
<td>0.039*</td>
</tr>
</tbody>
</table>

<sup>a</sup>The food liking factor immediate rating change is the rating at 0min after breakfast (T<sub>2</sub>) and the area under the curve calculation is the area from 0min after breakfast (T<sub>2</sub>) to 3hrs after breakfast (T<sub>4</sub>).
Figure 4.6: Plots of the calories consumed at that *ad libitum* snack for both oranges and oatmeal for each participant (N=30) versus the score for the immediate rating change, 2hr rating change or area under the curve for the scales that were significantly associated with calorie intake in the mixed model with calories as the response and immediate rating change, 2hr rating change or area under the curve as the predictor (Table 4.5). The linear association is shown as a trend line in the plots.
Comparison of the sensitivity of the factor scales to the traditional scales

**Scale Distribution Comparisons:** Overall, the factor scales generally showed less variability than the traditional scales (Table 4.6). For immediate rating change, the average standard deviation for the five factor scales and two foods (21mm) was significantly lower than the average over all four traditional scales (33mm) (df(9, 7), t-value = -4.4, p-value = <0.001). For 2hr rating change, the mean standard deviation for the five factor scales (15mm) was significantly lower than the mean over all four traditional scales combined (26mm) (df(9, 7), t-value = -4.8, p-value = <0.001). For the area under the curve (AUC), the mean standard deviation for the five factor scales (35mm h) was significantly lower than the mean over all four traditional scales (59mm h) (df(9, 7), t-value = -4.9, p-value = <0.001).
Table 4.6: Standard deviations around the mean (N=30) for immediate rating change, 2hr rating change and area under the curve (AUC) for each factor rating and the traditional measure for oatmeal and oranges.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Immediate Rating Change (mm)</th>
<th>2hr Rating Change (mm)</th>
<th>AUC (mm h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>oatmeal</td>
<td>oranges</td>
<td>oatmeal</td>
</tr>
<tr>
<td>Mental Hunger Factor</td>
<td>18</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>13</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>29</td>
<td>31</td>
<td>16</td>
</tr>
<tr>
<td>Food Liking Factor*</td>
<td>22*</td>
<td>15*</td>
<td>7</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>19</td>
<td>24</td>
<td>17</td>
</tr>
<tr>
<td>Traditional amount</td>
<td>26</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>28</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>33</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>31</td>
<td>32</td>
<td>24</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0min after breakfast (T₂) and the area under the curve calculation is the area from 0min after breakfast (T₂) to 3hrs after breakfast (T₄).

**Effect Size Comparisons:** Based on the correlations of the factor scales to the traditional scales completed in experiment 1, traditional fullness and traditional amount scales were compared to the mental hunger factor scale and the traditional hunger and desire scales were compared to both the mental hunger factor scale and the physical hunger factor scale. The factor scales produced higher effect sizes for the difference between oranges and oatmeal than the traditional scales with the exception of the traditional fullness scale having a higher effect size for 2hr rating change (-0.73) than the effect size for the mental hunger factor scale at the 2hr rating change (0.67) (Table 4.7). Each of the mental hunger factor’s effect sizes for each rating measurement of immediate rating change, 2hr rating change or area under the curve, were greater than the effect sizes for the traditional scales of amount, desire, and hunger. The mental hunger factor’s effect sizes were significantly larger than the traditional fullness effect sizes for immediate rating change and area under the curve, while the traditional fullness scale had a higher effect size for the 2hr rating change.
Table 4.7: Effect size of the difference between oranges and oatmeal for each of the factor scales and traditional scales for immediate rating change, 2hr rating change and area under the curve (AUC). Positive effect sizes indicate that oatmeal produced a greater change while negative effect sizes indicate that oranges produced a greater change.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Immediate Rating Change</th>
<th>2hr Rating Change</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor Scales</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental hunger factor</td>
<td>0.43</td>
<td>0.67</td>
<td>-0.79</td>
</tr>
<tr>
<td>Physical hunger factor</td>
<td>0.20</td>
<td>0.14</td>
<td>-0.49</td>
</tr>
<tr>
<td>Mental fullness factor</td>
<td>-0.03</td>
<td>-0.52</td>
<td>0.40</td>
</tr>
<tr>
<td>Food liking factor</td>
<td>0.58*</td>
<td>-0.33</td>
<td>-0.59*</td>
</tr>
<tr>
<td>Physical fullness factor</td>
<td>0.05</td>
<td>-0.20</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Traditional scales</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional amount</td>
<td>0.30</td>
<td>0.39</td>
<td>-0.60</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>0.22</td>
<td>0.40</td>
<td>-0.72</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>0.18</td>
<td>-0.73</td>
<td>0.22</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>0.01</td>
<td>0.58</td>
<td>-0.63</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0min after breakfast (T2) and the area under the curve calculation is the area from 0min after breakfast (T2) to 3hrs after breakfast (T4).

Internal consistency reliabilities comparisons: All factor scales had high Cronbach’s α (above 0.76), indicating high internal consistency reliability (Table 4.8). The mental hunger factor had the highest Cronbach’s α at 0.95. The physical hunger factor, mental fullness factor, food liking factor and physical fullness factor had Cronbach’s α’s of 0.87, 0.91, 0.95 and 0.76 respectively.

Table 4.8: Raw and standardized (items standardized to have a standard deviation of 1.0) Cronbach’s α’s for the factors (Mental Hunger, Physical Hunger, Mental Fullness, Food Liking, Extreme Physical Fullness).

<table>
<thead>
<tr>
<th>Scale</th>
<th>Raw Cronbach’s α</th>
<th>Standardized Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Hunger Factor</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>0.87</td>
<td>0.90</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>Food Liking Factor</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>0.76</td>
<td>0.82</td>
</tr>
</tbody>
</table>
PART II: THE TESTING AND VALIDATION THE HUNGER AND FULLNESS QUESTIONNAIRE WITH SMOOTHIES DIFFERING IN LIKING

Overview
The objectives of experiment 3 were (1) to determine if the factor scales created in chapter 3 were more sensitive to differences in hunger and fullness produced by two smoothies differing in liking than the four traditional scales of hunger, fullness, desire, and amount and (2) to compare the hunger and satiety sensations produced by the two smoothies using the factor scales and traditional scales. I hypothesized that the smoothie with the greater liking factor score would produce greater mental fullness feelings and fewer mental hunger feelings than the smoothie that was less liked, yet would be equal in physical fullness/hunger feelings.

Methods
Participants
Thirty people were recruited by the same procedures as in Part I of Chapter 4. To my knowledge, none of the participants had taken part in the previous experiment in Part I of Chapter 4 or in the experiment in Chapter 3.

Foods
Participants came for two separate breakfast sessions, at least 1 week apart, and received a regular strawberry blueberry smoothie or spiced strawberry blueberry smoothie (Figure 4.7) (Appendix N). The two breakfast smoothies were identical in ingredients with the exception of added cumin to the spiced smoothie. Both smoothies were served in identical glasses and participants were required to drink the entire smoothie. Breakfast order was balanced among participants with half the participants receiving the regular smoothie at their first session and half receiving the spiced smoothie at their first session.
Participants were offered a tray of snacks when they returned for the follow-up session two hours after the breakfast session (Table 4.9) (Appendix N). Procedures for the snack presentations were the same as in experiment 2.

**Figure 4.7: Smoothie Recipe**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount per serving (grams)</th>
<th>Company Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountain High® Lowfat All Natural Plain Yoghurt</td>
<td>78</td>
<td>Mountain High, Englewood, CO</td>
</tr>
<tr>
<td>Kirkland Signature® Frozen Strawberries</td>
<td>156</td>
<td>Costoco Wholesale Corporation, Seattle, WA</td>
</tr>
<tr>
<td>Wymann’s of Maine® Fresh Frozen Wild Blueberries</td>
<td>59</td>
<td>Jasper Wyman and Son, Milbridge, Maine</td>
</tr>
<tr>
<td>Land’O Lakes® 1% Milk</td>
<td>101</td>
<td>Land’O Lakes, Arden Hills, MN</td>
</tr>
<tr>
<td>Sucrose solution (250g water and 435g Crystal® Sugar brought to boil for 1 min to dissolve)</td>
<td>36</td>
<td>Kandiyohi Premium Water, Minneapolis, MN United Sugar Corporation, Minneapolis, MN</td>
</tr>
<tr>
<td>McCormick® ground cumin*</td>
<td>0.75</td>
<td>McCormick &amp; Co, Inc., Hunt Valley, MD</td>
</tr>
</tbody>
</table>

Note: *only added to the spiced smoothie

**Table 4.9: Snack items and weight (g) served to participants at the snack session for the smoothie study.**

<table>
<thead>
<tr>
<th>Snack Item</th>
<th>Amount Served</th>
<th>Company Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium filtered water</td>
<td>290g</td>
<td>Kandiyohi Premium Water, Minneapolis, MN</td>
</tr>
<tr>
<td>Yoplait® original creamy smooth style strawberry yogurt</td>
<td>150g</td>
<td>Yoplait USA, Inc., Minneapolis, MN</td>
</tr>
<tr>
<td>Basha® premium hommus original</td>
<td>80g</td>
<td>Basha, Inkster, MI</td>
</tr>
<tr>
<td>Farmstand® baby carrots</td>
<td>110g</td>
<td>Supervalue Inc., Eden Prairie, MN</td>
</tr>
<tr>
<td>Red seedless grapes</td>
<td>170g</td>
<td>Purchased from the local Cub Foods, Supervalue Inc., Eden Prairie, MN</td>
</tr>
<tr>
<td>Triscuits® Original</td>
<td>6 crackers (26g)</td>
<td>Kraft Foods Global, Inc., Northfield, IL</td>
</tr>
<tr>
<td>Tillamook® sliced medium Cheddar cheese sliced</td>
<td>2 slices cut into quarters (42g)</td>
<td>Tillamook Country Creamery Association, Tillamook, OR</td>
</tr>
<tr>
<td>Citterio® hard salame</td>
<td>4 slices cut into quarters (28g)</td>
<td>Euro Foods Inc., Freeland, PA</td>
</tr>
<tr>
<td>Little Debby® Blueberry muffin</td>
<td>1 muffin (52g)</td>
<td>McKee Foods, Colledgade, TN</td>
</tr>
<tr>
<td>Thomas® plain bagels</td>
<td>½ bagel cut into 8 pieces (35g)</td>
<td>Orograin Bakeries Products, Inc. Horsham, PA</td>
</tr>
<tr>
<td>Rasras® cream cheese spread</td>
<td>1 container (28g)</td>
<td>Schreiber Foods Inc., Green Bay, WI</td>
</tr>
</tbody>
</table>
Breakfast session and follow-up session

The same procedure followed in Part I, the orange and oatmeal study, was followed for the smoothie study for both the breakfast and the follow-up session.

Data Analysis

Since the purpose of this study was to evaluate hunger and fullness between smoothies differing in liking, only participants who rated their liking (food liking factor) for the regular smoothie at least 7mm greater than the cumin smoothie were included for the data analysis (N = 18). Twelve participants’ data who either did not indicate a difference in liking greater than 7mm or who liked the cumin smoothie better were not analyzed.

The data analysis was conducted using SAS version 9.2 in the same manner as in Part I.

Results

Participant Characteristics

The 18 participants included in the data analysis, 4 males and 14 females, ranged in age from 18 to 49 years with a mean age of 27.2 years (Table 4.10). They had an average BMI of 23.2 kg/m² with a range of 18.9 to 29.1 kg/m². Four indicated they were currently working on losing weight, 2 were currently working on gaining weight, 6 were currently working on maintaining weight and 6 were not involved in any weight management effort. For the 3 eating restraint measurements that were made, scores for the Flexible Control portion of the Eating Inventory ranged from 1 to 11 with a mean of 5.4; scores for the Rigid Control portion of the Eating Inventory ranged from 0 to 13 with a mean of 5.9; scores for the Dutch Eating Restraint Scale ranged from 11 to 39 with a mean of 25.8.
**Table 4.10:** Participant characteristics means or counts for the smoothie study. Participants in the ‘reg-spiced’ group received the regular smoothie at their first session and the spiced smoothie at their second session. Those in the ‘Spiced-Reg’ group received the spiced smoothie first followed by the regular smoothie.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Reg-Spiced</th>
<th>Spiced-Reg</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects (count)</td>
<td>13</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Dutch restraint score (mean)</td>
<td>25.5</td>
<td>26.4</td>
<td>25.8</td>
</tr>
<tr>
<td>Eating Inventory Flexible Control Score (mean)</td>
<td>5.3</td>
<td>5.6</td>
<td>5.4</td>
</tr>
<tr>
<td>Eating Inventory Rigid Control Score (mean)</td>
<td>5.4</td>
<td>7.4</td>
<td>5.9</td>
</tr>
<tr>
<td>Dieting Status – working on losing weight (count)</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Dieting Status – working on gaining weight (count)</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Dieting Status – working on maintaining weight (count)</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Dieting Status – no weight management effort (count)</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Age (mean)</td>
<td>27.7</td>
<td>25.8</td>
<td>27.2</td>
</tr>
<tr>
<td>Gender (number of males)</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Body mass index kg/m² (mean)</td>
<td>23</td>
<td>23.7</td>
<td>23.2</td>
</tr>
</tbody>
</table>

**Check for baseline differences and sequence effect**

There were no significant differences for any of the factors or traditional satiety questions at baseline (T₁) ratings taken immediately before breakfast (0min) between session day 1 and session day 2. There was also no significant difference in sequence (refers to the order that the samples were presented) for any of the factor scales or traditional scales.

**Expected satiety**

When participants were asked to ‘rate how full you expect to be (looking at the food to make the judgment before eating)’, the regular smoothie had higher expected fullness ratings (51mm) than the spiced smoothie (42mm) (F-value = 4.3; p-value = 0.05).

**Comparison of the foods**

*Immediate rating change:* There were no significant food main effects. Participants who had the regular smoothie on day 1 did not have a change in mental fullness factor immediate rating change due to breakfast consumption (0mm) while those who had the spiced smoothie on day 1 had a decrease in mental fullness factor immediate rating change indicating that they were less mentally full (-16mm) (Table 4.11; Figure 4.8). On
session day 2, participants who had the regular smoothie had a decrease in mental fullness factor (-35mm) and those who had the spiced smoothie had very little change (-0.7mm) in mental fullness feelings (\(df(1, 28), F\text{-value}_{\text{food-by-day}} = 7.4, p\text{-value} = 0.01\)). As expected, the regular smoothie had a significantly higher liking factor rating at the T\(_2\) rating 0min after breakfast (91mm) than the spiced smoothie (71mm) (\(df(1, 28), F\text{-value} = 28.9, p\text{-value} =<0.0001\)).

Two hour rating change: Traditional desire increased significantly more for the spiced smoothie (42mm) than for the regular smoothie (28mm) over the 2hr study time after the breakfast (Table 4.11; Figure 4.9) (\(df(1,28), F\text{-value}=4.9, p\text{-value}=0.042\)). There were no other significant effects between the smoothies for the 2hr rating change.

Area under the curve: The regular smoothie had a larger mental fullness factor area under the curve (110mm h) than the spiced smoothie (89mm h) indicating that the regular smoothie provided more mental fullness feelings than the spiced smoothie (Table 4.11; Figure 4.8) (\(df(1, 28), F\text{-value} = 4.1, p\text{-value} = 0.059\)). The regular smoothie also had a significantly larger area under the curve rating (178mm h) than the oatmeal (138mm h) (\(df(1, 28), F\text{-value} = 33.8, p\text{-value} = <0.0001\)).

Day effects
There were no significant day effects for any of the factor scales or traditional scales.
**Table 4.11:** Mean (N=18) immediate rating change, 2hr rating change and area under the curve (AUC) for each factor scale and traditional scale for the regular smoothie (regular) and the spiced smoothie (spiced). Mean scores could range from 0-120mm for the food liking factor and 0-150mm for all other factors and traditional scales. Means within a row within a specific rating measurement type followed by a different letter were significantly different [df(1,28), α=0.06].

<table>
<thead>
<tr>
<th>Scale</th>
<th>Immediate Rating Change (mm)</th>
<th>2hr Rating Change (mm)</th>
<th>Area Under the Curve (mm h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>regular</td>
<td>spaced</td>
<td>F</td>
</tr>
<tr>
<td>Mental Hunger Factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-31</td>
<td>-31</td>
<td>0.8</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>-18</td>
<td>-17</td>
<td>0.1</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>-10</td>
<td>-5</td>
<td>1.0</td>
</tr>
<tr>
<td>Food Liking Factor*</td>
<td>91b*</td>
<td>71a*</td>
<td>28.9</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>6</td>
<td>7</td>
<td>0.7</td>
</tr>
<tr>
<td>Traditional amount</td>
<td>-40</td>
<td>-42</td>
<td>0.7</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>-39</td>
<td>-51</td>
<td>2.9</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>32</td>
<td>36</td>
<td>1.5</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>-47</td>
<td>-40</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0min after breakfast (T<sub>2</sub>) and the area under the curve calculation is the area from 0min after breakfast (T<sub>2</sub>) to 3hrs after breakfast (T<sub>4</sub>).
Figure 4.8: Plots of the mean (mm) (N=18) factor ratings (mental hunger factor, physical hunger factor, mental fullness factor, food liking factor and physical fullness factor) at each of the time points (baseline – before breakfast 0hr, immediately after breakfast 0.25hr, one hour after breakfast 1.25hr, and two hours after breakfast 2.25hr) for the regular and cumin spiced smoothie. Mean scores could range from 0-120mm for the food liking factor and 0-150mm for all other factors and traditional scales. Standard error bars represent plus and minus the standard error of the mean.
Figure 4.9: Plots of the mean (mm) (N=18) traditional ratings (traditional amount, traditional fullness, traditional hunger, traditional desire and traditional satisfaction) at each of the time points (baseline before breakfast 0hr, immediately after breakfast 0.25hr, one hour after breakfast 1.25hr, and two hours after breakfast 2.25hr) for the regular and cumin spiced smoothie. Mean scores could range from 0-120mm for the food liking factor and 0-150mm for all other factors and traditional scales. Standard error bars represent plus and minus the standard error of the mean.
Analysis of the amount of calories consumed at the follow-up snack session

There was no significant difference between the amount of calories consumed after the regular (760 kcal) versus the spiced smoothie (843 kcal; df(1, 28), F-value = 1.6, p-value = 0.23). There was also no significant difference in the amount of calories consumed on session day 1 (763 kcal) versus session day 2 (841 kcal; df(1, 28), F-value = 1.1, p-value = 0.31).

The ability of the scales to predict snack calorie consumption

For immediate rating change, none of the scales, factor or traditional, significantly predicted calorie intake at the ad libitum snack (Table 4.12). For 2hr rating change, a larger increase in mental hunger factor score and physical hunger factor score were significantly associated with greater calorie intake at the ad libitum snack (Table 4.12, Figure 4.9). For area under the curve, higher mental hunger factor, physical hunger factor, traditional amount, traditional desire and traditional hunger scores were associated with higher calorie intake at the ad libitum snack.
Table 4.12: Smoothie Study β, F and p-values from the model with calories as the response and immediate rating change, 2hr rating change or area under the curve as the predictor. β represents the increase/decrease in calories consumed for every 1 point increase in scale rating. Scores could range from 0-120mm for the food liking factor and 0-150mm for all other factors and traditional scales. Each factor scale and traditional scale was analyzed separately. P-values marked with an asterisk were significant [df(1, 28), α=0.05].

<table>
<thead>
<tr>
<th>Scale</th>
<th>Immediate Rating Change</th>
<th>2hr Rating Change</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>F value</td>
<td>P value</td>
</tr>
<tr>
<td>Factor Scales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental Hunger Factor</td>
<td>2.4</td>
<td>1.3</td>
<td>0.262</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>1.3</td>
<td>0.3</td>
<td>0.586</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>-1.1</td>
<td>0.8</td>
<td>0.382</td>
</tr>
<tr>
<td>Food Liking Factora</td>
<td>-0.1</td>
<td>0.0*</td>
<td>0.971*</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>-3.9</td>
<td>0.89</td>
<td>0.355</td>
</tr>
<tr>
<td>Traditional scales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional amount</td>
<td>0.3</td>
<td>0.1</td>
<td>0.787</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>0.9</td>
<td>0.7</td>
<td>0.407</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>-1.7</td>
<td>0.7</td>
<td>0.419</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>1.2</td>
<td>1.4</td>
<td>0.246</td>
</tr>
</tbody>
</table>

*aThe food liking factor immediate rating change is the rating at 0min after breakfast (Tₐ) and the area under the curve calculation is the area from 0min after breakfast (T₂) to 3hrs after breakfast (T₄).
Figure 4.10: Plots of the calories consumed at ad libitum snack for both regular and spiced smoothie for each participant (N=18) versus the score for the immediate rating change, 2hr rating change or area under the curve for the scales that were significantly associated with calorie intake in the mixed model with calories as the response and immediate rating change, 2hr rating change or area under the curve as the predictor (Table 4.12). The linear association is shown as a trend line in the plots.
Comparison of the sensitivity of the factor scales to the traditional scales

Scale Distribution Comparisons: Overall, the factor scales generally showed less variability than the traditional scales (Table 4.13). For immediate rating change, the average standard deviation for the five factor scales and two foods was significantly lower (16mm) than the average over all four traditional scales (29mm) (df( 9, 7), t-value = -4.1, p-value <0.001). For 2hr rating change, the average standard deviation for the five factor scales was significantly lower (12mm) than the average over all four traditional scales (22mm) (df(9, 7), t-value = -5.7, p-value < 0.001). For the area under the curve (AUC), the average standard deviation for the five factor scales was significantly lower (31mm h) than the average over all four traditional scales (56mm h) (df(9, 7), t-value = -4.0, p-value = 0.001).

Table 4.13: Standard deviations around the mean (N=18) for immediate rating change, 2hr rating change and area under the curve (AUC) for each factor rating and the traditional measure for regular and less-liked cumin spiced smoothie.

<table>
<thead>
<tr>
<th>Scale</th>
<th>85</th>
<th>85</th>
<th>85</th>
<th>85</th>
<th>85</th>
<th>85</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Factor Scales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental Hunger Factor</td>
<td>15.9</td>
<td>18.7</td>
<td>15.4</td>
<td>14.8</td>
<td>44.5</td>
<td>56.0</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>16.5</td>
<td>12.6</td>
<td>15.4</td>
<td>13.0</td>
<td>22.7</td>
<td>23.4</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>26.0</td>
<td>27.3</td>
<td>21.3</td>
<td>11.7</td>
<td>52.1</td>
<td>37.6</td>
</tr>
<tr>
<td>Food Liking Factor*</td>
<td>9.0</td>
<td>15.0</td>
<td>5.9</td>
<td>4.3</td>
<td>18.3</td>
<td>29.1</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>11.1</td>
<td>8.2</td>
<td>13.6</td>
<td>7.5</td>
<td>17.5</td>
<td>9.4</td>
</tr>
<tr>
<td>Traditional scales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional amount</td>
<td>22.3</td>
<td>33.3</td>
<td>25.2</td>
<td>23.9</td>
<td>70.5</td>
<td>75.7</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>29.8</td>
<td>31.0</td>
<td>30.2</td>
<td>21.5</td>
<td>65.0</td>
<td>71.6</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>25.6</td>
<td>18.3</td>
<td>26.9</td>
<td>19.5</td>
<td>40.4</td>
<td>35.9</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>35.5</td>
<td>28.9</td>
<td>21.9</td>
<td>25.5</td>
<td>56.1</td>
<td>63.8</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0min after breakfast (T2) and the area under the curve calculation is the area from 0min after breakfast (T2) to 3hrs after breakfast (T4).
**Effect Size comparisons**: The food liking factor scale had the highest effect size for indicating the difference between the regular and spiced smoothie for the T2 time-point taken immediately after breakfast (1.5) and for the area under the curve rating (1.5) (Table 4.14). Traditional desire had the highest effect size for the 2 hour rating change (0.74) and was second highest for the immediate rating change (0.57). The mental fullness factor had a moderate effect size of 0.37 and 0.43 for the immediate rating change and area under the curve rating, respectively. All other effect sizes were moderate to low.

**Table 4.14**: Effect size of the difference between the regular and spiced smoothie for each of the factor scales and traditional scales for immediate rating change, 2hr rating change and area under the curve (AUC). Positive effect sizes indicate that the regular smoothie produced a greater change while negative effect sizes indicate that the spiced smoothie produced a greater change.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Immediate Rating Change</th>
<th>2hr Rating Change</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor Scales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental Hunger Factor</td>
<td>-0.29</td>
<td>0.09</td>
<td>-0.10</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>-0.11</td>
<td>0.00</td>
<td>0.03</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>0.37</td>
<td>-0.07</td>
<td>0.43</td>
</tr>
<tr>
<td>Food Liking Factor*</td>
<td>1.49*</td>
<td>0.34</td>
<td>1.50*</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>0.23</td>
<td>-0.39</td>
<td>0.26</td>
</tr>
<tr>
<td>Traditional scales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional amount</td>
<td>-0.31</td>
<td>0.22</td>
<td>-0.09</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>-0.57</td>
<td>0.74</td>
<td>-0.18</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>0.27</td>
<td>-0.10</td>
<td>0.20</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>-0.01</td>
<td>0.04</td>
<td>-0.07</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0min after breakfast (T2) and the area under the curve calculation is the area from 0min after breakfast (T2) to 3hrs after breakfast (T4).

**Internal consistency reliabilities comparisons**: Most of the factor scales had high Cronbach’s α’s (above 0.85), indicating high internal consistency reliability (Table 4.15). The mental hunger factor had the highest Cronbach’s α at 0.96, indicating the highest internal consistency reliability. The physical hunger factor, mental fullness factor, food
liking factor and physical fullness factor had Cronbach’s α’s of 0.87, 0.96, 0.85, and 0.58 respectively.

Table 4.15: Raw and standardized (items standardized to have a standard deviation of 1.0) Cronbach’s α’s for the factors (Mental Hunger, Physical Hunger, Mental Fullness, Food Liking, Extreme Physical Fullness)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Raw Cronbach’s α</th>
<th>Standardized Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Hunger Factor</td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>0.87</td>
<td>0.90</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>Food Liking Factor</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>0.58</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Discussion

Discriminant validity, the ability of the factor scales to distinguish between foods with known differences in hunger and/or fullness feelings, was measured in this study by effect sizes and used to compare the factor scales to the traditional scales. The oranges and oatmeal had been chosen as test foods because I expected to see differences in the hunger and satiety feelings evoked. The overall higher effect sizes for the factor scales in the orange and oatmeal study indicated that the factor scales were more sensitive to detecting the differences between the hunger and fullness feelings between the oranges and the oatmeal than were the traditional scales. While not all of the factor scales came out with higher effect sizes than the traditional scales in experiment 3, the area under the curve effect size for the mental fullness factor scale was relatively larger than the traditional scales of hunger, fullness, desire and amount, thus distinguishing the cumin smoothie as the less mentally filling smoothie compared to the regular smoothie.

Criterion-related validity, evidence that there was a relationship between the hunger and fullness rating scales and some external criterion performance (Crocker & Algina, 2008), was shown by the relationship between the hunger and fullness rating scales and the amount eaten at the ad libitum snack. For both experiments 2 and 3, the mental hunger
factor was the best predictor of calorie intake at the *ad libitum* snack at all 3 rating measures because it predicted calorie intake at all instances with p-values of 0.1 or below.

Evidence of reliability of the factor scales, the consistency of a measuring instrument, was shown by internal consistency reliability. Cronbach’s α’s, a measure of internal consistency reliability to assess the consistency of the questions within each of the factors, were high (>0.7) for most of the factor scales in both experiments 1 and 2. Cronbach’s α of 0.7 or higher are widely agreed upon as a high level of internal consistency (Dmitrienko et al., 2007).

In the smoothie study, the balance between the smoothies’ order (having the spiced or regular smoothie first) became unbalanced when data for participants who did not like the regular smoothie at least 7mm higher than the spiced smoothie were removed from the data set. This left 8 more people in the group that received the regular smoothie first followed by spiced smoothie than in the group who received the spiced smoothie first followed by the regular smoothie. The significant food-by-day interaction for the immediate rating change for the mental fullness factor could have been influenced by the unbalance in presentation order since more participants received the regular smoothie on day 1 than day 2.

Hunger appears to predict calorie intake better than fullness in my studies. In the smoothie study, the mental hunger factor and physical hunger factor predicted calorie intake at the *ad libitum* snack. In the orange and oatmeal study the mental hunger factor predicted calorie intake the most consistently across rating measurements. Stubbs *et al.* (2000) found, in their review of the literature, that a hunger visual analogue scale correlated with energy intake but did not always reliably predict the energy intake. While I could not find an example of a paper that compared the ability to predict calorie intake with a hunger scale versus a fullness scale, I did find that de Castro and Elmore (1988)
reported significant correlations between ratings made on a bipolar hunger/fullness scale to the energy content at a subsequent meal. Mattes (1990) found that on weekdays hunger ratings were correlated to food intake ($r = 0.50$), while on weekends, the correlation between hunger and food intake was not significant. There were also no significant correlations observed for individual subjects. Eating often occurred when hunger ratings were low and few individuals exhibited a significant correlation between hunger ratings and number of eating occurrences. They concluded that hunger ratings were not a valid index of energy intake computed from food records or the number of eating occurrences. Hill and Blundell (1982) found that the correlation between pre meal hunger rating and the amount of food consumed varied from moderate to weak. They believed that this occurred because the ratings of hunger and satiety may be unsuccessful predictors of behavior because they require subjects to describe all of their experiences on a single continuum by selecting a single sensation that is assumed to correlate highly with that category of subjective experiences, to the exclusion of other sensations. The multi-sensation nature of the mental hunger and mental fullness, physical hunger and physical fullness factors may provide improved understanding of these discrepancies in the ability of these rating to predict eating.

The increased sensitivity to detect differences in mental and physical hunger feelings could be influencing the increased ability of the hunger related scales to predict calorie intake. While the sensitivity of a scale may or may not influence the predictive ability of the scale, hunger scales have been shown to be more sensitive to food manipulations than fullness scales. Merrill et al. (2002) found that a unipolar hunger scale had the greatest sensitivity in their study while a unipolar fullness scale had the least. This seemed to be the case in the orange and oatmeal study, with the mental hunger factor having the highest effect sizes, indicating the highest sensitivity, and the highest predictive association to the calorie intake at the ad libitum snack. However, in the smoothie study,
the mental fullness factor had higher effect sizes, thus higher sensitivity to detect the differences between the smoothies, yet did not have the highest calorie predictive ability.

Another explanation for the inability of a fullness scale to predict food intake could be due to the more elusive nature of fullness. From my focus group research, I found that participants had greater difficulty describing feelings of fullness than feelings of hunger (Murray & Vickers, 2009). Lists describing hunger sensations were larger than lists describing fullness sensations in the focus groups. This was also seen in the creation of the fullness scales in Chapter 3 with fewer items grouping into the mental fullness and physical fullness factors than in the mental hunger and physical hunger factors (Figure 3.5). This is in agreement with research by Monello and Mayer (1967) where 603 participants were asked to describe their hunger and fullness feelings. Participants described many diverse sensations of hunger yet only vague sensations of gastric bulk and feelings of satisfaction when describing fullness.

Use of the factor scales, which differentiate physical hunger and physical fullness from mental hunger and mental fullness, may help in understanding the influence of palatability on hunger and satiety feelings. The discrepancy in the influence of palatability on satiety seen in the literature could be due to a ‘dumping’ effect that occurred when participants did not have the scales to evaluate both their mental and physical hunger and fullness feelings. In the smoothie study, I found that while physical fullness and physical hunger factors did not differentiate the smoothies, the mental fullness factor did show that the spiced smoothie was significantly less mentally filling than the regular smoothie. Since participants were able to rate their mental fullness feelings such as contentedness and satisfaction with the food, they did not have to ‘dump’ those feelings into a single hunger or single fullness scale. My research is in agreement with research by Bobroff and Kissileff (1986) and Warwick et al. (1993) who found that participants had greater hunger scores after a less palatable meal than a meal with higher
palatability. However, Rogers (1992) and Hill et al. (1984) found the opposite with the less palatable meal being more filling than the higher palatable meal.

Although it would seem that asking 41 questions would be time consuming and burdensome to the study participants, based on the SIMS collection software participants took between 4 to 6 min to complete the 41 questions with the average around 4 min after the initial questionnaire.

**Conclusion**
The factor scales created in this research exhibited the same or greater validity than the traditional scales for detecting differences between the oranges and the oatmeal and between the two smoothies differing in liking. The factor scales showed discriminant validity and criterion related validity to levels equal to or superior to the traditional scales. The internal consistency reliability for the factor scales was high. A limitation of the traditional scales was that internal consistency reliability could not be measured due to the single-scale nature of the traditional scales. The factor scales offered an increased understanding of the hunger and satiety differences between the oranges and the oatmeal and the smoothies differing in liking by tapping in to both the physical and the mental aspects of hunger and satiety. The oranges were found to produce much more mental hunger and slightly more physical hunger than the oatmeal. The smoothies differing in liking were both equally physically filling yet the cumin smoothie provided less mental fullness feelings than the regular smoothie. The hunger and satiety factor scales created in this research will be a useful tool to provide enhanced sensitivity and understanding of the satiety produced by foods.
Chapter 5

SATIETY RESPONSE OF OLIGOFRUCTOSE, INULIN, SOLUBLE CORN FIBER AND RESISTANT STARCH IN NON-RESTRAINED NORMAL AND OVERWEIGHT WOMEN AND THE RELATIONSHIP TO FERMENTATION

In response to the interest in understanding satiety that added fibers provide, the present study was undertaken to evaluate the hunger and satiety of 10g of oligofructose, inulin, soluble corn fiber, and resistant wheat starch in chocolate crisp bars. A no added fiber bar was evaluated as the control. Twenty-two non-restrained women (BMI of 18-29) participated in this crossover design study. The night before each of five separate days, subjects consumed a dinner bar containing one of the fiber treatments. Twelve hours after consumption of the dinner bar, subjects reported to the lab to consume a breakfast fiber bar with the same fiber as the dinner bar. Satiety ratings were made using three satiety scale protocols: (1) Slavin scales of hunger, fullness, satisfaction and prospective consumption, (2) traditional scales of fullness, hunger, amount, and desire and (3) factor scales of mental hunger, physical hunger, mental fullness, physical fullness and food liking. Ratings were made at baseline before breakfast and at 0, 60, 120 and 180 min after breakfast. Food intake was measured at an ad libitum lunch served 180min after breakfast and subjects recorded food intake over the remainder of the 24hr study day. Breath hydrogen measurements were collected prior to breakfast (0min) and right before the lunch (180min). Gastrointestinal tolerance was evaluated at the end of the 24hr study day. While there were no significant differences in hunger or satiety found using the Slavin scales, traditional scales or factor scales among the fiber treatment bars during the three hour study duration, the factor scales exhibited the least amount of variability. This indicated that the factor scales had higher sensitivity to the differences between the bars than the Slavin or traditional scales. There was also no significant difference found in the ad libitum lunch or 24hr calorie consumption among the different fibers. The bar with
oligofructose produced the greatest amount of breath hydrogen, bloating and flatulence ratings, while the control bar produced the least.

**Forward:** The work presented in this chapter was the result of collaboration with Dr. Joanne Slavin and Master’s student Michelle Diedrick from the Department of Food Science and Nutrition at the University of Minnesota and Dr. Kathy Greaves from the Kellogg Company. The study had already been funded and initial planning had been completed before I took over the complete execution and data analysis of the study. Since the study had already been planned with the use of 4 visual analogue scales (VAS) that were commonly used in Slavin’s previous research (Hess et al., 2011; Willis et al., 2011), those 4 scales were kept in the study and evaluated at the time-points planned. In this dissertation, these 4 scales are called the Slavin scales. Flint et al. (2000) previously tested the same set of scales and found the scores to be reproducible. Since my objective was to evaluate my newly created hunger and fullness factor scales created in Chapter 3, these questions were added to the original protocol and are termed the factor scales. As in Chapter 4, I also compared the factor scales to traditional scales that represent 4 single scales, already embedded in my factor scales. I agreed to take on the running of this study because I hypothesized that the bars with added fiber would result in higher physical fullness feelings than the control bar, and thus allow me to evaluate the validity and reliability of the physical fullness scale of my factor scales.

Fiber bar treatments, lunch food choice, number of participants, participant recruitment criteria, GI tolerance methods, breath collection methods, and 24hr food log methods were already in place before I took over the study. I was responsible for the inclusion of my factor scales, the creation of the SIMS computer program to run the study, the recruitment of the participants and all study implementation, data collection, data analysis and reporting of findings.
Introduction
Researchers have suggested that intrinsic, hormonal, and colonic effects of dietary fiber decrease food intake by promoting satiety. It is thought that the fibers influence satiety by causing a decrease in gastric emptying and/or slowed energy and nutrient absorption. Dietary fiber may also influence fat oxidation, fat storage and hormonal levels. While fiber has been shown to play a role in satiety, not all fibers have been shown to be equally effective (Slavin & Green, 2007).

Howarth et al. (2001) summarized the effects of dietary fiber on hunger, satiety, energy intake, and body weight. Most studies with controlled energy intake reported an increase in post-meal satiety and a decrease in subsequent hunger with increased dietary fiber. With ad libitum energy intake, the average effect of increasing dietary fiber across all the studies indicated that an additional 14 g of fiber per day resulted in a 10% decrease in energy intake and a weight loss of over 1.9 kg through about 3.8 months of intervention. The effects of increasing dietary fiber were reported to be even more impressive in obese individuals. The results of increased dietary fiber from high-fiber foods or from fiber supplements on weight regulation were similar. Additionally, the beneficial effect of dietary fiber on weight regulation was seen for both soluble and insoluble dietary fiber. This group concluded that increasing the population mean dietary fiber intake from the current average of about 15 g/day to 25-30 g/day would be beneficial and may help reduce the prevalence of obesity.

Research on how different types of fiber affect appetite, energy and food intake has been inconsistent. Results differ according to the type of fiber and whether it is added as an isolated fiber supplement or naturally occurring in a food. Short-term studies that assess energy intake after subjects are fed fiber-containing meals suggest large amounts of total fiber are most successful for reducing subsequent energy intake. Additionally, higher viscosity fibers appear most successful in promoting satiety, while new, soluble fibers
appear to have minimal effects on satiety, even if consumed in very large doses. Longer-term studies that examine how both intrinsic and functional fibers impact satiety are required. Yet there is ample evidence to suggest that increasing consumption of high-fiber foods—especially viscous fibers—may decrease feelings of hunger by inducing satiation and satiety.

The purpose of this study was to determine and compare the hunger and satiety effects of 10 grams of oligofructose, inulin, soluble corn fiber, or resistant wheat starch, added to chocolate crisp bars given in the evening meal and at breakfast. A control chocolate crisp bar with no added fiber was also evaluated. Because of the varied findings from previous researchers about the satiety value of added fibers, I used three hunger and satiety questionnaire scales to evaluate the satiety of the chocolate crisp bars with and without the added fibers. The first, termed the factor scales, were created in Chapter 2 of this dissertation to measure mental hunger, physical hunger, mental fullness, physical fullness and food liking. The second, the traditional scales, were single-item scales of hunger, fullness, desire and prospective consumptions that were embedded in the factor scales. The traditional scales were analyzed separately to be compared to the factor scales. The third set of scales, termed the Slavin scales, consisted of four visual analogue scales (hunger, fullness, prospective consumption and fullness satisfaction) used by committee member Slavin in recent research (Hess et al., 2011; Willis et al., 2011). The objectives of the scale comparison portion of this study were to (1) determine if the factor scales were more sensitive to differences in hunger and fullness produced by the 4 treatment bars and control bar than the traditional scales or the Slavin scales, (2) compare the hunger and satiety sensations produced by the treatment and control bars using the factor scales, traditional scales and Slavin scales, (3) compare food intake at an ad libitum lunch offered 3 hours after breakfast bar consumption and over the 24 hours post study session between the 4 fibers and the control, and (4) compare gastrointestinal tolerance and breath hydrogen (indication of fermentation in the gut) between the 4 fibers and
control chocolate crisp bars. I hypothesized that the bars with added fiber would result in higher physical fullness sensations than the control bar and that the factor scales would result in more sensitive and reliable results than the traditional scales or the Slavin scales.

**Methods**

**Participants**

Twenty-two women between the ages of 18 and 40 years, who were nonsmoking, not taking weight loss medications, non-dieting (weight had not changed more than 5kg in either direction over three months), had a body mass index between 18 and 29 Kg/m$^2$, were not currently pregnant or lactating, were pre-menopausal with a regular/consistent menstrual cycle, had no food allergies, ate breakfast on most days of the week, liked granola bars, candy bars and pizza, were not taking any lipid-lowering or cholesterol-lowering medications, not taking any medications to lose weight or lower blood pressure, not taking any steroid medications for chronic inflammation, had not been diagnosed with any form of cancer within the last five years, had not been diagnosed with heart disease, kidney disease, liver disease, diabetes, Crohn’s disease, or any other gastrointestinal disease, had not taken antibiotics within the last 3 months or during the months of the study, had not participated in an intervention research study in the last year, had not had treatment for drug or alcohol abuse in the last 6 months, all ate less than 3 servings of fiber a day, all indicated they were in a good state of health and all spoke English as their first language. Participants were also non-restrained eaters (score less than 11) determined using cognitive restraint subscale of the Eating Inventory (Stunkard & Messick, 1985). The screening protocol used and the restraint questions asked are shown in Appendix O.

**Screening visit protocol**

Each participant attended a screening visit to verify her answers to the e-mail screener and restraint questionnaire (Appendix O). Each participant’s height and weight were measured to ensure her body mass index was between 18 and 29 Kg/m$^2$. 

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Foods
Participants received four treatment chocolate crisp bars with one of four added fibers
and a no added fiber control chocolate crisp bar on five separate days. Bars were
manufactured and provided to us by The Kellogg Company. For each session,
participants received an evening bar (144g) and a breakfast bar (83g), with the same fiber
treatment given in the evening and breakfast per session. All bars, within the breakfast
set and evening set, were identical in ingredients with the exception of the fiber type
(Table 5.1; Appendix P). Analysis of the nutrients of the bars was conducted by Kellogg
Company (Table 5.1). The control bar was a low fiber treatment with no added fiber.
The test bars contained one of the following: 10g of oligofructose (P95 low molecular
weight inulin, Beneo-Orafti, Tienen, Belgium), 10g of inulin (HPX high molecular
weight inulin, Beneo-Orafti, Tienen, Belgium), 10g of corn fiber (Promitor™ soluble
corn fiber, Tate & Lyle, Decatur, IL), or 10g of resistant wheat starch (Fibersym
crosslinked starch, MGP Ingredients, Inc. Atchison, KS). Participants were allowed to
drink as much or little water as they wanted with the dinner bar and throughout the
evening and night.

When participants arrived for the morning session, they were provided with their
breakfast test bar and 8oz of water, black tea (Earl Grey, R.C.Bigelow Inc., Fairfield,
CT), or coffee (Folgers Original, The Folgers Coffee Company, Orrville, OH) made
according to package directions. They were given the option to have sugar (Natural Cane
Turbinado Sugar, Sugar In the Raw, Brooklyn, NY) and/or creamer (French Vanilla
International Delight, WhiteWave Foods, Broomfield, CO) with the black tea and coffee.
Participants were given the same drink (including the same amount of sugar and/or
creamer) for each of their five sessions.
Table 5.1: Treatment ID, fiber and nutrient descriptions for the chocolate crisp breakfast bars. Dinner bar content is shown in brackets following the breakfast bar content. Method for nutritional analysis is indicated by the superscripted numbers.

<table>
<thead>
<tr>
<th>ID</th>
<th>Fiber description</th>
<th>Energy (kcal)</th>
<th>Fiber content (g)</th>
<th>Carbohydrate$^5$ (g)</th>
<th>Sugar$^6$ (g)</th>
<th>Protein$^7$ (g)</th>
<th>Fat$^8$ (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Atchison, KS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inulin</td>
<td>HPX high molecular weight inulin (Beneo-Orafti, Tienen,</td>
<td>378 [719]</td>
<td>12.3 [13.3]$^{2,3}$</td>
<td>60.5 [75.0]</td>
<td>27.9 [47.4]</td>
<td>3.0 [27.3]</td>
<td>16.5 [37.3]</td>
</tr>
<tr>
<td></td>
<td>Belgium)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oligo</td>
<td>P95 low molecular weight inulin (Beneo-Orafti, Tienen,</td>
<td>383 [719]</td>
<td>10.6 [11.4]$^3$</td>
<td>60.4 [72.0]</td>
<td>26.9 [44.9]</td>
<td>3.0 [29.2]</td>
<td>16.7 [37.7]</td>
</tr>
<tr>
<td></td>
<td>Belgium)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>Promitor™ soluble corn fiber (Tate &amp; Lyle, Decatur, IL)</td>
<td>383 [718]</td>
<td>11.1 [12.0]$^4$</td>
<td>60.2 [73.6]</td>
<td>27.6 [47.9]</td>
<td>2.9 [28.4]</td>
<td>17.0 [37.2]</td>
</tr>
</tbody>
</table>

$^1$Fiber content for the Wheat and Control bar was determined following AOAC 991.43.
$^2$Fiber content (non-inulin fiber) for the Inulin bar was determined following modified AOAC 991.43 (with inulinase in assay).
$^3$Inulin in the Inulin bar and the Oligo bar was determined following AOAC 997.08.
$^4$Fiber content for the Corn bar was determined following AOAC 2001.03.
$^5$Carbohydrate content was determined following carbs = 100 – moisture – protein – lipid – ash. Moisture was determined following AOAC 934.06 and ash was determined following AOAC 923.03.
$^6$Sugar content (profiled by HPLC) was determined following AOAC 982.14.
$^7$Protein content was determined following AOAC 968.06.
$^8$Fat content was determined by acid hydrolysis following AOAC 922.06.
**Study Session**

Study visits were scheduled within the first 14 days of each participant’s monthly menstrual cycle and spaced at least one week apart, allowing a maximum of two visits per month. Presentation order of the bars was balanced over the twenty-two participants for position and carryover effects using a William’s Latin Square design (Appendix Q).

Twelve hours before coming for a study session, participants consumed the dinner bar. After consumption of the dinner bar they were required to fast from all food and drink except for water. During the 24hrs prior to the study, participants were also asked to consume a low-fiber diet (example of low and high fiber foods was provided to the participants; Appendix R). They were also asked to avoid alcohol and excessive exercise in the 24hrs prior to their visit.

On the morning of each study visit (12hrs after consumption of their dinner bar), participants arrived between the hours of 7am and 8:30am with a given participant attending at the same time for all five of her sessions. All questionnaires and instructions were given using SIMS 2000© (Sensory computer Systems, Morristown, NJ, USA).

Three sets of scales were evaluated in this study: (1) the factor scales created in Chapter 3 of this dissertation, (2) traditional scales of hunger, fullness, desire, and amount, and (3) Slavin visual analogue scales of hunger, fullness, prospective consumption and fullness satisfaction (Figure 5.1). To begin the study, participants were given instructions and shown examples of the three types of scales they would be using to make ratings (Figure 5.2; Appendix S). The majority of the questions in Figure 1 were presented on 150mm labeled magnitude scales (Green et al., 1996). The labeled magnitude scales were anchored with ‘none’ at 0mm, ‘barely detectable’ at 2mm, ‘weak’ at 9mm, ‘moderate’ at 26mm, ‘strong’ at 53mm, ‘very strong ‘at 80mm and ‘strongest imaginable’ at 150mm. Slight modifications in the end anchors were made to make sense with the questions (see superscripted numbers of Figure 5.1 for end anchor modifications). The first two
questions of the mental hunger factor were presented using a 150mm visual analog scale with ‘none’ at 0mm and ‘greatest possible amount’ at 150mm. The food liking factor questions were asked using a 120mm scale with anchors labeled ‘Greatest imaginable disliking’ at 0mm, ‘dislike extremely’ at 13mm, ‘dislike very much’ at 25mm, ‘dislike moderately’ 40mm, ‘dislike slightly’ at 53mm, ‘neutral’ at 60mm, ‘like slightly’ at 67mm, ‘like moderately’ at 81mm, ‘like very much’ at 93mm, ‘like extremely’ at 104mm, and ‘greatest imaginable liking’ at 120mm. The Slavin questions were presented using a 150mm visual analog scale (see superscripted numbers of Figure 5.1 for end anchor modifications). After receiving instructions on how to make ratings on the scales, the participants completed the before breakfast questionnaire (0min, Figure 5.1; Appendix S) and were told to “remember to please base your ratings on your feelings right now.” Once they finished the first questionnaire, they were served a breakfast, one of the five breakfast bars with the same fiber treatment as the bar they had for dinner the night before and their choice of beverage (water, tea or coffee). For a given participant, the beverage remained the same for all five visits. They were instructed “after being served your breakfast, but before beginning to consume your breakfast, please answer the following question.” This question was ‘Rate how full you expect to be (Please look at the breakfast to determine your answer)”. They were then instructed to “please take the next 10 minutes to consume the entire breakfast that you have been served. Try to pace your meal to fill the 10 minutes.”

The Slavin visual analogue scales were asked before breakfast (0min), 15 min after breakfast (25min), 30 min after breakfast (40min), 45 min after breakfast (55min), 1 hour after breakfast (70min), 1.5 hours after breakfast (100min), 2 hours after breakfast (130min) and 3 hours after breakfast (140min). The factor scales and traditional scales were asked before breakfast (0min), immediately after breakfast (10min), 1 hour after breakfast (70min), 2 hours after breakfast (130min), and 3 hours after breakfast (190min).
**Figure 5.1:** Slavin scales, factor scales and traditional scales evaluated in the fiber study (Appendix S for full questionnaire with scales). All ratings were made on the general labeled magnitude scale ranging from ‘none’ to ‘strongest imaginable’ unless otherwise noted by the superscripted number. Traditional scales are shown by a superscripted letter following the question. Factor and traditional scales were evaluated right before breakfast, after breakfast at 0, 60, 120, 180min, and after lunch. Slavin scales were evaluated before breakfast, after breakfast at 15, 30, 45, 60, 90, 120, and 180min, and after lunch.

<table>
<thead>
<tr>
<th>Mental hunger factor</th>
<th>Physical hunger factor</th>
<th>Mental fullness factor</th>
<th>Physical fullness factor</th>
<th>Food liking factor</th>
<th>Slavin scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rate the amount of food you currently desire\textsuperscript{1,a}</td>
<td>1. Rate the extent to which your stomach currently aches\textsuperscript{3}</td>
<td>1. Rate your contentedness with the food you last ate</td>
<td>1. Rate the extent to which your stomach currently feels bloated</td>
<td>1. How hungry do you feel?\textsuperscript{5}</td>
<td>1. How much do you think you can eat?\textsuperscript{8}</td>
</tr>
<tr>
<td>2. Rate the current amount of food you could eat\textsuperscript{1,b}</td>
<td>2. Rate the extent to which you currently feel stomach pain\textsuperscript{3}</td>
<td>2. Rate your feeling of fullness from the food you last ate\textsuperscript{2}</td>
<td>2. Rate the extent to which your stomach feels like it is currently bursting\textsuperscript{3}</td>
<td>2. How satisfied do you feel?\textsuperscript{6}</td>
<td>2. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>3. Rate your current desire to eat any food</td>
<td>3. Rate your current feeling of fullness\textsuperscript{2,d}</td>
<td>3. Rate your appetite satisfaction from the food you last ate</td>
<td>3. Rate the extent to which your stomach currently feels stuffed\textsuperscript{3}</td>
<td>3. How full do you feel?\textsuperscript{7}</td>
<td>3. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>4. Rate your current desire to eat your next meal\textsuperscript{2}</td>
<td>4. Rate your current feeling of hunger\textsuperscript{2,d}</td>
<td>4. Rate your satisfaction with the food you last ate</td>
<td>4. Rate your liking of the flavor of the food you last ate\textsuperscript{4}</td>
<td>4. How much do you think you can eat?\textsuperscript{8}</td>
<td>4. How much do you think you can eat?\textsuperscript{8}</td>
</tr>
<tr>
<td>5. Rate your current desire to eat something fatty</td>
<td>5. Rate your current motivation to eat</td>
<td>5. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>5. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>5. How full do you feel?\textsuperscript{7}</td>
<td>5. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>6. Rate your current desire to eat something salty</td>
<td>6. Rate the extent to which you are currently thinking of food\textsuperscript{3}</td>
<td>6. Rate your feeling that the meal or snack was a sufficient size</td>
<td>6. Rate your liking of the odor of the food you last ate\textsuperscript{4}</td>
<td>6. How full do you feel?\textsuperscript{7}</td>
<td>6. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>7. Rate your current desire to eat something savory</td>
<td>7. Rate your current urge to eat\textsuperscript{2}</td>
<td>7. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>7. Rate your liking of the flavor of the food you last ate\textsuperscript{4}</td>
<td>7. How full do you feel?\textsuperscript{7}</td>
<td>7. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>8. Rate your current desire to eat something sweet</td>
<td>8. Rate your current willingness to eat</td>
<td>8. Rate your liking of the odor of the food you last ate\textsuperscript{4}</td>
<td>8. Rate your liking of the odor of the food you last ate\textsuperscript{4}</td>
<td>8. How much do you think you can eat?\textsuperscript{8}</td>
<td>8. How much do you think you can eat?\textsuperscript{8}</td>
</tr>
<tr>
<td>9. Rate your current desire to eat your favorite food</td>
<td>9. Rate your desire for more of the food you last ate</td>
<td>9. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>9. Rate your liking of the flavor of the food you last ate\textsuperscript{4}</td>
<td>9. How full do you feel?\textsuperscript{7}</td>
<td>9. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>10. Rate your current desire to eat a snack</td>
<td>10. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>10. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>10. Rate your liking of the flavor of the food you last ate\textsuperscript{4}</td>
<td>10. How full do you feel?\textsuperscript{7}</td>
<td>10. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>11. Rate your current appetite</td>
<td>11. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>11. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>11. Rate your liking of the flavor of the food you last ate\textsuperscript{4}</td>
<td>11. How full do you feel?\textsuperscript{7}</td>
<td>11. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>12. Rate your current appetite for a meal</td>
<td>12. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>12. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>12. Rate your liking of the flavor of the food you last ate\textsuperscript{4}</td>
<td>12. How full do you feel?\textsuperscript{7}</td>
<td>12. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>13. Rate your current feeling of fullness\textsuperscript{2,a}</td>
<td>13. Rate your current desire to eat a snack</td>
<td>13. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>13. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>13. How full do you feel?\textsuperscript{7}</td>
<td>13. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>14. Rate your current feeling of hunger\textsuperscript{2,b}</td>
<td>14. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>14. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>14. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>14. How full do you feel?\textsuperscript{7}</td>
<td>14. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>15. Rate your current motivation to eat</td>
<td>15. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>15. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>15. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>15. How full do you feel?\textsuperscript{7}</td>
<td>15. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>16. Rate the extent to which you are currently thinking of food\textsuperscript{3}</td>
<td>16. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>16. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>16. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>16. How full do you feel?\textsuperscript{7}</td>
<td>16. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>17. Rate your current urge to eat\textsuperscript{2}</td>
<td>17. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>17. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>17. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>17. How full do you feel?\textsuperscript{7}</td>
<td>17. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>18. Rate your current willingness to eat</td>
<td>18. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>18. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>18. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>18. How full do you feel?\textsuperscript{7}</td>
<td>18. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>19. Rate your desire for more of the food you last ate</td>
<td>19. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>19. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>19. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>19. How full do you feel?\textsuperscript{7}</td>
<td>19. How full do you feel?\textsuperscript{7}</td>
</tr>
<tr>
<td>20. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>20. Rate your current desire for a different food than you last ate\textsuperscript{1}</td>
<td>20. Rate your satisfaction with your feeling of fullness from the food you last ate</td>
<td>20. Rate your liking of the texture of the food you last ate\textsuperscript{4}</td>
<td>20. How full do you feel?\textsuperscript{7}</td>
<td>20. How full do you feel?\textsuperscript{7}</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Rating made on a scale that ranged from ‘none’ to ‘greatest possible amount’
\textsuperscript{2}Rating made on a scale that ranged from ‘no sensation’ to ‘strongest imaginable’
\textsuperscript{3}Rating made on a scale that ranged from ‘not at all’ to ‘strongest imaginable’
\textsuperscript{4}Ratings made on a scale that ranged from ‘Greatest imaginable disliking’ to ‘Greatest imaginable liking’
\textsuperscript{5}Ratings made on a scale that ranged from ‘I am not hungry at all’ to ‘I have never been more hungry’
\textsuperscript{6}Ratings made on a scale that ranged from ‘I am completely empty’ to ‘I cannot eat another bite’
\textsuperscript{7}Ratings made on a scale that ranged from ‘not at all’ to ‘totally full’
\textsuperscript{8}Ratings made on a scale that ranged from ‘Nothing at all’ to ‘A lot’

\textsuperscript{9}Traditional desire scale
\textsuperscript{10}Traditional amount scale (prospective consumption)
\textsuperscript{11}Traditional fullness scale
\textsuperscript{12}Traditional hunger scale
Figure 5.2: An example of the four types of scales used in the fiber study. The full questionnaire can be found in Appendix S.

<table>
<thead>
<tr>
<th>Scale Type 1:</th>
<th>Used for the Slavin questions 1-4 in Figure 5.1. (Modification in end anchors were made to match the question asked)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale Type 2:</td>
<td>Used for the food liking factor questions 5-9 in Figure 5.1</td>
</tr>
<tr>
<td>Scale Type 3:</td>
<td>Used for the factor questions 10-43 in Figure 5.1 (Modification in end anchors were made to match the question asked)</td>
</tr>
<tr>
<td>Scale Type 4:</td>
<td>Used for the factor questions 44-45 in Figure 5.1</td>
</tr>
</tbody>
</table>

After the 3hr hunger and fullness questionnaire, the study participants were served 3 pieces of pepperoni French bread pizza (Stouffer’s, Nestlé USA Inc., Solon, OH) that were each cut into thirds (Appendix T). The frozen pizza was cooked at 350°F for 26 minutes just prior to serving. The pizza lunch was served with 380ml of water. Pizza and water were covertly weighed before and after consumption. A final hunger and fullness questionnaire was completed immediately after lunch (Figure 5.1).
**Breath hydrogen measurement**

Two breath samples were collected at each visit. A breath sample was collected immediately before breakfast (0min) and immediately before lunch (180min) using the Quintron GaSampler™ System (Quintron Instruments, Milwaukee, WI; Appendix U). Samples were analyzed for hydrogen and methane content in duplicate.

**Twenty-four-hour Food Record**

Participants were asked to record a detailed list of all food and beverage consumed for the 24 hours following each of their visits. They were provided with instructions and portion guidelines to aid in their food intake estimation (Appendix V). The time of consumption, food and beverage description, preparation method and amount eaten were recorded.

**Gastrointestinal Tolerance Questionnaire**

At the end of the 24 hours after the study, participants were asked to rate their stool frequency by indicating the number of stools in the last 24 hours, their stool consistency on a 100mm scale ranging from ‘diarrhea’ to ‘hard stool/constipation’, their degree of intestinal bloating on a 100mm scale ranging from ‘minimal’ to ‘excessive’ and their degree of flatulence on a 100mm scale ranging from ‘minimal’ to ‘excessive’ (Appendix W).

**Data Analysis**

The data analysis was conducted using SAS version 9.2. Factor scores for each subject, each fiber type and each time point were calculated by averaging the rating from each question in a given scale for each participant at each time point (the inverse of the fullness rating was used in the mental hunger factor score calculation since fullness was negatively associated with the other questions in the factor).
the Slavin scales were analyzed as individual questions by using the rating for each of the scales for each participant at each time point for each fiber type.

**Expected Satiety**
A repeated measures mixed model analysis of variance procedure was run to determine if the expected satiety differed among the fiber types. A Kenwardroger correction was used for the calculation of the degrees of freedom, and judge was set as a random intercept. The expected satiety rating was the response, and fiber type, day and a fiber type by day interaction were predictors. The fiber type-by-day interaction was removed from the final model since it was not significant ($\alpha = 0.05$).

**Investigation of the factor scales, traditional scales and Slavin scales**
Each of the factor scales, traditional scales and Slavin scales was evaluated using three rating measurements to compare the 4 treatments and the control (Figure 5.3). The first rating measurement, the immediate change due to breakfast consumption, was used to compare immediate hunger and fullness change due to breakfast consumption. This immediate change was calculated by subtracting the rating made immediately before breakfast ($T_1$) from the rating made immediately after breakfast ($T_2$). The immediate rating change was not computed for the liking factor. Instead, the liking factor rating made immediately after breakfast ($T_2$) was used to measure the effect of eating the breakfast on liking. The second rating measurement, the change in rating over the 3 hour session time after breakfast, was calculated by subtracting the rating made right after breakfast ($T_2$) from the rating made 3 hours after breakfast ($T_3$). The third rating measurement, the area under the curve starting from the before breakfast rating ($T_1$) to the 3 hours after breakfast rating ($T_3$), was calculated to assess the overall effect from the breakfast over the entire session. The AUC for the liking factor only included area from the immediately after breakfast rating ($T_2$) to the 3 hours after breakfast rating ($T_3$). SAS
version 9.2 was used to calculate the area under the curve (AUC) using the trapezoidal rule.

**Figure 5.3:** Hypothetical curve showing scale rating change over time. Breakfast was consumed between time 1 (T₁) and time 2 (T₂). The scale ratings were made right before breakfast (T₁), right after breakfast (T₂), 1 hour after breakfast (T₃), 2 hours after breakfast (T₄), and 3 hours after breakfast (T₅). The rating curve was evaluated in three ways: (1) immediate rating change due to breakfast consumption (rating at T₂ – rating at T₁) (the food liking factor immediate rating change was the rating at T₂), (2) change in rating over the 2 hours after breakfast (rating at T₅ – rating at T₂), and (3) the overall session rating [shown as the area under the curve (AUC) from T₁ to T₅ (the food liking factor AUC calculation was the area from T₂ to T₅)].

Repeated measures mixed model analysis of variance procedures, with the Kenwardroger correction and judge set as a random intercept, were used to determine if the ratings on each of the factor scales, and each of the traditional scales, and Slavin scales differed among the bars (4 fiber bars and control bar). Separate mixed procedures were run for each of the three rating measurements (immediate rating change, 2hr rating change or area under the curve) and for each of the factor scales, traditional scales and Slavin scales. The value for a particular rating measurement was set as the response, and food and day were the predictors. A food-by-day interaction and a carryover term (previous sample) were also set as additional predictors in two other separate models with food and
day. Since none of the food-by-day interactions or carryover terms were significant ($\alpha=0.05$), the interaction and carryover term were removed from the final models.

Example SAS code for carryover check:

```sas
proc sort data = auc0;
by judge day;
run;

data auc;
set auc0;
by judge day;
carryover = lag(food);
if (day=1) then carryover=-1;

proc print data=auc (obs=10);
run; quit;

proc mixed data=auc;
class judge food day carryover;
model fac1_AUC = food day carryover;
random intercept / subject = judge v vcorr;
lsmeans food day /pdiff;
ods select tests3;
run;
```

Example SAS code for food by day interaction check:

```sas
proc mixed data=auc;
class judge food day carryover;
model fac1_AUC = food day food*day/ ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans food day /pdiff;
ods select tests3;
run;
```

Example final SAS code:

```sas
proc mixed data=auc;
class judge food day carryover;
model fac1_AUC = food day / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans food day /pdiff;
ods select tests3;
run;
```
Analysis of the amount of calories consumed at the follow-up snack session and over the 24hr post study period

A repeated measures mixed analysis of variance procedure, with the Kenwardroger correction and judge set as a random intercept, was used to determine if there was a significant difference in the amount of lunch calories consumed at the *ad libitum* lunch session among the fiber bars or over the five session days. Calories consumed were set as the response, and food, day, and a food-by-day interaction were set as the predictors. Again, the food-by-day interaction was removed from the final model since it was not significant ($\alpha = 0.05$). Another similar mixed analysis of variance procedure was used to determine if the total number of calories consumed over the 24hr period after the test session differed among the five treatments or the five session days. The total calories consumed over the 24 hour period were determined using the University of Minnesota’s Nutrition Data System for Research Program (NDSR) (Nutrition Coordinating Center, 2007).

SAS code for the pizza lunch calorie intake:

```sas
proc mixed data = pizza;
class session treatment judge;
model calories = session treatment / ddfm=kenwardroger;
random intercept / subject = judge v_corr;
lsmeans treatment/pdiff;
ods select tests3 lsmeans diffs;
run;
```

SAS code for the 24 hour calorie intake:

```sas
proc mixed data = twentyfour;
class session treatment judge;
model calories = session treatment / ddfm=kenwardroger;
random intercept / subject = judge v_corr;
lsmeans treatment/pdiff;
ods select tests3 lsmeans diffs;
run;
```
Comparison of the sensitivity of the factor scales, traditional scales and Slavin scales
To determine the relative performance of the factor scales, traditional scales and the Slavin scales, distributions around each factor scale, traditional scale and Slavin scale mean were compared, and internal consistency (Cronbach’s α) was investigated as described below. Sensitivity of the scales is the ability of the scales to discriminate among food samples. A scale rating with smaller variability would be more sensitive for determining differences between the food samples.

Scale Distribution Comparisons: To compare the distribution of scores for each factor scale, traditional scale and Slavin scale, standard deviations around the means over all fiber bars for each scale for immediate rating change (exception: T2 rating for the food liking factor was used instead of an immediate rating change), 2hr rating change, and area under the curve were investigated. Each factor scale was renamed to ‘factor’, each of the traditional scales to ‘traditional’, and each of the Slavin scales to ‘Slavin’ so they would be evaluated as separate groups before the t-test was completed. The data file contained a column for the scale (factor, traditional or basic), a column for rating method (immediate, 3hr, or AUC) and a column for the standard deviation. Differences in the size of the standard deviations between the factor scales, the traditional scales, and the Slavin scales over the five fiber bars were tested using a pooled t-test procedure for each rating measurement (immediate rating change, 2hr rating change and area under the curve) separately.

SAS code for scale distribution comparisons:

```
proc sort data = sd;
by rating_measurement;
run;

proc mixed data = sd;
title 'fiber study standard deviation difference investigation';
class scale;
by rating_measurement;
```
model standard_deviation = scale / ddfm=kenwardroger;
lsmeans scale/pdiff;
ods select tests3 lsmeans diffs;
run;

(T-values and p-values were taken from the differences of least squares means to determine how the 3 scales differed.)

Internal consistency reliabilities comparisons: The internal consistency of the factor scales, a measure of the degree to which each item of a rating scale measured the same construct, was calculated using Cronbach’s α, a measure of the average correlation of items within a scale (Cronbach, 1951; Dmitrienko et al., 2007). Cronbach’s α was computed using the proc corr procedure in SAS version 9.2.

Breath Hydrogen and Methane

A repeated measures mixed analysis of variance model (proc mixed in SAS version 9.2) was run to determine if there were significant differences in breath hydrogen or methane, among the fiber bars, at the two measurement times of before breakfast and 3hrs after breakfast. The two measurement replicates were averaged before analysis. When there were significant differences, differences of least squares mean output was examined to determine which of the fiber bars differed significantly.

SAS code for hydrogen and methane:

```sas
proc sort data = breath;
by time;
run;

proc mixed data = breath;
title 'Breath Hydrogen';
by time;
class session treatment judge;
model H2 = session treatment / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans treatment/diff;
ods select tests3 lsmeans diffs;
run;
```
**Gastrointestinal Tolerance**

A repeated measures mixed analysis of variance model (proc mixed in SAS version 9.2) was run to determine if there were significant differences in stool frequency, stool consistency, bloating or flatulence among the test bars. When there were significant differences, differences of least squares mean output was examined to determine which of the test bars differed significantly.

**SAS code for gastrointestinal tolerance**

```
proc mixed data = gi;
title 'stool_frequency';
class judge session treatment;
model stool_frequency = judge treatment session / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans treatment/pdiff;
ods select tests3 lsmeans diffs;
run;

proc mixed data = gi;
title 'stool consistency';
class judge session treatment;
model consistency = judge treatment session / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans treatment/pdiff;
ods select tests3 lsmeans diffs;
run;

proc mixed data = gi;
title 'bloating';
class judge session treatment;
model bloating = judge treatment session / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans treatment/pdiff;
```
ods select tests3 lsmeans diffs;
run;

proc mixed data = gi;
title 'flatulence';
class judge session treatment;
model flatulence = judge treatment session / ddfm=kenwardroger;
random intercept / subject = judge v vcorr;
lsmeans treatment/pdiff;
ods select tests3 lsmeans diffs;
run;

Results

Participant characteristics

The 22 female participants ranged in age from 18-38 years of age with a mean age of 25 years. They had an average body mass index of 23.7 with a range of 18.3 to 29. They had an average eating restraint score of 5.7 with a range of 0-9.

Expected Satiety

When participants were asked ‘rate how full you expect to be (looking at the food to make the judgment before eating), there was no significant difference between the 5 bars (df(4, 80), F-value = 0.3; p-value = 0.89).

Comparison of the fiber bars

There were no significant differences found for any of the factor scales, traditional scales or Slavin scales for immediate rating change, 3hr rating change or area under the curve (Figures 5.4-5.6; Tables 5.2-5.4). There were also no significant main effects for day (data not shown).
Figure 5.4: Plots of the mean (mm) (N = 22) factor ratings (mental hunger factor, physical hunger factor, mental fullness factor, food liking factor and physical fullness factor) at each of the time points (baseline before breakfast 0min, immediately after breakfast 10min, one hour after breakfast 70min, and two hours after breakfast 130min and three hours after breakfast 190min) for the fiber study treatments. Mean scores could range from 0-150mm for the mental hunger, physical hunger, mental fullness, and physical fullness factors and from 0-120mm for the food liking factor. Standard error bars represent plus and minus the standard error of the mean.
Figure 5.5: Plots of the mean (mm) \((N = 22)\) traditional ratings (traditional amount, traditional fullness, traditional hunger, and traditional desire) at each of the time points (baseline before breakfast 0min, immediately after breakfast 10min, one hour after breakfast 70min, and two hours after breakfast 130min and three hours after breakfast 190min) for the fiber study treatments. Mean scores could range from 0-150mm. Standard error bars represent plus and minus the standard error of the mean.
Figure 5.6: Plots of the mean (mm) (N = 22) Slavin ratings (Slavin hunger, Slavin satisfaction, Slavin fullness and Slavin amount) at each of the time points (baseline before breakfast 0min, fifteen minutes after breakfast 25min, thirty minutes after breakfast 40min, forty-five minutes after breakfast 55min, one hour after breakfast 70min, one and a half hours after breakfast 100min, two hours after breakfast 130min, and three hours after breakfast 190min) for the five fiber study treatments. Mean scores could range from 0-150mm. Standard error bars represent plus and minus the standard error of the mean.
Table 5.2: Mean immediate rating change scores (mm) with F and P values for the food main effect for each factor scale, traditional scale and Slavin scale for the five treatments [inulin, corn soluble fiber (corn), oligofructose (oligo), wheat soluble fiber (wheat) and the control].

<table>
<thead>
<tr>
<th>Scale</th>
<th>Inulin</th>
<th>Corn</th>
<th>Oligo</th>
<th>Wheat</th>
<th>Control</th>
<th>F-value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental hunger factor</td>
<td>-26</td>
<td>-28</td>
<td>-24</td>
<td>-22</td>
<td>-23</td>
<td>0.8</td>
<td>0.509</td>
</tr>
<tr>
<td>Physical hunger factor</td>
<td>-14</td>
<td>-12</td>
<td>-12</td>
<td>-11</td>
<td>-11</td>
<td>0.1</td>
<td>0.982</td>
</tr>
<tr>
<td>Mental fullness factor</td>
<td>-3</td>
<td>-1</td>
<td>-2</td>
<td>5</td>
<td>2</td>
<td>1.1</td>
<td>0.366</td>
</tr>
<tr>
<td>Food liking factor*</td>
<td>54</td>
<td>60</td>
<td>61</td>
<td>58</td>
<td>56</td>
<td>1.04</td>
<td>0.390</td>
</tr>
<tr>
<td>Physical fullness factor</td>
<td>6</td>
<td>9</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>0.7</td>
<td>0.569</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>Inulin</th>
<th>Corn</th>
<th>Oligo</th>
<th>Wheat</th>
<th>Control</th>
<th>F-value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional amount</td>
<td>-42</td>
<td>-44</td>
<td>-39</td>
<td>-40</td>
<td>-33</td>
<td>1.0</td>
<td>0.412</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>-45</td>
<td>-48</td>
<td>-41</td>
<td>-39</td>
<td>-35</td>
<td>1.1</td>
<td>0.373</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>23</td>
<td>28</td>
<td>22</td>
<td>26</td>
<td>20</td>
<td>0.7</td>
<td>0.569</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>-34</td>
<td>-33</td>
<td>-35</td>
<td>-35</td>
<td>-33</td>
<td>0.1</td>
<td>0.992</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>Inulin</th>
<th>Corn</th>
<th>Oligo</th>
<th>Wheat</th>
<th>Control</th>
<th>F-value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slavin amount</td>
<td>-38</td>
<td>-40</td>
<td>-35</td>
<td>-44</td>
<td>-42</td>
<td>0.9</td>
<td>0.821</td>
</tr>
<tr>
<td>Slavin fullness</td>
<td>42</td>
<td>45</td>
<td>59</td>
<td>54</td>
<td>50</td>
<td>1.1</td>
<td>0.378</td>
</tr>
<tr>
<td>Slavin hunger</td>
<td>-44</td>
<td>-42</td>
<td>-36</td>
<td>-46</td>
<td>-40</td>
<td>0.5</td>
<td>0.743</td>
</tr>
<tr>
<td>Slavin satisfaction</td>
<td>27</td>
<td>41</td>
<td>36</td>
<td>38</td>
<td>41</td>
<td>1.0</td>
<td>0.435</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0 min after breakfast (T2).
**Table 5.3:** Mean 3hr rating change scores (mm) with F and P values for the food main effect for each factor scale, traditional scale and Slavin scale for the five treatments [inulin, corn soluble fiber (corn), oligofructose (oligo), wheat soluble fiber (wheat) and the control].

<table>
<thead>
<tr>
<th>Scale</th>
<th>Inulin</th>
<th>Corn</th>
<th>Oligo</th>
<th>Wheat</th>
<th>Control</th>
<th>F-value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental hunger factor</td>
<td>31</td>
<td>30</td>
<td>31</td>
<td>27</td>
<td>27</td>
<td>0.4</td>
<td>0.821</td>
</tr>
<tr>
<td>Physical hunger factor</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td>0.3</td>
<td>0.887</td>
</tr>
<tr>
<td>Mental fullness factor</td>
<td>-7</td>
<td>-11</td>
<td>-8</td>
<td>-8</td>
<td>-10</td>
<td>0.4</td>
<td>0.804</td>
</tr>
<tr>
<td>Food liking factor</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1.0</td>
<td>0.437</td>
</tr>
<tr>
<td>Physical fullness factor</td>
<td>-7</td>
<td>-7</td>
<td>-9</td>
<td>-6</td>
<td>-6</td>
<td>0.3</td>
<td>0.854</td>
</tr>
<tr>
<td>Traditional amount</td>
<td>42</td>
<td>43</td>
<td>53</td>
<td>44</td>
<td>41</td>
<td>0.8</td>
<td>0.536</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>50</td>
<td>47</td>
<td>50</td>
<td>45</td>
<td>45</td>
<td>0.3</td>
<td>0.879</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>-29</td>
<td>-34</td>
<td>-29</td>
<td>-32</td>
<td>-26</td>
<td>0.6</td>
<td>0.640</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>33</td>
<td>33</td>
<td>34</td>
<td>33</td>
<td>36</td>
<td>0.1</td>
<td>0.987</td>
</tr>
<tr>
<td>Slavin amount</td>
<td>35</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>44</td>
<td>0.3</td>
<td>0.889</td>
</tr>
<tr>
<td>Slavin fullness</td>
<td>-40</td>
<td>-47</td>
<td>-59</td>
<td>-47</td>
<td>-48</td>
<td>1.1</td>
<td>0.372</td>
</tr>
<tr>
<td>Slavin hunger</td>
<td>53</td>
<td>54</td>
<td>59</td>
<td>46</td>
<td>52</td>
<td>0.9</td>
<td>0.482</td>
</tr>
<tr>
<td>Slavin satisfaction</td>
<td>-32</td>
<td>-41</td>
<td>-44</td>
<td>-39</td>
<td>-45</td>
<td>0.5</td>
<td>0.709</td>
</tr>
</tbody>
</table>
Table 5.4: Mean (mm h) (N=22) area under the curve rating with F and P values for the food main effect for each factor scale, traditional scale and Slavin scale for the five treatments [inulin, corn soluble fiber (corn), oligofructose (oligo), wheat soluble fiber (wheat) and the control].

<table>
<thead>
<tr>
<th>Scale</th>
<th>Inulin</th>
<th>Corn</th>
<th>Oligo</th>
<th>Wheat</th>
<th>Control</th>
<th>F-value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental hunger factor</td>
<td>107</td>
<td>104</td>
<td>95</td>
<td>108</td>
<td>103</td>
<td>0.7</td>
<td>0.604</td>
</tr>
<tr>
<td>Physical hunger factor</td>
<td>24</td>
<td>22</td>
<td>18</td>
<td>21</td>
<td>22</td>
<td>0.7</td>
<td>0.579</td>
</tr>
<tr>
<td>Mental fullness factor</td>
<td>121</td>
<td>133</td>
<td>136</td>
<td>123</td>
<td>134</td>
<td>0.7</td>
<td>0.600</td>
</tr>
<tr>
<td>Food liking factor*</td>
<td>165</td>
<td>180</td>
<td>178</td>
<td>169</td>
<td>166</td>
<td>1.1</td>
<td>0.361</td>
</tr>
<tr>
<td>Physical fullness factor</td>
<td>30</td>
<td>25</td>
<td>32</td>
<td>24</td>
<td>20</td>
<td>0.7</td>
<td>0.586</td>
</tr>
</tbody>
</table>

*The food liking factor area under the curve calculation is the area from 0min after breakfast (T2) to 3hrs after breakfast (T3).

Analysis of the amount of calories consumed at the lunch and over 24hrs

There were no significant differences among the fiber bars in the amount of calories consumed at the pizza lunch (df(4, 80), F-value = 0.3, p-value = 0.885) or over the 24hrs following the study visit (df(4, 80), F-value = 1.0, p-value = 0.403) (Table 5.5).

Table 5.5: Mean calorie intake (N = 22) and F and P values from the mixed analysis of variance for each of the treatments [inulin, corn soluble fiber (corn), oligofructose (oligo), wheat soluble fiber (wheat) and the control] at the pizza lunch and over the 24hrs after the study visit.

<table>
<thead>
<tr>
<th>Calorie Intake</th>
<th>Inulin</th>
<th>Corn</th>
<th>Oligo</th>
<th>Wheat</th>
<th>Control</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pizza calorie intake</td>
<td>633</td>
<td>667</td>
<td>680</td>
<td>674</td>
<td>656</td>
<td>0.3</td>
<td>0.885</td>
</tr>
<tr>
<td>24hr calorie intake</td>
<td>1684</td>
<td>1697</td>
<td>1702</td>
<td>1941</td>
<td>1668</td>
<td>1.0</td>
<td>0.403</td>
</tr>
</tbody>
</table>
Comparison of the sensitivity of the factor scales to the traditional scales

Scale Distribution Comparisons: Overall, the factor scales generally showed less variability than the traditional scales or the Slavin scales (Table 5.6). For immediate rating change, the average standard deviation for the five factor scales and two foods was significantly lower (17) than the average over all five traditional scales (30; df(2, 62), t-value = -6.0, p-value = <0.001) and the Slavin scales (39; df(2, 62), t-value = 7.80, p-value = <0.001). For 3hr rating change, the average standard deviation for the five factor scales was significantly lower (13) than the average over all five traditional scales (26; df(2, 62), t-value = -8.6, p-value=<0.001) and the Slavin scales (32; df(2, 62), t-value =12.9, p-value = <0.001). For the area under the curve (AUC), the average standard deviation for the five factor scales was significantly lower (50) then the average over all five traditional scales (77; t-value = -6.0, p-value = <0.001) and the Slavin scales (85; df(2, 62), t-value = 7.8, p-value = <0.001).
Table 5.6: Standard deviations around the mean (N = 22) for immediate rating change, 3hr rating change and area under the curve (AUC) for each factor scale, traditional scale and Slavin scale for the five treatments [inulin, corn soluble fiber (corn), oligofructose (oligo), wheat soluble fiber (wheat) and the control].

<table>
<thead>
<tr>
<th>Scale</th>
<th>inulin</th>
<th>corn</th>
<th>oligo</th>
<th>wheat</th>
<th>control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Hunger Factor</td>
<td>12</td>
<td>9</td>
<td>11</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>12</td>
<td>23</td>
<td>17</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>19</td>
<td>25</td>
<td>18</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Food Liking Factor*</td>
<td>22</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>14</td>
<td>17</td>
<td>17</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Traditional scales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional amount</td>
<td>39</td>
<td>37</td>
<td>27</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>42</td>
<td>41</td>
<td>32</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>20</td>
<td>36</td>
<td>21</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>24</td>
<td>25</td>
<td>35</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>Slavin scales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slavin amount</td>
<td>35</td>
<td>41</td>
<td>38</td>
<td>31</td>
<td>34</td>
</tr>
<tr>
<td>Slavin fullness</td>
<td>45</td>
<td>53</td>
<td>36</td>
<td>44</td>
<td>41</td>
</tr>
<tr>
<td>Slavin hunger</td>
<td>39</td>
<td>34</td>
<td>35</td>
<td>36</td>
<td>33</td>
</tr>
<tr>
<td>Slavin satisfaction</td>
<td>42</td>
<td>43</td>
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<td>32</td>
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</table>

*Table continued on next page*
Table 5.6 continued:

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<tr>
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<tbody>
<tr>
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<td>inulin</td>
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<tr>
<td>Mental Hunger Factor</td>
<td>8</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>11</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>18</td>
</tr>
<tr>
<td>Food Liking Factor</td>
<td>11</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>3hr Rating Change (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inulin</td>
</tr>
<tr>
<td>Factor Scales</td>
<td></td>
</tr>
<tr>
<td>Traditional amount</td>
<td>28</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>29</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>17</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>3hr Rating Change (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inulin</td>
</tr>
<tr>
<td>Slavin amount</td>
<td>29</td>
</tr>
<tr>
<td>Slavin fullness</td>
<td>36</td>
</tr>
<tr>
<td>Slavin hunger</td>
<td>28</td>
</tr>
<tr>
<td>Slavin satisfaction</td>
<td>35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>Area Under the Curve (mm h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inulin</td>
</tr>
<tr>
<td>Factor Scales</td>
<td></td>
</tr>
<tr>
<td>Mental Hunger Factor</td>
<td>65</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>67</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>58</td>
</tr>
<tr>
<td>Food Liking Factor*</td>
<td>62</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>23</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>Area Under the Curve (mm h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inulin</td>
</tr>
<tr>
<td>Traditional scales</td>
<td></td>
</tr>
<tr>
<td>Traditional amount</td>
<td>86</td>
</tr>
<tr>
<td>Traditional desire</td>
<td>81</td>
</tr>
<tr>
<td>Traditional fullness</td>
<td>82</td>
</tr>
<tr>
<td>Traditional hunger</td>
<td>64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>Area Under the Curve (mm h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inulin</td>
</tr>
<tr>
<td>Slavin scales</td>
<td></td>
</tr>
<tr>
<td>Slavin amount</td>
<td>87</td>
</tr>
<tr>
<td>Slavin fullness</td>
<td>97</td>
</tr>
<tr>
<td>Slavin hunger</td>
<td>77</td>
</tr>
<tr>
<td>Slavin satisfaction</td>
<td>94</td>
</tr>
</tbody>
</table>

*The food liking factor immediate rating change is the rating at 0min after breakfast (T<sub>2</sub>) and the area under the curve calculation is the area from 0min after breakfast (T<sub>2</sub>) to 3hrs after breakfast (T<sub>5</sub>).
Internal consistency reliabilities comparisons: All factor scales had high Cronbach’s α’s (above 0.74), indicating high internal consistency reliability (Table 5.7). The mental hunger factor had the highest Cronbach’s α at 0.96, indicating the highest internal consistency reliability.

Table 5.7: Raw and standardized (items standardized to have a standard deviation of 1.0) Cronbach’s α’s for the factor scales (mental hunger factor, physical hunger factor, mental fullness factor, food liking factor, physical fullness factor).

<table>
<thead>
<tr>
<th>Scale</th>
<th>Raw Cronbach’s α</th>
<th>Standardized Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Hunger Factor</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>Physical Hunger Factor</td>
<td>0.84</td>
<td>0.88</td>
</tr>
<tr>
<td>Mental Fullness Factor</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>Food Liking Factor</td>
<td>0.92</td>
<td>0.92</td>
</tr>
<tr>
<td>Physical Fullness Factor</td>
<td>0.69</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Breath Hydrogen and Methane Results

The bar with oligofructose produced the greatest amount of hydrogen in the breath at both baseline (df(4, 80), F-value = 7.9, p-value = <0.0001) and 3hrs after breakfast (df(4, 80), F-value = 22.4, p-value = <0.0001) with hydrogen levels at 13ppm and 39ppm, respectively (Table 5.8). The control bar produced the least amount of hydrogen in the breath at both baseline and 3hrs after breakfast with hydrogen levels at 3ppm and 4ppm, respectively. The bar with oligofructose and inulin produced the greatest amount of methane at 180min after breakfast (df(4, 80), F-value = 4.4, p-value = 0.002) with methane levels of 5ppm for both bars while the control bar produced the least methane at 3ppm. There was no significant difference in methane production between the fiber bars at baseline (df(4, 80), F-value = 1.5, p-value = 0.209).
Table 5.8: Mean (N = 22) breath hydrogen and methane for each of the five treatments [inulin, corn soluble fiber (corn), oligofructose (oligo), wheat soluble fiber (wheat) and the control] at two times (baseline before breakfast and at 3hrs after breakfast). Each mean represents a mean over 2 measurement replications for all participants. Means within each compound measured and each measurement time with letters in common do not differ significantly based on a mixed analysis of variance procedure (α = 0.05).

<table>
<thead>
<tr>
<th></th>
<th>Baseline Before Breakfast</th>
<th>Three Hours After Breakfast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inulin</td>
<td>Corn</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>8.0b</td>
<td>3.6cd</td>
</tr>
<tr>
<td>Methane</td>
<td>3.4</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Gastrointestinal Tolerance

There was no significant difference in stool frequency (df(4, 80), F-value = 2.0, p-value = 0.109) or in stool consistency (df(4, 80), F-value = 1.0, p-value = 0.393). The control bar produced the least amount of bloating and flatulence feelings, 18mm and 20mm respectively (Table 5.9). The treatment bar with oligofructose produced the greatest amount of bloating and flatulence feelings, 41mm and 56mm respectively.

Table 5.9: Gastrointestinal tolerance mean ratings (mm) (N = 22) for stool frequency, consistency, bloating and flatulence taken 24hrs after leaving the study for each of the five bars (inulin, corn, oligo, wheat and control). Means within each row with letters in common do not differ significantly based on a mixed analysis of variance procedure (α = 0.05).

<table>
<thead>
<tr>
<th></th>
<th>Inulin</th>
<th>Corn</th>
<th>Oligo</th>
<th>Wheat</th>
<th>Control</th>
<th>F-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stool frequency</td>
<td>2.0</td>
<td>1.5</td>
<td>2.0</td>
<td>1.9</td>
<td>1.5</td>
<td>2.0</td>
<td>0.109</td>
</tr>
<tr>
<td>Consistency</td>
<td>48.0</td>
<td>51.1</td>
<td>52.7</td>
<td>47.7</td>
<td>53.4</td>
<td>1.0</td>
<td>0.393</td>
</tr>
<tr>
<td>Bloating</td>
<td>30.4ab</td>
<td>21.4bc</td>
<td>40.7a</td>
<td>32.7a</td>
<td>17.6c</td>
<td>5.6</td>
<td>0.0006</td>
</tr>
<tr>
<td>Flatulence</td>
<td>41.9b</td>
<td>30.0bc</td>
<td>55.7a</td>
<td>29.7bc</td>
<td>20.2cd</td>
<td>8.2</td>
<td>0.0005</td>
</tr>
</tbody>
</table>
Discussion

While there were no significant differences found between the fiber bars using any of the three scales (factor scales, traditional scales or Slavin scales), there does seem to be a trend with the oligofructose treatment evoking lower mental and physical hunger feelings and higher physical fullness feelings for the area under the curve measurement. In a study of the fiber oligofructose, Cani et al. (2006) found that an oligofructose supplement (8g eaten twice a day for 2 weeks) significantly increased satiety (‘I cannot eat another bite’) after breakfast and dinner, and significantly reduced hunger and prospective food consumption ratings after dinner. The energy intake at breakfast and lunch was also significantly lower (by about 10%) after the oligofructose treatment as compared to a placebo of dextrin maltose. In the Cani et al. (2006) study, subjects were on the 16g/day oligofructose diet or the maltodextrin placebo for 2 weeks before coming in for an ad libitum free-choice buffet breakfast, lunch and dinner where intake was covertly recorded. In my study, participants received 10g of oligofructose the night before the study session and 10g at breakfast session 3 hours before the ad libitum lunch. I may not have seen a significant difference in the satiety produced by the two doses of 10g of oligofructose because of the food matrix that the oligofructose was delivered in, because of the smaller exposure to the fiber additive, or because of the lack of power of this study to find such small differences. There is a possibility that the oligofructose fiber in the chocolate bars could not adequately escape the chocolate bar food matrix to completely solubilize in the gut and thus did not elicit as great of a satiating increase as in Cani et al.’s (2006) study. It is also a possibility that longer exposure with oligofructose is necessary before that satiating increase could be seen.

A retrospective power calculation of the data found that the powers to detect the difference between the oligofructose sample and the control for the mental hunger factor AUC, physical hunger factor AUC and physical fullness factor AUC were 0.14, 0.16, and 0.29, respectively. With such small differences between the oligofructose bar and the control bar, I would have needed 215 people for the mental hunger factor, 169 people for the physical fullness factor, and 82 people for the physical fullness factor to have had
80% power to detect the differences. With this study's number of subjects (N=22) at an 80% power level, I could have found mean differences of 26mm for the mental hunger factor AUC, 11mm for the physical hunger factor, and 24mm for the physical fullness factor. While it may have been possible to significantly detect the difference between the oligofructose treatment bar and the control bar if the power of the study were higher, the effect appears to be quite small. When looking at the area under the curve ratings, the treatment bar made with oligofructose was 8-13mm lower than any of the other fiber or control bars for mental hunger, 4-6mm lower for the physical hunger scale, 2-15mm higher for the mental fullness and 2-12mm higher for physical fullness. These represent small differences when looking at the 150mm labeled magnitude scale. On the labeled magnitude scale, the mental hunger ratings for all treatments were above ‘very strong’ sensation on the scale, the physical hunger ratings were all between ‘weak’ and ‘moderate’, the mental fullness ratings were above ‘very strong’ and the physical fullness ratings were all right around a ‘moderate’ sensation. Even though this study did not have enough participants to detect such small differences, it appears that if the differences are actually this small, the fibers did not have a very big effect of hunger and satiety or food consumption.

While none of the scales were able to significantly differentiate the fiber bars in this study, there was evidence of high reliability for the factor scales. Evidence of reliability, the consistency of a measuring instrument, was shown by investigation of the internal consistency reliability. Cronbach’s α’s, measures of internal consistency reliability, were high (>0.7) for all of the factor scales. Cronbach’s α of 0.7 or higher have been widely agreed upon as a high level of internal consistency (Dmitrienko et al., 2007).
Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

In the research of this dissertation, I developed the Five Factor Satiety Questionnaire to measure mental hunger, physical hunger, mental fullness, physical fullness and food liking sensations. The factor scales exhibited greater sensitivity to detect the differences between the oranges and the oatmeal, the two smoothies differing in liking and the five fiber bars than did the traditional single-item scales. The factor scales showed discriminant validity and criterion related validity to levels equal to or superior to the traditional scales. The internal consistency reliabilities for the factor scales were high in each of the studies. This was again superior to the single-item traditional scales since internal consistency could not be computed for single-item scales.

The factor scales offered an increased understanding of the hunger and satiety differences between the oranges and the oatmeal and the smoothies differing in liking by tapping into both the physical and the mental aspects of hunger and satiety. The oranges were found to produce much more mental hunger and slightly more physical hunger than the oatmeal. The smoothies differing in liking were both equally physically filling yet the cumin smoothie provided less mental fullness feelings than the regular smoothie. The factor scales allowed a separation of the mental and physical feelings of hunger and fullness to differentiate the smoothies while the traditional scales did not allow this separation, and therefore, did not find the differences seen in the smoothie study with the factor scales.

While this research has shown positive improvements on understanding the hunger and fullness evoked by foods, future validation studies should be continued. Future validation studies for the factor scales could include studies to test the physical fullness and mental fullness scales. One possible study could include investigation of varying volumes of food with at least one volume pushing participants into a more extreme
fullness feeling with high physical and mental fullness sensations. Future studies could also investigate the differences between varying groups of participants. Body mass index level, gender, or eating restraint level could be investigated to see how different groups of participants respond to the Five Factor Satiety Questionnaire. While much work still can be done to continue validating the Five Factor Satiety Questionnaire, this initial creation and testing of the scales has shown that the Five Factor Satiety Questionnaire will be a useful tool to provide enhanced sensitivity and understanding of the satiety produced by foods.
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Appendix A: Focus group screener

Hello!

The Sensory Center at the University of Minnesota is recruiting panelists to participate in a focus group on hunger and fullness. On five days prior to the focus group you would be provided five breakfast meals and asked to evaluate the meals at home on five consecutive days. You will also be asked to fill out a 1-day food journal of all foods consumed on one of the five days. After the pre-activities are complete, you would be asked to take part in a 2 hour focus group to discuss the activities and additional topics related to hunger and fullness. The focus group will be held in the Food Science and Nutrition building on the University of Minnesota St. Paul campus.

Compensation will be provided for all participation (A total of $50). Participants will be compensated $5.00 for the 5 pre-focus group activities and $45 for participation in the 2 hour focus group. To be eligible for participation in the focus group, all 5 pre-focus group activities must be completed. Payment will be provided after the completion of each section of the study.

***To be eligible for the study, we need people with the following qualifications***

-Willing to evaluate five breakfast meals (meals can be picked up from the Sensory Center on Friday July 18th) in your home on four consecutive mornings (Monday July 14th, Tuesday July 15th, Wednesday July 16th, Thursday July 17th, and Friday July 18th of the week prior to the focus group). Questionnaires are due by 5:00pm on Friday July 18th. Questionnaires need to be returned to the sensory center in the Food Science and Nutrition Building Room 97.

-Available to attend a 2 hour focus group that will be scheduled on Tuesday July 29th, Wednesday July 30th or Thursday July 31st (depending on participant availability).

-Have no food allergies

If you are interested, please fill out the attached screener and return by e-mail to sensory@umn.edu. Your responses will be evaluated to see if you qualify to be part of the study. Your responses to all questions on this form will be kept confidential. If you qualify, we will contact you to schedule your participation. You may choose not to participate, even if you have qualified.

Thanks!
Appendix B: Focus group pre-activity instructions

**Focus Group Activity Instructions**

Please read all the following carefully before beginning the activities.

The following materials are provided in your package:

1. **Day 1 Activity**
   - Monday July 21st
   - Cereal with milk (please provide your own milk (1 cup)
   - Day 1 Questionnaire

2. **Day 2 Activity**
   - Tuesday July 22nd
   - Cereal with milk (please provide your own milk (1 cup)
   - Day 2 Questionnaire

3. **Day 3 Activity**
   - Wednesday July 23rd
   - Coffee/Instant Breakfast Beverage - Milk Chocolate
   - Day 3 Questionnaire

4. **Day 4 Activity**
   - Thursday July 24th
   - Quaker Oatmeal - Golden Brown Sugar
   - Day 4 Questionnaire

5. **Day 5 Activity**
   - Friday July 25th
   - Energy bar - Balance Yogurt honey peanut
   - Day 5 Questionnaire
   - Summary Questionnaire

6. **One day feeding**
   - Friday July 21st
   - One day feeding to be completed on one of the pre-group activity days.

Please choose a day that will best represent your usual eating patterns.

You will need to provide the following:

1. cup of milk for your cereal

At the start of each day please do the following:

1. Before eating the provided food, please answer the pre-consumption questions.
2. Please eat the entire provided food at the start of each day on an empty stomach.
3. Please do not eat anything along with the provided food. You may eat after you have finished eating the provided food and answering the pre-consumption questions.

Please turn in your completed questionnaires by 5:00pm on Friday July 28th

To be eligible to participate in the focus group, all activities must be completed.

**Day 1 Activity**

To be completed on Monday July 21st

On an empty stomach (first thing in the morning) please answer the pre-consumption questions. Please eat the provided food (2), and answer the post-consumption questions about your feelings related to hunger, fullness, satisfaction, safety, etc. Please eat ALL of the product.

Please answer the following questions **BEFORE** eating the product:

1. How do you expect to feel the eating this product? Explain.

2. Do you expect this meal to satisfy your hunger? Explain.

Please answer the following questions **AFTER** eating the product:

3. What kind of milk did you use on your cereal?
   - Skim milk 2.2% milk 2% milk Whole milk Other

4. How do you feel after eating the product (feelings related to hunger, fullness, satisfaction, safety, etc)?

5. At what time do you expect to feel hungry again? Explain why.

6. At what time did you actually begin to feel hungry and/or eat something after consuming the product?

**Day 2 Activity**

To be completed on Tuesday July 22nd

On an empty stomach (first thing in the morning) please answer the pre-consumption questions. Please eat the provided food (2), and answer the post-consumption questions about your feelings related to hunger, fullness, satisfaction, safety, etc. Please eat ALL of the product.

Please answer the following questions **BEFORE** eating the product:

1. How do you expect to feel after eating this product? Explain.

2. Do you expect this meal to satisfy your hunger? Explain.

Please answer the following questions **AFTER** eating the product:

3. What kind of milk did you use on your cereal?
   - Skim milk 2.2% milk 2% milk Whole milk Other

4. How do you feel after eating the product (feelings related to hunger, fullness, satisfaction, safety, etc)?

5. At what time do you expect to feel hungry again? Explain why.

6. At what time did you actually begin to feel hungry and/or eat something after consuming the product?

**Day 3 Activity**

To be completed on Wednesday July 23rd

On an empty stomach (first thing in the morning) please answer the pre-consumption questions. Please consume the provided coffee/Instant breakfast drink, and answer the post-consumption questions about your feelings related to hunger, fullness, satisfaction, safety, etc. Please drink the ENTIRE beverage.

Please answer the following questions **BEFORE** eating the product:

1. How do you expect to feel after eating this product? Explain.

2. Do you expect this meal to satisfy your hunger? Explain.

Please answer the following questions **AFTER** eating the product:

3. What kind of milk did you use on your cereal?
   - Skim milk 2.2% milk 2% milk Whole milk Other

4. How do you feel after eating the product (feelings related to hunger, fullness, satisfaction, safety, etc)?

5. At what time do you expect to feel hungry again? Explain why.

6. At what time did you actually begin to feel hungry and/or eat something after consuming the product?
Day 4 Activity
To be completed on Thursday July 24th

On an empty stomach (first thing in the morning) please answer the pre-consumption questions. Prepare (follow instructions on package) and eat the provided Quaker Oatmeal and answer the pre-consumption questions about your feelings related to hunger, fullness, satisfaction, satiety, etc. Please eat all of the product.

Please answer the following questions BEFORE eating the product:

1. How do you expect to feel after eating this product? Explain.

2. Do you expect this meal to satisfy your hunger? Explain.

Please answer the following questions AFTER eating the product:

3. How do you feel after eating the product (feelings related to hunger, fullness, satisfaction, satiety, etc.)?

4. At about what time do you expect to feel hungry again? Explain why.

5. At what time did you actually begin to feel hungry and/or eat something after consuming the product?

Day 5 Activity
To be completed on Friday July 25th

On an empty stomach (first thing in the morning) please answer the pre-consumption questions. Please eat the provided Balance Energy Bar and answer the post-consumption questions about your feelings related to hunger, fullness, satisfaction, satiety, etc. Please eat all of the product.

Please answer the following questions BEFORE eating the product:

6. How do you expect to feel after eating this product? Explain.

7. Do you expect the meal to satisfy your hunger? Explain.

Please answer the following questions AFTER eating the product:

8. How do you feel after eating the product (feelings related to hunger, fullness, satisfaction, satiety, etc.)?

9. At about what time do you expect to feel hungry again? Explain why.

10. At what time did you actually begin to feel hungry and/or eat something after consuming the product?

Day 5 Summary Questionnaire
To be completed on Friday July 25th

After completing the Day 5 Activity please answer the following questions:

1. Which of the 3 products did you like the best? Please explain.

2. Which product(s) filled you up the most immediately after eating? Please explain.

3. Which of the 3 products was the best at reducing your hunger throughout the morning? Please explain.

4. Did you need to eat additional foods/beverages after you ate any of the 3 products? What feelings/situations triggered you to eat more?

5. Which sensations related to hunger and/fulness did you like best? Which product(s) provided these sensations?

Please return all completed questionnaires to the Sensory Center in room 97 of the Food Science & Nutrition Building by X. Wyman on Friday July 25th.

Thanks for your participation!
Appendix C: Focus group one day food log

### One-day Food Log
To be completed on or before Thursday July 24th
Over a 24hr period, please record all foods consumed. This should be completed on Tuesday July 22nd or Wednesday July 23rd. Please choose 1 day that best represents your normal eating routine.

<table>
<thead>
<tr>
<th>Time</th>
<th>Place</th>
<th>Food and Beverage (please include the amount consumed)</th>
<th>Describe any feelings of hunger or fullness you have before eating</th>
<th>Describe any feelings of hunger or fullness you have after eating</th>
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Please return all completed questionnaires to the Sensory Center in room 57 of the Food Science & Nutrition Building by 5:00pm on Friday July 25th.

Thanks for your participation!
Appendix D: Focus group moderator introduction and outline

Focus Group Introduction

Time: Focus group to take place in the late afternoon to early evening (before dinner).

Good afternoon and thank you for participating in today's focus group on hunger and fullness. You were chosen to participate in today's group because you are all women who have expressed interest in pursuing strategies for losing weight or you are all men who have expressed interest in pursuing strategies for losing weight...

My name is Melinda and I will be the moderator of today's session along with my co-moderator woman who will be here to help me take notes and make sure we don't miss anything that is said. We are conducting research at the University in order to better understand the feelings of hunger and fullness. This research will help us understand what makes a food satisfying and will help in the development of foods that help you feel good over the next meal. As the moderator, I am here to help keep us on track so we can get through all of the questions planned for today's session.

Today's discussion will be audio and video recorded so I can make sure I don't miss anything important that is said. Since today's session will be recorded, it is important to speak only to the person at a time so we can be sure that all thoughts and ideas are heard. Since we would like this to be a relaxed discussion atmosphere, please feel free to speak your thoughts whenever you have something to say and add to what someone else is saying. There are no wrong answers and all input and ideas are very valuable to our research. Remember that all discussions will be kept confidential and your names will not be given out.

Before we begin, let me remind you of a few ground rules. Please take a moment to turn off your cell phones and pagers. If you have to take a call during our session, please step out quietly and join back as soon as you can since your input is very valuable to our research.

Our session will last about two hours, and we will not be taking a formal break. Let's begin. We've placed name cards on the table in front of you to help us remember each other's names. Now let's find out some more about each other by going around the room one at a time.

1. What is your name? Where are you from? What are you doing today?
2. What is your favorite meal of the day? Why?
3. Have you ever tried to lose weight? If yes, how did you go about it?
4. What are some common foods that you eat for breakfast, lunch, and dinner?
5. Have you ever tried a diet? If yes, how did it go?
6. Do you like to eat alone or with others?
7. Do you ever get hungry before you get a chance to eat?
8. What do you do when you get hungry?
9. Do you ever eat when you're not hungry?
10. Are there any foods you really love but try to avoid?

Focus Questions

1. What is your favorite meal of the day? Why?
2. Have you ever tried to lose weight? If yes, how did you go about it?
3. What is your favorite type of exercise? Why?
4. Are there any foods you really love but try to avoid?
5. Do you ever eat when you're not hungry?
6. Are there any foods you really love but try to avoid?

Hunger Questions

1. What is your favorite meal of the day? Why?
2. Have you ever tried to lose weight? If yes, how did you go about it?
3. What is your favorite type of exercise? Why?
4. Are there any foods you really love but try to avoid?
5. Do you ever eat when you're not hungry?
6. Are there any foods you really love but try to avoid?

7. Are there any foods you really love but try to avoid?
8. Do you ever eat when you're not hungry?
9. Are there any foods you really love but try to avoid?
10. Do you ever eat when you're not hungry?

Fullness Questions

1. What is your favorite meal of the day? Why?
2. Have you ever tried to lose weight? If yes, how did you go about it?
3. What is your favorite type of exercise? Why?
4. Are there any foods you really love but try to avoid?
5. Do you ever eat when you're not hungry?
6. Are there any foods you really love but try to avoid?

Satiety Focus Group Questions Outline

1. Intro Questions (5-10 minutes)
   a. Opening question: Please tell us your name and about what you've been doing today.

2. Satiety Focus Group Questions Outline (45 minutes)
   a. Satiety: What do you feel when you're hungry? Have you ever been so hungry that you...?
   b. Satiety: What are some common foods that you eat for breakfast, lunch, and dinner?
   c. Satiety: Do you ever eat when you're not hungry?
   d. Satiety: Are there any foods you really love but try to avoid?

3. Satiety: What do you feel when you're hungry? Have you ever been so hungry that you...
   a. Satiety: What are some common foods that you eat for breakfast, lunch, and dinner?
   b. Satiety: Do you ever eat when you're not hungry?
   c. Satiety: Are there any foods you really love but try to avoid?

4. Satiety: What do you feel when you're hungry? Have you ever been so hungry that you...
   a. Satiety: What are some common foods that you eat for breakfast, lunch, and dinner?
   b. Satiety: Do you ever eat when you're not hungry?
   c. Satiety: Are there any foods you really love but try to avoid?

5. Satiety: What do you feel when you're hungry? Have you ever been so hungry that you...
   a. Satiety: What are some common foods that you eat for breakfast, lunch, and dinner?
   b. Satiety: Do you ever eat when you're not hungry?
   c. Satiety: Are there any foods you really love but try to avoid?
Appendix E: Facebook note used to recruit participants

I need 200 people to fill out a 15 min online questionnaire related to hunger feelings - Please read this note if you can help!

by Melinda Karalus on Thursday, January 28, 2010 at 1:13pm

As part of my PhD thesis, I am conducting an online survey related to many aspects of hunger and fullness. Understanding feelings of hunger and fullness is very important, because it will help food developers better understand what makes people feel satisfied after having a meal. This study has been approved by the University of Minnesota IRB (#1001E75852)

To participate in the online survey, you need to:
- Be between the age of 18 and 65
- Speak English as your first language
- Have approximately 30 minutes to fill out an online questionnaire

If you are interested in participating, please go to the following website and fill out the questionnaire related to many aspects of hunger and fullness.

http://www.sensorytest.com/?MyI=016000836584736984895200005

The questionnaire will take between 15-30 minutes of your time and can be filled out at any time of day. Please try and fill out the entire questionnaire at one time without having to take breaks and DO NOT eat while filling out the questionnaire.

If you know others who would be willing to fill out the questionnaire, please forward this note to them and have them go to the link above.

Thanks,
Melinda Murray
Appendix F: Hunger and Fullness Questionnaire Ballot for study ‘Creation of a Hunger and Fullness Questionnaire’

Hunger and Fullness Questionnaire

Welcome to the study to help better understand what it means to be hungry and full! Your participation in this research is greatly appreciated and will help to make an impact on researchers’ and food developers’ knowledge related to the feelings of hunger and fullness.

This questionnaire will take about 15-30 minutes to complete and can be completed at any time of day.

To participate you need to:
- be between the age of 18 and 65
- speak English as your first language
- have approximately 30 minutes to fill out this online questionnaire

Please DO NOT eat while taking this questionnaire.

Click the hand to move to the next page.

CONSENT FORM

You are invited to be in a research study to help better understand hunger and fullness. You were selected as a possible participant because of your interest in participating in our study. We ask that you read this form and ask any questions you may have before participating in this study.

This study is being conducted by: Melinda Murray and Zalia Volckers, from the Department of Food Science and Nutrition.

Procedures:
If you agree to be in this study, we would ask you to continue on to fill out this questionnaire by rating your feelings towards many aspects of hunger and fullness.

Confidentiality:
The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records.

Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to withdraw any question or withdraw at any time without affecting those relationships.

Contacts and Questions:
The researchers conducting this study are: Melinda Murray and Zalia Volckers. You may ask any questions you have now. If you have questions later, you are encouraged to contact them at Room 67 or 146, Food Science and Nutrition, 612-625-5712, mmurray@umn.edu, and zvolckers@umn.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact the Research Subjects’ Advocate Line, 2525 Mayo, 430 Delaware St, Southwest, Minneapolis, Minnesota 55405, (612) 625-1000.

You may print a copy of this information to keep for your records

Before you begin the questionnaire, please answer the following 7 demographic questions.

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records.

What is your age?
- <18 years old
- 18-24 years old
- 25-39 years old
- 40-49 years old
- 50-54 years old
- 55-59 years old
- 60-64 years old
- >65 years old

What is your gender?
- Female
- Male

Click the hand to move to the next page.
What is your height?
- <4 feet 8 inches
- 4 feet 8 inches
- 4 feet 9 inches
- 4 feet 10 inches
- 4 feet 11 inches
- 5 feet
- 5 feet 1 inch
- 5 feet 2 inches
- 5 feet 3 inches
- 5 feet 4 inches
- 5 feet 5 inches
- 5 feet 6 inches
- 5 feet 7 inches
- 5 feet 8 inches
- 5 feet 9 inches
- 5 feet 10 inches
- 5 feet 11 inches
- 6 feet
- 6 feet 1 inch
- 6 feet 2 inches
- 6 feet 3 inches
- 6 feet 4 inches
- 6 feet 5 inches
- 6 feet 6 inches
- 6 feet 7 inches
- 6 feet 8 inches
- 6 feet 9 inches
- 6 feet 10 inches
- 6 feet 11 inches
- > 7 feet

Click the hand to move to the next page.

What is your weight in pounds?

Do you speak English as your first language?
- Yes
- No

Which of the following statements describes you?
- I am currently working on losing weight
- I am currently working on gaining weight
- I am actively maintaining my current weight
- I am not currently involved in any weight management effort

How long ago was the last time you ate food (meal or snack)?
- 0-1 hours ago
- 2-3 hours ago
- 3-4 hours ago
- 4-5 hours ago
- 5-6 hours ago
- 6-7 hours ago
- 7-8 hours ago
- 8-9 hours ago
- 9-10 hours ago
- More than 10 hours ago

Click the hand to move to the next page.

On the next 16 pages you will be asked to evaluate the intensity of 95 statements.

For the first series of statements you will be making your intensity ratings on a scale that ranges from NONE to GREATEST POSSIBLE AMOUNT.

To make your rating, read the statement and then click a circle on the line that represents the intensity of your "current feeling".

An example is shown below. The person in the example was first asked to "Rate the amount of time you spend driving each day." The person in the example marked a circle on the scale near the middle of the scale which represents a moderate amount of driving each day. Next the person was asked to "Rate the amount of money you hope to earn in one year." The person in the example marked a circle at the "GREATEST POSSIBLE AMOUNT" end of the scale because the person hopes to earn as much money as possible in one year.

Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

Click the hand to move to the next page.
Now you may begin the questionnaire. In the first box statements below, you will be making your ratings on a scale that ranges from NONE to GREATEST POSSIBLE AMOUNT.

Please base your ratings on your "feelings right now".

Note: If you are even unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

<table>
<thead>
<tr>
<th>None</th>
<th>Greatest possible amount</th>
<th>Unfamiliar with the statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate the amount of food you currently desire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate the current amount of food you could eat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Click the hand to move to the next page.

For the second series of statements you will be making your intensity ratings on a scale that ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

To make your rating, read the statement and then click a circle on the line that represents the intensity of your "current feeling".

An example is shown below. The person in the example was first asked to "Rate the loudness of a jet plane taking off 10 feet from you". The person in the example marked a circle on the scale near the STRONGEST IMAGINABLE SENSATION OF ANY KIND end of the scale because the intensity of the jet plane sound was extremely loud. Next the person was asked to "Rate the brightness of a dirtyיצ room". The person in the example marked a circle near the NONE end of the scale because the intensity of the light was very low.

Note: If you are even unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

Click the hand to move to the next page.

Now you may begin the questionnaire. Again, the scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

Please base your ratings on your "feelings right now".

Note: If you are even unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

<table>
<thead>
<tr>
<th>None</th>
<th>Greatest possible amount</th>
<th>Unfamiliar with the statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate your current desire to eat any food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current desire to eat your next meal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current desire to eat something fatty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current desire to eat something salty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current desire to eat something savory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current desire to eat something sweet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current desire to eat your favorite food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current desire to eat a snack</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of satiety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate the extent to which your stomach currently aches</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Click the hand to move to the next page.
The scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

Please base your ratings on your "feelings right now".

Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

<table>
<thead>
<tr>
<th>None</th>
<th>Strongest imaginable sensation</th>
<th>Unfamiliar with the statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate your current feeling of agitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of aloneness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current amount of energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of anxiety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of anxiousness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current appetite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate the extent to which you currently have stomach pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of calmness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current alertness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate the extent to which your stomach currently feels bloated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Click the hand to move to the next page.

(Page 5 of 18)

The scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

Please base your ratings on your "feelings right now".

Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

<table>
<thead>
<tr>
<th>None</th>
<th>Strongest imaginable sensation</th>
<th>Unfamiliar with the statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate the extent to which your stomach feels like it is currently burning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of coldness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of depression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current appetite for a meal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of dizziness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of fullness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of dreaminess</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of drowsiness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate your current feeling of faintness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate the extent to which you currently feel lightheaded</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Click the hand to move to the next page.

(Page 6 of 18)
The scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.
Please base your ratings on your "feelings right now".

Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Mild</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Strong</td>
</tr>
<tr>
<td>5</td>
<td>Very Strong</td>
</tr>
<tr>
<td>6</td>
<td>Struggling</td>
</tr>
<tr>
<td>7</td>
<td>Completely</td>
</tr>
</tbody>
</table>

Rate your current feeling of...  
Rate your current feeling of...  
Rate the extent to which you currently feel...  
Rate the extent to which you currently feel...  
Rate your current feeling of...  
Rate the extent to which you currently feel...  
Rate the extent to which you currently feel...  
Rate your current feeling of...  

Click the hand to move to the next page.

(Page 7 of 16)
The scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.
Please base your ratings on your "**feelings right now**".

Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

<table>
<thead>
<tr>
<th>None</th>
<th>Strongest imaginable sensation of any kind</th>
<th>Unfamiliar with the statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate the extent to which your stomach currently feels distended</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current feeling of ravenousness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current feeling of relaxedness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current feeling of restlessness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate the extent to which your ears are currently ringing</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current feeling of sadness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current rate of salivation</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current feeling of sickness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current feeling of sleepiness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate the extent to which you currently have stomach contractions</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
</tbody>
</table>

Click the hand to move to the next page.

The scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.
Please base your ratings on your "**feelings right now**".

Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

<table>
<thead>
<tr>
<th>None</th>
<th>Strongest imaginable sensation of any kind</th>
<th>Unfamiliar with the statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate the extent to which you currently have stomach cramps</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate the extent to which your stomach currently feels empty</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate the extent to which you currently feel stomach pain</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate the extent to which your stomach currently feels stuffed</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate the extent to which your stomach is currently growing</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current non-stomach bodily pains</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current level of thirst</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current feeling of gastric tightness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current tiredness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
<tr>
<td>Rate your current urge to eat</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
</tr>
</tbody>
</table>

Click the hand to move to the next page.
The scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

Please base your ratings on your *** "feelings right now"***.

*Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

---

Rate your current feeling of warmth:  
Rate your current feeling of weakness:  
Rate your current feeling of weakness with hunger:  
Rate your current willingness to eat:  

---

Click the hand to move to the next page.

(page 11 of 16)

For the last two sets of questions please make your ratings based on *** "how you felt right after eating your most recent food (meal or snack)"***.

The scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

*Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

Please describe the last food you ate (meal and/or snack):

Be very specific and make sure to include an estimate of the amount of each component of the meal and/or snack:

---

Rate your contentedness with the food you last ate:  
Rate your feeling of fullness from the food you last ate:  
Rate your appetite satisfaction from the food you last ate:  
Rate your desire for more of the food you last ate:  
Rate your desire for more of a different food than you last ate:  
Rate the difficulty to eat the food you last ate:  
Rate the enjoyment you had from the food you last ate:  
Rate the satisfaction with the food you last ate:  

---

Click the hand to move to the next page.

(page 12 of 16)

For the last two sets of questions please make your ratings based on *** "how you felt right after eating your most recent food (meal or snack)"***.

The scale ranges from NONE to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

*Note: If you are ever unfamiliar with a statement, click the last circle on the far right end of the scale under the UNFAMILIAR WITH THE STATEMENT label.

---

Rate the self control it required you to stop eating the food you last ate:  
Rate the strength of the feeling that you had enough to eat from the food you last ate:  
Rate the satisfaction with the feeling of fullness from the food you last ate:  
Rate your feeling that the meal or snack was a sufficient size:  

---

Click the hand to move to the next page.

(page 13 of 16)
For the last 4 questions you will be making Liking ratings on a scale that ranges from GREATEST IMAGINABLE DISLIKING at the top to GREATEST IMAGINABLE LIKING at the bottom of the scale.

Please make your ratings based on "How you felt right after eating your most recent food (meal or snack)?".

Rate your overall liking of the food you last ate:
- Greatest imaginable disliking
- Dislike extremely
- Dislike very much
- Dislike moderately
- Dislike slightly
- Neutral
- Like slightly
- Like moderately
- Like very much
- Like extremely
- Greatest imaginable liking

Rate your liking of the appearance of the food you last ate:
- Greatest imaginable disliking
- Dislike extremely
- Dislike very much
- Dislike moderately
- Dislike slightly
- Neutral
- Like slightly
- Like moderately
- Like very much
- Like extremely
- Greatest imaginable liking

Click the hand to move to the next page.

(Page 14 of 16)

Please make your Liking ratings on the scales below that range from GREATEST IMAGINABLE DISLIKING at the top to GREATEST IMAGINABLE LIKING at the bottom of the scale.

Please make your ratings based on "How you felt right after eating your most recent food (meal or snack)?"

Rate your liking of the odor of the food you last ate:
- Greatest imaginable disliking
- Dislike extremely
- Dislike very much
- Dislike moderately
- Dislike slightly
- Neutral
- Like slightly
- Like moderately
- Like very much
- Like extremely
- Greatest imaginable liking

Rate your liking of the flavor of the food you last ate:
- Greatest imaginable disliking
- Dislike extremely
- Dislike very much
- Dislike moderately
- Dislike slightly
- Neutral
- Like slightly
- Like moderately
- Like very much
- Like extremely
- Greatest imaginable liking

Click the hand to move to the next page.

(Page 15 of 16)

Please make your Liking ratings on the scales below that range from GREATEST IMAGINABLE DISLIKING at the top to GREATEST IMAGINABLE LIKING at the bottom of the scale.

Please make your ratings based on "How you felt right after eating your most recent food (meal or snack)?"

Rate your liking of the texture of the food you last ate:
- Greatest imaginable disliking
- Dislike extremely
- Dislike very much
- Dislike moderately
- Dislike slightly
- Neutral
- Like slightly
- Like moderately
- Like very much
- Like extremely
- Greatest imaginable liking

Thank you for your participation! If you know of others who would be interested in participating, please send them to:

http://www.SensoryTest.com/RAj+018000395473689520006

(Page 16 of 16)
Appendix G: SAS code for Factor Analysis and Parallel Analysis

SAS code for Factor Analysis

```sas
proc factor data=factordata method=principal scree
mineigen=0 priors=smc nfacators=10 rotate=varimax outstat=fact_varimax;
run;
```

SAS code for Parallel Analysis (O’Connor, 2000)

```sas
/* Parallel Analysis Program For Raw Data and Data Permutations

This program conducts parallel analyses on data files in which
the rows of the data matrix are cases/individuals and the
columns are variables; Data are read/entered into the program
using the READ command (see the READ command below);
Alternative procedures for entering data in PROC IML include
the USE, READ, INFILE, INPUT, and EDIT commands;
There can be no missing values;

You must also specify:
-- the # of parallel data sets for the analyses;
-- the desired percentile of the distribution and random
data eigenvalues;
-- whether principal components analyses or principal axis/common
factor analysis are to be conducted, and
-- whether normally distributed random data generation or
permutations of the raw data set are to be used in the
parallel analyses;

options nocenter nodate nonumber linesize=100 pagesize=500; title;
proc iml;
reset noname;

/* Enter your specifications: */

/* Enter or read a raw data matrix, where rows = cases,
& columns = variables
Use the following name for the raw data matrix: "raw".
Cases with missing values are not permitted in the data file. */
use factordata;
/* read all var _num_ into raw; */
read all into raw;

/* Enter the desired number of parallel data sets here */
ndatsets = 1000;

/* Enter the desired percentile here */
percent = 95;

/* Specify the desired kind of parallel analysis, where:
1 = principal components analysis
2 = principal axis/common factor analysis */
kind = 2;```
/* Enter either
   1 for normally distributed random data generation parallel analysis, or
   2 for permutations of the raw data set */
randtype = 2;

/* When seed = 0, the clock is used as the seed for the random number generations. This produces different
random numbers on different runs of the program. To use the same random numbers on different runs of
the program, set seed to a value other than 0 */
seed = 0;

************* End of user specifications ***********************/
ncases = nrow(raw);
nvars = ncol(raw);

/* set diagonal to a column vector module */
start setdiag(matname,vector);
do i = 1 to nrow(matname);
do j = 1 to ncol(matname);
if (i = j) then;  matname[i,j] = vector[i,1];
end;end;
finish;

/* row sums module */
start rsum(matname);
rsums=j(nrow(matname),1);
do rows = 1 to nrow(matname);
dumr = matname[rows,];
rsums[rows,1]=sum(dumr);
end;
return(rsums);
finish;

/* Pearson correlation matrix module */
start corrcoef(matname);
ncases = nrow(matname);
nml1 = 1 / (ncases-1);
vcv = nml1 * (t(matname)*matname - ((t(matname[+,:])*matname[+,:])/ncases));
d = inv(diag(sqrt(vecdiag(vcv))));
r = d * vcv * d;
return(r);
finish;

/* principal components analysis & random normal data generation */
if kind = 1 & randtype = 1 then do;
  realeval = eigval(corrcoef(raw));
evals = j(nvars,ndatsets,-9999);
do nds = 1 to ndatsets;
evals[,nds] = eigval(corrcoef(normal(j(ncases,nvars,seed))));
end;
end;

/* principal components analysis & raw data permutation */
if kind = 1 & randtype = 2 then do;
realeval = eigval(corrcoef(raw));
evals = j(nvars,ndatsets,-9999);
do nds = 1 to ndatsets;
x = raw;
do lupec = 1 to nvars;
do luper = 1 to (ncases -1);
k = int( (ncases - luper + 1) * uniform(seed) + 1 ) + luper - 1;
d = x[luper,lupec];
x[luper,lupec] = x[k,lupec];
x[k,lupec] = d;
end;
end;
evals[,nds] = eigval(corrcoef(x));
end;
end;
/* PAF/common factor analysis & random normal data generation */
if kind = 2 & randtype = 1 then do;
r = corrcoef(raw);
smc = 1 - (1 / vecdiag(inv(r)) )];
run setdiag(r,smc);
realeval = eigval(r);
evals = j(nvars,ndatsets,-9999);
do nds = 1 to ndatsets;
r = corrcoef(normal(j(ncases,nvars,seed)));
smc = 1 - (1 / vecdiag(inv(r)) )];
run setdiag(r,smc);
evals[,nds] = eigval(r);
end;
end;
/* PAF/common factor analysis & raw data permutation */
if kind = 2 & randtype = 2 then do;
r = corrcoef(raw);
smc = 1 - (1 / vecdiag(inv(r)) )];
run setdiag(r,smc);
realeval = eigval(r);
evals = j(nvars,ndatsets,-9999);
do nds = 1 to ndatsets;
x = raw;
do lupec = 1 to nvars;
do luper = 1 to (ncases -1);
k = int( (ncases - luper + 1) * uniform(seed) + 1 ) + luper - 1;
d = x[luper,lupec];
x[luper,lupec] = x[k,lupec];
x[k,lupec] = d;
end;
end;
r = corrcoef(x);
smc = 1 - (1 / vecdiag(inv(r)) )];
run setdiag(r,smc);
evals[,nds] = eigval(r);
end;
end;
end;

/* identifying the eigenvalues corresponding to the desired percentile */
um = round((percent * ndatsets) / 100);
results[1] = t(1:nvars, 4.9999);
results[,2] = realeval;
do root = 1 to nvars;
ranks = rank(evals[root,]);
do col = 1 to ndatsets;
if (ranks[1,col] = num) then do;
results[root,4] = evals[root,col];
col = ndatsets;
end;
end;
results[,3] = evals[,] / ndatsets;

print, "Parallel Analysis:";
if (kind = 1 & randtype = 1) then;
print, "Principal Components & Random Normal Data Generation";
if (kind = 1 & randtype = 2) then;
print, "Principal Components & Raw Data Permutation";
if (kind = 2 & randtype = 1) then;
print, "PAF/Common Factor Analysis & Random Normal Data Generation";
if (kind = 2 & randtype = 2) then;
print, "PAF/Common Factor Analysis & Raw Data Permutation";
specifs = (ncases // nvars // ndatsets // percent);
rlabels = {"Ncases" "Nvars" "Ndatsets" "Percent"};
print, "Specifications for this Run:", specifs[rowname=rlabels];
clabels={"Root" "Raw Data" "Means" "Prcntyle"};
print, "Raw Data Eigenvalues, & Mean & Percentile Random Data Eigenvalues",
    results[colname=clabels format=12.6];
if (kind = 2) then do;
quit;"

SAS output for Parallel Analysis
Parallel Analysis:
PAF/Common Factor Analysis & Raw Data Permutation

Specifications for this Run:
Ncases  212
Nvars   73
Ndatsets 1000
Percent 95

Raw Data Eigenvalues, & Mean & Percentile Random Data Eigenvalues

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**Appendix H:** Table containing all questions (items) that had 1 or more participants mark 'unfamiliar with the statement' along with the number who marked 'unfamiliar with the statement' and the decision to keep or remove the item.

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Appendix 1: Complete correlation matrix ordered by cluster determined from McQuitty's Elementary Linkage Analysis
<table>
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<tr>
<th>Cluster 1</th>
<th>Cluster 2</th>
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<td>comfort eating</td>
<td>relaxation</td>
<td>feeling</td>
<td>hunger</td>
<td>food craving</td>
<td>desire to eat</td>
<td>desire to eat food</td>
<td>nutrition</td>
<td>satiety</td>
<td>relief from eating</td>
<td>degree of appetite</td>
<td>desire to eat a snack</td>
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<td>relaxation</td>
<td>feeling</td>
<td>hunger</td>
<td>food craving</td>
<td>desire to eat</td>
<td>desire to eat food</td>
<td>nutrition</td>
<td>satiety</td>
<td>relief from eating</td>
<td>degree of appetite</td>
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<td>0.096</td>
<td>0.096</td>
<td>0.139</td>
<td>0.467</td>
<td>0.397</td>
<td>0.189</td>
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<td>comfort eating</td>
<td>relaxation</td>
<td>feeling</td>
<td>hunger</td>
<td>food craving</td>
<td>desire to eat food</td>
<td>nutrition</td>
<td>satiety</td>
<td>relief from eating</td>
<td>degree of appetite</td>
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<td>0.203</td>
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<td>0.200</td>
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<td>0.420</td>
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<td>comfort eating</td>
<td>relaxation</td>
<td>feeling</td>
<td>hunger</td>
<td>food craving</td>
<td>desire to eat</td>
<td>nutrition</td>
<td>satiety</td>
<td>relief from eating</td>
<td>degree of appetite</td>
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<td>0.232</td>
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<td>food craving</td>
<td>desire to eat</td>
<td>desire to eat food</td>
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<td>degree of appetite</td>
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<td>relaxation</td>
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<td>hunger</td>
<td>food craving</td>
<td>desire to eat</td>
<td>desire to eat food</td>
<td>nutrition</td>
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<td>comfort eating</td>
<td>relaxation</td>
<td>feeling</td>
<td>hunger</td>
<td>food craving</td>
<td>desire to eat</td>
<td>desire to eat food</td>
<td>nutrition</td>
<td>satiety</td>
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<td>0.044</td>
<td>0.056</td>
<td>0.056</td>
<td>0.069</td>
<td>0.058</td>
<td>0.058</td>
<td>0.104</td>
<td>0.241</td>
<td>0.175</td>
<td>0.110</td>
</tr>
<tr>
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<td>comfort eating</td>
<td>relaxation</td>
<td>feeling</td>
<td>hunger</td>
<td>food craving</td>
<td>desire to eat</td>
<td>desire to eat food</td>
<td>nutrition</td>
<td>satiety</td>
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<td>hunger</td>
<td>food craving</td>
<td>desire to eat</td>
<td>desire to eat food</td>
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<td>relief from eating</td>
<td>degree of appetite</td>
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<td>0.104</td>
<td>0.241</td>
<td>0.175</td>
<td>0.110</td>
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</table>

**Clustering results:***

- **Cluster 1**: anxiety, motivation to eat, comfort eating, relaxation, feeling, hunger, food craving, desire to eat, desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 2**: motivation to eat, comfort eating, relaxation, feeling, hunger, food craving, desire to eat, desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 3**: comfort eating, relaxation, feeling, hunger, food craving, desire to eat, desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 4**: relaxation, feeling, hunger, food craving, desire to eat, desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 5**: feeling, hunger, food craving, desire to eat, desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 6**: hunger, food craving, desire to eat, desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 7**: food craving, desire to eat, desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 8**: desire to eat, desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 9**: desire to eat food, nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 10**: nutrition, satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 11**: satiety, relief from eating, degree of appetite, desire to eat a snack.
- **Cluster 12**: relief from eating, degree of appetite, desire to eat a snack.
| Cluster 1 | anxiety | 0.046 | 0.108 | 0.128 | 0.054 | 0.107 | 0.059 | 0.255 | 0.038 | 0.189 | 0.156 | 0.488 | 0.560 | 0.532 | 0.367 | 0.017 | 0.257 | 0.171 | 0.295 | 0.108 | 0.465 | 0.334 | 0.224 | 0.130 |
| Cluster 2 | motivation to eat | 0.050 | 0.117 | 0.134 | 0.029 | 0.116 | 0.045 | 0.365 | 0.023 | 0.231 | 0.098 | 0.508 | 0.566 | 0.525 | 0.289 | 0.261 | 0.123 | 0.035 | 0.145 | 0.024 | 0.460 | 0.322 | 0.201 | 0.130 |
| Cluster 3 | urge to eat | 0.044 | 0.096 | 0.135 | 0.006 | 0.168 | 0.064 | 0.249 | 0.088 | 0.203 | 0.135 | 0.395 | 0.209 | 0.517 | 0.311 | 0.069 | 0.114 | 0.264 | 0.203 | 0.033 | 0.025 | 0.178 | 0.000 |
| Cluster 4 | appetite for a meal | 0.040 | 0.012 | 0.063 | 0.274 | 0.197 | 0.811 | 0.126 | 0.079 | 0.034 | 0.135 | 0.209 | 0.157 | 0.312 | 0.111 | 0.069 | 0.114 | 0.264 | 0.203 | 0.033 | 0.025 | 0.178 | 0.000 |
| Cluster 5 | food thoughts | 0.042 | 0.009 | 0.082 | 0.223 | 0.164 | 0.286 | 0.118 | 0.039 | 0.195 | 0.197 | 0.210 | 0.150 | 0.011 | 0.000 | 0.058 | 0.177 | 0.206 | 0.032 | 0.030 | 0.173 | 0.051 |
| Cluster 6 | willingness | 0.012 | 0.024 | 0.058 | 0.200 | 0.154 | 0.271 | 0.057 | 0.007 | 0.030 | 0.120 | 0.187 | 0.107 | 0.089 | 0.021 | 0.147 | 0.295 | 0.165 | 0.187 | 0.011 | 0.031 | 0.157 | 0.037 |
| Cluster 7 | desire to eat your next meal | 0.006 | 0.018 | 0.005 | 0.159 | 0.108 | 0.294 | 0.084 | 0.048 | 0.107 | 0.230 | 0.153 | 0.083 | 0.018 | 0.082 | 0.298 | 0.151 | 0.139 | 0.084 | 0.085 | 0.056 | 0.056 |
| Cluster 8 | fullness | 0.137 | 0.111 | 0.149 | 0.321 | 0.265 | 0.881 | 0.180 | 0.306 | 0.023 | 0.136 | 0.166 | 0.097 | 0.088 | 0.055 | 0.249 | 0.342 | 0.544 | 0.000 | 0.038 | 0.103 | 0.210 |
| Cluster 9 | desirefoodrelatedness | 0.117 | 0.176 | 0.072 | 0.109 | 0.079 | 0.128 | 0.072 | 0.039 | 0.015 | 0.145 | 0.124 | 0.115 | 0.014 | 0.019 | 0.189 | 0.260 | 0.171 | 0.012 | 0.504 | 0.161 | 0.056 | 0.044 |
| Cluster 10 | desire to eat your favorite food | 0.008 | 0.013 | 0.005 | 0.214 | 0.175 | 0.211 | 0.111 | 0.020 | 0.020 | 0.248 | 0.224 | 0.211 | 0.040 | 0.093 | 0.205 | 0.219 | 0.310 | 0.118 | 0.039 | 0.054 | 0.014 |
| Cluster 11 | non-stomach body aches | 0.096 | 0.223 | 0.125 | 0.106 | 0.011 | 0.386 | 0.155 | 0.302 | 0.054 | 0.043 | 0.436 | 0.416 | 0.404 | 0.034 | 0.100 | 0.140 | 0.264 | 0.255 | 0.080 | 0.079 | 0.123 | 0.018 |
| Cluster 12 | stomach body aches | 0.113 | 0.246 | 0.150 | 0.120 | 0.044 | 0.480 | 0.165 | 0.285 | 0.009 | 0.040 | 0.470 | 0.425 | 0.295 | 0.201 | 0.073 | 0.085 | 0.196 | 0.226 | 0.248 | 0.166 | 0.009 | 0.114 |
| Cluster 13 | food relatedness | 0.004 | 0.201 | 0.077 | 0.219 | 0.082 | 0.348 | 0.079 | 0.007 | 0.106 | 0.111 | 0.177 | 0.111 | 0.079 | 0.009 | 0.288 | 0.310 | 0.180 | 0.132 | 0.012 | 0.012 | 0.056 |
| Cluster 14 | Cluster 15 | 0.018 | 0.048 | 0.030 | 0.008 | 0.029 | 0.015 | 0.028 | 0.024 | 0.021 | 0.029 | 0.028 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 | 0.029 |
| Cluster 16 |Cluster 17 | 0.055 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 | 0.065 |
| Cluster 18 | Cluster 19 | 0.051 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 |
| Cluster 20 | Cluster 21 | 0.051 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 | 0.105 |
Appendix J: Factor contribution matrix after varimax rotation along with factor
placement
Factor
8

Factor
9

Factor
10

Factor
Placement

Rate the amount of food you currently desire

Factor
1
0.828

0.170

0.158

0.074

0.004

-0.072

-0.035

-0.035

-0.051

0.080

Factor 1

Rate the current amount of food you could eat

0.716

0.092

0.158

0.085

-0.069

-0.077

-0.026

-0.105

-0.062

0.040

Factor 1

Rate your current desire to eat any food

0.882

0.096

0.059

0.066

0.009

-0.038

-0.049

0.011

-0.064

-0.068

Factor 1

Rate your current desire to eat your next meal

0.815

0.229

0.082

0.055

-0.084

0.051

-0.057

-0.023

-0.026

-0.022

Factor 1

Rate your current desire to eat something fatty

0.811

-0.077

0.044

0.095

-0.136

-0.035

-0.008

0.151

0.066

0.094

Factor 1

Rate your current desire to eat something salty

0.780

-0.054

-0.002

0.201

-0.049

-0.086

-0.021

0.079

0.003

0.006

Factor 1

Rate your current desire to eat something savory

0.848

0.083

0.147

0.059

0.037

-0.066

-0.061

0.014

-0.014

0.008

Factor 1

Rate your current desire to eat something sw eet

0.688

-0.121

0.027

-0.029

-0.021

-0.095

-0.051

0.209

-0.088

-0.075

Factor 1

Rate your current desire to eat your favorite food

0.839

-0.026

0.069

0.060

-0.102

0.002

-0.008

-0.037

0.019

0.044

Factor 1

Rate your current desire to eat a snack

0.761

-0.072

0.044

0.146

-0.068

-0.068

0.100

0.059

-0.077

-0.056

Factor 1

Rate the extent to w hich your stomach currently aches

0.307

0.706

0.189

0.105

0.020

-0.102

-0.034

0.227

-0.170

0.047

Factor 2

Rate your current feeling of agitation

0.286

0.201

0.577

0.273

-0.023

-0.297

0.134

0.097

-0.066

0.081

Factor 3

Rate your current feeling of alertness

0.028

-0.075

0.017

-0.048

0.211

0.101

-0.172

-0.054

0.780

-0.077

Factor 9

Rate your current amount of energy

0.068

-0.052

-0.157

-0.123

0.148

0.108

-0.239

0.025

0.757

0.009

Factor 9

Rate your current feeling of anxiety

0.119

0.115

0.788

0.100

0.056

-0.154

0.045

0.261

0.045

0.069

Factor 3

Rate your current feeling of anxiousness

0.148

0.199

0.758

0.125

0.047

-0.169

0.049

0.228

0.033

0.062

Factor 3

Rate your current appetite

0.796

0.391

0.046

0.061

-0.057

-0.012

-0.023

-0.127

0.017

0.080

Factor 1

Rate the extent to w hich you currently feel stomach pain

0.249

0.687

0.306

0.248

0.008

-0.137

-0.047

0.186

-0.130

0.079

Factor 2

Rate your current feeling of calmness

-0.028

0.024

-0.668

-0.073

0.034

-0.014

0.029

0.001

0.345

-0.086

Factor 3

Rate your current attentiveness

-0.063

-0.081

-0.136

-0.033

0.029

0.104

-0.153

-0.013

0.793

-0.120

Factor 9

Rate the extent to w hich your stomach currently feels bloated

-0.066

0.094

0.169

0.154

-0.123

-0.007

0.135

0.732

-0.006

0.111

Factor 8

Rate the extent to w hich your stomach feels like it is currently bursting

-0.133

0.088

0.157

0.056

-0.024

0.050

0.092

0.735

-0.040

0.018

Factor 8

Rate your current feeling of coldness

0.157

0.156

0.099

0.109

-0.002

-0.009

0.029

0.070

-0.022

0.489

Factor 10

Rate your current feeling of depression

0.072

0.009

0.549

0.249

-0.147

-0.106

0.378

0.118

0.101

0.287

Factor 3

Rate your current appetite for a meal

0.798

0.373

-0.014

0.039

-0.081

0.079

0.038

-0.150

-0.007

-0.009

Factor 1

Rate your current feeling of dizziness

0.183

0.238

0.076

0.582

-0.096

-0.273

0.131

0.154

-0.165

0.428

Factor 4

Rate your current feeling of fullness

-0.496

-0.243

-0.063

0.006

0.262

0.000

0.089

0.440

0.164

-0.053

Factor 1

Rate your current feeling of drow siness

0.087

0.044

0.010

0.198

0.023

-0.082

0.630

0.296

-0.407

0.010

Factor 7

Rate your current feeling of faintness

0.111

0.292

-0.002

0.489

0.015

-0.203

0.147

0.119

-0.223

0.371

Rate the extent to w hich you currently feel famished

0.441

0.615

0.109

0.158

-0.052

-0.179

0.147

-0.125

-0.164

0.064

Factor 2

Rate the guilt you currently have from eating your last meal

-0.031

0.067

0.220

0.005

-0.225

-0.046

0.367

0.362

-0.071

0.395

Factor 10

Rate your current feeling of happiness

0.207

-0.063

-0.493

-0.150

0.258

-0.007

-0.214

0.023

0.346

-0.119

Factor 3

Rate the extent to w hich your head currently aches

0.109

0.295

0.080

0.619

-0.084

-0.033

0.159

0.069

-0.114

0.160

Factor 4

Rate the extent to w hich your stomach is currently rumbling

0.334

0.682

0.050

0.189

-0.202

-0.072

0.101

-0.035

0.015

0.134

Factor 2

Rate your current feeling of hunger

0.708

0.523

0.003

0.089

-0.114

-0.038

0.080

-0.207

-0.043

0.045

Factor 1

Rate your current feeling of irritability

0.132

0.232

0.507

0.333

-0.206

-0.162

0.295

0.138

0.016

0.150

Factor 3

Rate your current motivation to eat

0.810

0.300

-0.036

-0.025

-0.130

0.057

0.175

-0.134

0.023

0.084

Factor 1

Rate the extent to w hich your mouth currently feels dry

0.117

0.111

0.244

0.109

0.034

-0.095

0.415

0.010

-0.057

0.386

Rate the extent to w hich you are currently thinking of food

0.588

0.260

-0.053

0.029

-0.140

-0.043

0.170

-0.090

0.058

0.119

Factor 1

Rate your current feeling of nausea

0.020

0.217

0.267

0.322

-0.105

-0.133

0.140

0.306

-0.012

0.492

Factor 10

Rate your current non-stomach body aches

0.146

0.087

0.296

0.755

-0.093

-0.097

0.177

-0.017

-0.016

-0.112

Factor 4

Rate your current feeling of relaxedness

0.003

0.035

-0.597

-0.099

0.295

-0.117

0.147

0.100

0.258

-0.046

Factor 3

Rate your current feeling of restlessness

0.116

0.150

0.527

0.345

-0.072

-0.301

0.140

0.053

0.057

0.115

Factor 3

Rate the extent to w hich your ears are currently ringing

0.065

0.236

0.191

0.378

0.093

-0.191

0.052

-0.014

0.098

0.112

Factor 4

Rate your current feeling of sadness

-0.019

0.079

0.511

0.360

-0.115

-0.028

0.473

-0.021

0.036

0.266

Factor 3

Rate your current feeling of sickness

0.036

0.180

0.156

0.567

-0.129

-0.094

0.166

0.266

-0.134

0.185

Factor 4

Rate your current feeling of sleepiness

0.028

0.081

0.095

0.195

0.023

-0.042

0.771

0.161

-0.322

-0.070

Factor 7

Rate the extent to w hich you currently have stomach cramps

0.070

0.419

0.174

0.365

-0.007

-0.201

0.055

0.263

0.045

0.368

Factor 2

Rate the extent to w hich your stomach currently feels empty

0.537

0.580

0.016

0.062

-0.102

-0.018

0.181

-0.274

0.034

0.124

Factor 2

Rate the extent to w hich your stomach currently feels stuffed

-0.287

-0.019

0.038

0.053

0.046

-0.043

0.205

0.677

-0.037

0.078

Factor 8

Rate the extent to w hich your stomach is currently grow ling

0.297

0.664

0.038

0.159

-0.175

-0.037

0.162

-0.018

0.025

0.037

Factor 2

Rate your current non-stomach body pains

0.122

0.063

0.328

0.754

-0.055

-0.085

0.182

-0.010

-0.045

-0.163

Factor 4

Rate your current level of thirst

0.140

0.000

0.021

0.219

0.002

-0.050

0.420

0.049

0.082

0.310

Factor 7

Rate your current tiredness

0.044

0.133

0.090

0.199

-0.002

-0.015

0.779

0.187

-0.302

-0.091

Factor 7

Rate your current urge to eat

0.797

0.329

-0.014

-0.027

-0.152

0.085

0.211

-0.161

0.011

0.074

Factor 1

Rate your current feeling of w armth

-0.020

-0.024

-0.196

0.082

0.171

0.003

0.145

0.101

0.223

-0.439

Factor 10

Rate your current feeling of w eakness

0.160

0.298

0.139

0.428

-0.048

-0.156

0.453

0.110

-0.244

0.144

Factor 7

Rate your current w illingness to eat

0.789

0.284

-0.030

-0.085

-0.105

0.034

0.203

-0.189

0.071

0.071

Factor 1

Rate your contentedness w ith the food you last ate

-0.018

-0.129

-0.091

-0.030

0.761

0.276

-0.069

-0.150

0.144

-0.135

Factor 5

Rate your feeling of fullness from the food you last ate

-0.304

-0.110

-0.028

-0.073

0.716

0.121

0.065

0.197

0.072

0.018

Factor 5

Rate your appetite satisfaction from the food you last ate

-0.167

-0.055

-0.035

-0.093

0.806

0.282

0.016

0.042

0.055

-0.048

Factor 5

Rate your desire for more of the food you last ate

0.430

-0.092

-0.024

0.100

0.234

0.240

-0.008

-0.043

0.172

0.140

Factor 1

Rate your current desire for a different food than you last ate

0.660

0.116

-0.098

-0.026

-0.037

-0.010

0.162

-0.199

0.218

0.131

Factor 1

Rate the difficulty to eat the food you last ate

-0.060

0.145

0.200

-0.023

0.016

-0.251

0.122

0.059

-0.060

0.223

None

Rate your satisfaction w ith the food you last ate

0.058

0.000

-0.170

0.051

0.626

0.439

0.002

-0.041

0.141

0.029

Factor 5

Rate your satisfaction w ith your feeling of fullness from the food you last ate

-0.198

0.006

-0.116

-0.078

0.759

0.142

-0.098

-0.010

0.046

-0.094

Factor 5

Rate your feeling that the meal or snack w as a sufficient size

-0.197

-0.072

0.015

-0.056

0.676

0.133

0.013

-0.121

0.040

0.007

Factor 5

Rate your overall liking of the food you last ate3

0.001

-0.084

-0.099

0.004

0.274

0.831

0.047

0.018

-0.010

-0.023

Factor 6

Rate your liking of the appearance of the food you last ate

3

Factor Factor Factor
2
3
4

Factor
5

Factor Factor
6
7

Factor 4

Factor 7

-0.068

-0.047

-0.130

-0.150

0.177

0.736

0.028

-0.010

0.092

0.018

Factor 6

Rate your liking of the odor of the food you last ate3

-0.007

-0.018

-0.032

-0.235

0.129

0.586

-0.157

0.042

0.037

-0.101

Factor 6

Rate your liking of the flavor of the food you last ate3
Rate your liking of the texture of the food you last ate3

0.000

-0.152

-0.028

-0.079

0.262

0.817

-0.080

-0.015

0.004

-0.073

Factor 6

-0.071

-0.054

-0.101

-0.128

0.187

0.756

-0.029

-0.033

0.162

-0.021

Factor 6

214


Appendix K: E-mail Screener used for the orange and oatmeal and smoothie study.

Hello!

The Sensory Center at the University of Minnesota is recruiting panelists to participate in a study on breakfast foods beginning this month and going throughout the summer. The test will be held in McNeal Hall or the Food Science and Nutrition Building on the Saint Paul Campus and will be scheduled based on your availability.

***To be eligible for the study, we need people with the following qualifications***

- Have no food allergies
- Be between the ages of 18-64
- Speak English as your first language
- Willing to evaluate two breakfast meals on two separate mornings between the times of 7am-8:30am that will be scheduled based on your availability (each breakfast session will last approximately 1 hour)
- Willing to answer a series of questions one hour after the morning breakfast session. You will be able to take this questionnaire with you out of the Sensory Center, so you can go back to work/class. You will need to have a flexible enough schedule to be able to fill out the questionnaire one hour after leaving the lab (5 min of your time)
- Willing to come back to the Sensory Center 2 hours after your breakfast session to return your questionnaires and answer a few more questions (30 min of your time).

Compensation will be provided for all participation (A total of $13 + 2 breakfast meals + 2 snacks). Participants will be compensated $1.00 for coming to the first breakfast and $1.00 for returning for the second session 2 hours after the breakfast session. Another $1.00 will be paid for attending the second breakfast and then the remaining $10 for returning to the final session 2 hours after the second breakfast. Payment will be provided after the completion of each section of the study.

If you are interested in participating please fill out the screener below and return by e-mail to sensory@umn.edu. Your responses will be evaluated to see if you qualify to be part of the study. Your responses to all questions on this form will be kept confidential. If you qualify, we will contact you to schedule your participation. You may choose not to participate, even if you have qualified.

Thanks!

Breakfast Study Screener

First Name: _____________________    Last Name: ______________________

E-mail Address: _____________________

Gender: Female ____  Male____

Age: _____

Height: _____

Weight: _____

Do you have any food allergies? Yes____  No____

Do you usually eat breakfast? Yes____  No____
Check all of the following breakfast foods that you like and are willing to eat:

___ Cereal such as cheetos
___ Plain Oatmeal
___ Cinnamon sugar flavored oatmeal
___ Oranges
___ Apples
___ Grapes
___ Cantaloupe
___ Honeydew
___ Scrambled eggs
___ Bacon
___ Sausages
___ Biscuits
___ Pancakes
___ Cheese and crackers
___ Yogurt
___ Pastries
___ Bagels
___ Waffles
___ Breakfast bars
___ Breakfast beverages such as Carnation instant breakfast

Are you a native English speaker? Yes___ No____

Which of the following statements describes you?
___ I am currently working on losing weight
___ I am currently working on gaining weight
___ I am actively working on maintaining my current weight
___ I am not currently involved in any weight management effort – for weight loss, weight gain or weight maintenance.

Are you currently on a medically supervised diet of any kind? Yes____ No____

Have you ever had, or currently have any of the following medical conditions?
___ Diabetes
___ Diagnosed with an eating disorder
___ Celiac disease
___ Depression

Do you have any condition that restricts your diet in any way? Yes____ No____

If you qualify for the study, I will contact you to schedule a date and time for your first breakfast session. There will be availability for this study beginning in mid-July and throughout the rest of the summer. Again, your responses to all questions on this form will be kept confidential. You may choose not to participate, even if you have qualified.
**Appendix L:** Photo of the two test breakfasts (oatmeal and oranges) and the snack tray served in Chapter 4 Part I – Testing the Hunger and Fullness Questionnaire with Oranges and Oatmeal
Appendix M: Orange and Oatmeal Study and Smoothie Study Screen Shots of ballot

During this study you will be asked to do the following:

1. Answer a series of questions related to your hunger and fullness feelings
2. Consume a provided breakfast in its entirety
3. Answer a second series of questions related to hunger and fullness
4. Take a questionnaire packet with you and fill out the questionnaire 1 hour after the breakfast session.
5. Return to the lab 2 hours after consuming your breakfast to answer a final questionnaire.

***Please pass your panelist ID card through the window before beginning the study.***

Instructions

Each questionnaire that you will be asked to answer during this study will contain 3 types of scales. These 3 scales will be described below and on the following 2 pages.

Scale 1: For the majority of statements you will be making your intensity ratings on a scale that ranges from NO SENSATION to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

Please read through an example of scale 1 shown below:

![Example with Scale 1](image)

Scale 2: For several of the statements you will be asked to make intensity ratings on a scale that ranges from NONE to GREATEST POSSIBLE AMOUNT.

Please read through an example of scale 2 shown below:

![Example with Scale 2](image)

Scale 3: For several of the questions you will be asked to make LIKING ratings on a scale that ranges from GREATEST IMAGINABLE DISLIKE to GREATEST IMAGINABLE LIKE.

Please read through an example of scale 3 shown below:

![Example with Scale 3](image)
Part 1: Before Breakfast Questionnaire

Please answer the questions on the following pages before being served your breakfast.

Remember to please base your ratings on your ***feelings right now***

Rate your overall liking of the food you last ate

|-----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|

Rate your liking of the flavor of the food you last ate

|-----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|

Rate your liking of the appearance of the food you last ate

|-----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|

Rate your liking of the texture of the food you last ate

|-----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|

Rate your liking of the odor of the food you last ate

|-----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|--------|----------|--------|-------------|-------------|

Rate the enjoyment you had from the food you last ate

<table>
<thead>
<tr>
<th>How</th>
<th>Strong</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>Weak</td>
<td>Moderate</td>
<td>Strong</td>
<td>Very Strong</td>
</tr>
<tr>
<td>Difficult</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rate your current desire for more of the same food you last ate

<table>
<thead>
<tr>
<th>How</th>
<th>Strong</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>Weak</td>
<td>Moderate</td>
<td>Strong</td>
<td>Very Strong</td>
</tr>
<tr>
<td>Difficult</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rate your current desire for a different food than the food you last ate

<table>
<thead>
<tr>
<th>How</th>
<th>Strong</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>Weak</td>
<td>Moderate</td>
<td>Strong</td>
<td>Very Strong</td>
</tr>
<tr>
<td>Difficult</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rate your feeling of fullness from the food you last ate

<table>
<thead>
<tr>
<th>How</th>
<th>Strong</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Satisfied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfied</td>
<td>Weak</td>
<td>Moderate</td>
<td>Strong</td>
<td>Very Strong</td>
</tr>
<tr>
<td>Somewhat Satisfied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Satisfied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Not Satisfied</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

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<table>
<thead>
<tr>
<th>Rate your appetite satisfaction from the food you last ate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Rate your contentedness with the food you last ate</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rate your satisfaction with the food you last ate</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rate your satisfaction with your feeling of fullness from the food you last ate</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rate the extent to which you felt the food you last ate was a sufficient size</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rate the strength of the feeling that you had enough to eat from the food you last ate</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rate how difficult it was to eat the food you last ate</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rate your current motivation to eat</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Rate your current urge to eat</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Rate your current appetite for a meal

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate the extent to which you are currently thinking of food

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current willingness to eat

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current desire to eat

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current feeling of fullness

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current desire to eat something savory

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current desire to eat your favorite food

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current desire to eat something fatty

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current desire to eat something salty

<table>
<thead>
<tr>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>
Rate your current desire to eat any food

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current desire to eat a snack

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current desire to eat something sweet

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate the extent to which you currently have stomach cramps

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate the extent to which you currently feel stomach pain

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current stomach muscle spasms

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>No spasms</th>
<th>Slightly palpable</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate your current feeling of nausea

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>No nausea</th>
<th>Slightly noticeable</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate the extent to which your stomach currently aches

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>Not at all</th>
<th>Slightly</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>

Rate the extent to which your stomach currently feels bloated

<table>
<thead>
<tr>
<th>Intensity Level</th>
<th>Not at all</th>
<th>Slightly</th>
<th>Strong</th>
<th>Very Strong</th>
</tr>
</thead>
</table>
Rate the extent to which your stomach feels it is currently burning

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Severe</th>
<th>Completely</th>
</tr>
</thead>
</table>

Rate your current feeling of indigestion

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Severe</th>
<th>Completely</th>
</tr>
</thead>
</table>

Rate the extent to which your stomach currently feels stuffed

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Severe</th>
<th>Completely</th>
</tr>
</thead>
</table>

Rate your current feeling of gastric tightness

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Severe</th>
<th>Completely</th>
</tr>
</thead>
</table>

Rate the amount of food you currently desire

| None | | | | | | | |

Rate the current amount of food you could eat

| None | | | | | | | |
The questionnaire continues on the same as the before breakfast questionnaire.

Participants are given a packet containing the same hunger and fullness questionnaire as above to be filled out 1 hour after they leave.

They return 2 hours after their breakfast to fill the hunger and fullness questionnaire (2 hours after breakfast) and attend the snack session.

Once the timer has reached zero, you may begin the final questionnaire.

The snack time is now over. Please pass your tray through the window before beginning the final questionnaire.

Click the hand when you are ready to begin the final questionnaire.

Remember to please base your ratings on your ***feelings right now***

Participants then fill out the hunger and fullness questionnaire 1 last time.
On participants’ second session, they answer the following questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>When you have put on weight do you eat less than you usually do?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you try to eat less at meals than you would like to eat?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you refuse food or desirably offered to you because you are worried about your weight?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you watch exactly what you eat?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you deliberately eat less that are slimming?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When you have eaten too much, do you eat less than usual the following day?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you deliberately eat less in order not to become heavier?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you try not to eat between meals because you are watching your weight?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often in the evenings do you try not to eat because you are watching your weight?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you take your weight into account with what you eat?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When have eaten my quota of calories I am usually good about not eating any more.</td>
<td>True</td>
<td>False</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I deliberately take small helpings as a means of weight control.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.</td>
<td>True</td>
<td>False</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I consciously hold back at meals in order not to gain weight.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I pay a great deal of attention to changes in my figure.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How conscious are you of what you are eating?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How are you likely to consistently eat less than you want?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If I eat a little bit more on one day, I make up for it the next day.</td>
<td>True</td>
<td>False</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I pay attention to my figure, but I still enjoy a variety of foods.</td>
<td>True</td>
<td>False</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I prefer light foods that are not fattening.</td>
<td>True</td>
<td>False</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If I eat a little bit more during one meal, I make up for it at the next meal.</td>
<td>True</td>
<td>False</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you deliberately restrict your intake during meals even though you would like to eat more?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have a pretty good idea of the number of calories in common food.</td>
<td>True</td>
<td>False</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I count calories as a conscious means of controlling my weight.</td>
<td>True</td>
<td>False</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How often are you dying in a conscious effort to control your weight?

☐ Rarely  ☐ Sometimes  ☐ Usually  ☐ Always

Would a weight fluctuation of 5 lbs affect the way you live your life?

☐ Not at all  ☐ Slightly  ☐ Moderately  ☐ Very much

Do feelings of guilt about overeating help you to control your food intake?

☐ Never  ☐ Rarely  ☐ Often  ☐ Always

How frequently do you avoid 'stocking up' on tempting foods?

☐ Almost never  ☐ Seldom  ☐ Usually  ☐ Almost always

How likely are you to shop for low calorie foods?

☐ Unlikely  ☐ Slightly unlikely  ☐ Moderately likely  ☐ Very likely

I eat diet foods, even if they do not taste very good.

☐ True  ☐ False

Without a diet plan I wouldn’t know how to control my weight.

☐ True  ☐ False

Quick success is most important for me during a diet.

☐ True  ☐ False

Do you usually eat breakfast?

☐ Yes  ☐ No

Which of the following statements describe you?

☐ I am currently working on losing weight
☐ I am currently working on gaining weight
☐ I am actively working on maintaining my current weight
☐ I am not currently involved in any weight management effort

Are you currently on a medically supervised diet of any kind?

☐ Yes  ☐ No

A diet would be too boring a way for me to lose weight.

☐ True  ☐ False

I would rather skip a meal than stop eating in the middle of one.

☐ True  ☐ False

I alternate between times when I diet strictly and times when I don’t pay much attention to what and how much I eat.

☐ True  ☐ False

Sometimes I skip meals to avoid gaining weight.

☐ True  ☐ False

I avoid some foods on principle even though I like them.

☐ True  ☐ False

I try to stick to a plan when I lose weight.

☐ True  ☐ False
Have you ever had, or currently have any of the following medical conditions? Check all that apply.
- Diabetes
- Diagnosed with an eating disorder
- Celiac disease
- Diagnosed with depression
- I have never been diagnosed with any of the above conditions

Do you have any condition that restricts your diet in any way?
- Yes
- No

What is your age?
- <18 years old
- 18-24 years old
- 25-29 years old
- 30-34 years old
- 35-39 years old
- 40-44 years old
- 45-49 years old
- 50-54 years old
- 55-59 years old
- 60-64 years old
- 65-69 years old
- ≥70 years old

What is your gender?
- Female
- Male

What is your height?
- <4 feet 8 inches
- 4 feet 8 inches
- 4 feet 9 inches
- 4 feet 10 inches
- 4 feet 11 inches
- 5 feet
- 5 feet 1 inch
- 5 feet 2 inches
- 5 feet 3 inches
- 5 feet 4 inches
- 5 feet 5 inches
- 5 feet 6 inches
- 5 feet 7 inches
- 5 feet 8 inches
- 5 feet 9 inches
- 5 feet 10 inches
- 5 feet 11 inches
- 6 feet
- 6 feet 1 inch
- 6 feet 2 inches
- 6 feet 3 inches
- 6 feet 4 inches
- 6 feet 5 inches
- 6 feet 6 inches
- 6 feet 7 inches
- 6 feet 8 inches
- 6 feet 9 inches
- 6 feet 10 inches
- 6 feet 11 inches
- 7 feet
- >7 feet
What is your weight in pounds?

Do you speak English as your first language?

- Yes
- No
Appendix N: Photo of the smoothie (one smoothie was served with cumin added and one without) and the snack tray served in Chapter 4 Part II – Testing the Hunger and Fullness Questionnaire with smoothies differing in liking.
Appendix O: Study III Fiber Nutrition Study Screening Information

Initial E-mail Screener

Hello!
The Sensory Center at the University of Minnesota is recruiting panelists to participate in a Fiber Nutrition Study. The study will be held in McNeal Hall or the Food Science and Nutrition Building on the Saint Paul Campus and will be scheduled based on your availability. This is a study of fibers in a dinner and breakfast meal. These fibers are already used in food products and are safe to consume.

***To be eligible for the study, we need people with the following qualifications***
- Female between the age of 18-40 years old
- Speak English as your first language
- Willing to attend a 1 hour screening session to learn more about the study and to verify your eligibility to participate in the study
- Willing to attend 5 visits (3.5 hours each) to consume a breakfast bar, answer surveys, and eat a provided lunch scheduled during the months of November-March
- Willing to consume a provided dinner the night before coming to each of the 5 visits
- Willing to fast for 12 hours before coming to each of the 5 visits
- Willing to provide breath samples during each of the 5 visits (this involves blowing your breath into a collection bag)

Compensation will be provided for all participation. A total of $625 will be paid for completion of the entire study. Payment will be provided after the completion of the study.

If you are interested in participating, please fill out the screener below and return by e-mail to sensory@umn.edu. Your responses will be evaluated to see if you qualify to attend the screening session. The screening session will ultimately determine your enrollment in the study. At the screening session, you will learn about the study and what you would be asked to do if you were to participate in the study. After the screening session, you will have the option not to participate in the study if you decide you cannot make the time commitment or are no longer interested in participating in the study. Your responses to all questions on this form will be kept confidential.

Thanks!
----
Fiber Nutrition Study Screener

You will be answering a medical screening questionnaire, but you do not need to answer any questions that you do not feel comfortable answering. If you do not meet the criteria for the study, we will destroy the information collected. If you do meet the first phase of the screening, we will e-mail you to set up the 1 hour screening session.

Name ___________________  
Daytime phone number:_________________  
Home phone or cell phone number (evening):________________________________________
Email: ________________________  
Best time of day and manner to be reached__________________________
Date of birth_______________  
Age______  
Height (feet and inches)_____   Weight (pounds)_____  
Are you currently pregnant or lactating? Yes____No____  
Do you plan on becoming pregnant in the next 6 months? Yes____No____  
Are you pre-menopausal (still get your menstrual cycle)? Yes____No____  
If yes, is your menstrual cycle regular/consistent? Yes, it is regular____No, it is irregular____  
What is the average length of your cycle? _____days  
Do you keep track of when your menstrual cycle starts each month? Yes____No____  
Do you have any food or other allergies? Yes____No____  
If YES, what are they?  
Do you eat breakfast most days of the week? Yes____No____

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Do you like granola bars, candy bars, and pizza? Yes____No____
Do you enjoy sweets? Yes____No____
Are you taking any lipid-lowering or cholesterol-lowering medications? Yes____No____
Are you taking any medications to lose weight? Yes____No____
Are you taking any medications to lower your blood pressure? Yes____No____
Are you taking any steroid medications for chronic inflammation? Yes____No____
Do you currently smoke or chew tobacco? Yes____No____
Are you a vegetarian? Yes____No____
Have you been diagnosed with any form of cancer within last 5 years? Yes____No____
If yes, were you diagnosed with skin cancer? Yes____No____
Have you ever been diagnosed with:
Heart disease Yes____No____
Kidney disease Yes____No____
Liver disease Yes____No____
Diabetes Yes____No____
Eating disorder Yes____No____
Ulcerative Colitis Yes____No____
Crohns Disease Yes____No____
Any other gastrointestinal conditions Yes____No____
Have you lost or gained weight in the past 3 months? Yes____No____
If yes, how much weight have you lost or gained? ________
Have you taken antibiotics within the last 3 months? Yes____No____
Have you participated in an intervention research study before? Yes____No____
If yes, when and what was the study (please describe)? ______________________
In the past 6 months, have you had treatment for drug or alcohol abuse? Yes____No____
Do you eat any of the following foods on MOST DAYS of the WEEK? If you only eat these foods occasionally please answer NO to each category.
High-fiber cereals (All Bran, Fiber One, Raisin Bran, etc.)
Yes, I eat these on most days of the week____
No, I do not eat these foods or I do not eat these foods on most days of the week____
High-fiber bread products (100% whole wheat bread, 100% whole wheat bagels, 100% whole wheat pasta)
Yes, I eat these on most days of the week____
No, I do not eat these foods or I do not eat these foods on most days of the week____
Beans (black, kidney, pinto, white, etc.)
Yes, I eat these on most days of the week____
No, I do not eat these foods or I do not eat these foods on most days of the week____
High-fiber grains (barley, quinoa, buckwheat, spelt, etc)
Yes, I eat these on most days of the week____
No, I do not eat these foods or I do not eat these foods on most days of the week____
High-fiber fruits and vegetables (more than 1 cup berries, apples, pears, dried fruits, peas, beets, and/or artichokes)
Yes, I eat these on most days of the week____
No, I do not eat these foods or I do not eat these foods on most days of the week____
Do you take vitamin/mineral supplements? Yes____No____
If yes, what is/are the supplement(s)?____
How often do you take it?____
Do you take fiber supplements such as Metamucil or Citrucel? Yes____No____
If yes, what is the supplement?____
How often do you take it?____
Do you take any herbal supplements? Yes____No____
If yes, what is the supplement?____
How often do you take it?____
Do you consume alcohol? Yes____No____
If yes, how many drinks per week do you typically consume?(One drink = 12 oz beer, 4 oz wine, 1 oz hard liquor)____
How would you rate your present state of health compared to other people about your age?
Excellent____ Good____ Fair____ Poor____
Have you taken any medication in the past month (over the counter or prescription) or are you currently taking any medication? Yes____No____
If yes, please list the medication(s) and the dose/frequency.
____________________________  ______________________________
____________________________  ______________________________

Do you exercise regularly? Yes____No____
If yes, what type, how frequently, and for how long each time? ______________________________

**This study will include 5 morning visits (Monday-Friday beginning between 7-8:30am and lasting 3.5 hours) to McNeal Hall on the Saint Paul Campus. The 5 visits will last approximately 3.5 hours each. Are you willing to make this commitment? Yes____No____
Since the study sessions need to be scheduled during the first 14 days of your menstrual cycle, would you be willing to track your menstrual cycle during the months of the study and let the study coordinator know what day you are on in your cycle? Yes____No____
Since scheduling of study visits will be based on where you are in your menstrual cycle, which can vary from month to month, do you have at least 1 day a week (Monday-Friday) that you would be able to attend a 3.5 hour session? (At most, you will only attend 2 sessions a month). Yes____No____
Are you willing to follow a low-fiber lead-in diet the day before each visit? Yes____No____
Are you willing to consume a provided dinner the evening before each visit? Yes____No____
Are you willing to come in a fasted state (nothing to eat for 12 hours) before each visit? Yes____No____
At each visit, are you willing to eat a breakfast and lunch, provide breath samples, and answer questions about hunger and palatability? Yes____No____
Are you willing and able to record all that you eat during a 24 hr period 5 times during the study? Yes____No____
Do you have reliable transportation to get to the Saint Paul Campus? Yes____No____
Do you travel out of the Twin Cities area frequently? Yes____No____
Are there specific dates you will not be available (holidays, etc, Note: We will not be running the study Nov 25th-28th or Dec 23rd - Jan 2nd)? Yes____No____
If yes, what are these dates (you do not need to include the Thanksgiving or Winter break dates I already listed since the study will not be run during those dates)? ______________________________
Are you planning on living in the area for the next 10 months? Yes____No____
Do you speak English as your first language? Yes____No____
After hearing about the study, how do you feel about the time commitment and effort involved to complete the study? ______________________________

We will get back to you if you have met the screening requirements to set up the screening session. The screening session will ultimately determine your enrollment in the study. At the screening session, you will learn about the study and what you would be asked to do if you were to participate in the study. After the screening session, you will have the option not to participate in the study if you decide you cannot make the time commitment or are no longer interested in participating in the study.

Thanks,
Melinda
Once a participant qualified based on the e-mail screener, she was sent a link to an online questionnaire to measure her eating restraint. The online questionnaire was created using SIMS 2000 (Sensory Computer Systems, Morristown, NJ, USA). Screen shots of this questionnaire are shown below:

<table>
<thead>
<tr>
<th>Eating Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please answer the following questions about your eating habits that you feel most accurately describes your eating behavior.</td>
</tr>
<tr>
<td>When you have put on weight do you eat less than you usually do?</td>
</tr>
<tr>
<td>Never</td>
</tr>
<tr>
<td>Seldom</td>
</tr>
<tr>
<td>Sometimes</td>
</tr>
<tr>
<td>Often</td>
</tr>
<tr>
<td>Very often</td>
</tr>
<tr>
<td>Do you try to eat less at mealtime than you would like to eat?</td>
</tr>
<tr>
<td>Never</td>
</tr>
<tr>
<td>Seldom</td>
</tr>
<tr>
<td>Sometimes</td>
</tr>
<tr>
<td>Often</td>
</tr>
<tr>
<td>Very often</td>
</tr>
<tr>
<td>How often do you refuse food or drink offered to you because you are concerned about your weight?</td>
</tr>
<tr>
<td>Never</td>
</tr>
<tr>
<td>Seldom</td>
</tr>
<tr>
<td>Sometimes</td>
</tr>
<tr>
<td>Often</td>
</tr>
<tr>
<td>Very often</td>
</tr>
</tbody>
</table>

Please click the ‘next page’ button at the top of the page to continue with the questionnaire.

| Do you watch exactly what you eat? |
| Never |
| Seldom |
| Sometimes |
| Often |
| Very often |
| Do you deliberately eat foods that are slimming? |
| Never |
| Seldom |
| Sometimes |
| Often |
| Very often |
| When you have eaten too much, do you eat less than usual the following day? |
| Never |
| Seldom |
| Sometimes |
| Often |
| Very often |

Please click the ‘next page’ button at the top of the page to continue with the questionnaire.

| Do you deliberately eat less in order not to become heavier? |
| Never |
| Seldom |
| Sometimes |
| Often |
| Very often |
| How often do you try not to eat between meals because you are watching your weight? |
| Never |
| Seldom |
| Sometimes |
| Often |
| Very often |
| How often in the evenings do you try not to eat because you are watching your weight? |
| Never |
| Seldom |
| Sometimes |
| Often |
| Very often |

Please click the ‘next page’ button at the top of the page to continue with the questionnaire.

| Do you take your weight into account what you eat? |
| Never |
| Seldom |
| Sometimes |
| Often |
| Very often |

When I have eaten my quota of calories, I am usually good about not eating any more. |
| True |
| False |

I deliberately take small helpings as a means of weight control. |
| True |
| False |
How conscious are you of what you are eating?
- Not at all
- Slightly
- Moderately
- Extremely

How likely are you to consciously eat less than you want?
- Unlikely
- Slightly unlikely
- Moderately likely
- Very likely

I'll eat a little bit more on one day. I make up for it the next day.
- True
- False

Please click the 'next page' button at the top of the page to continue with the questionnaire.

I pay attention to my figure, but I still enjoy a variety of foods.
- True
- False

I prefer light foods that are not fattening.
- True
- False

I'll eat a little bit more during one meal. I make up for it at the next meal.
- True
- False

Please click the 'next page' button at the top of the page to continue with the questionnaire.

Do you deliberately restrict your intake during meals even though you would like to eat more?
- Always
- Often
- Seldom
- Never

I have a pretty good idea of the number of calories in common foods.
- True
- False

I count calories as a conscious means of controlling my weight.
- True
- False

Please click the 'next page' button at the top of the page to continue with the questionnaire.

How often are you dieting in a conscious effort to control your weight?
- Frequently
- Occasionally
- Occasionally
- Always

Would a weight fluctuation of 5 lbs affect the way you live your life?
- Not at all
- Slightly
- Moderately
- Very much

Do feelings of guilt about overeating help you to control your food intake?
- Never
- Seldom
- Rarely
- Always

Please click the 'next page' button at the top of the page to continue with the questionnaire.

How frequently do you avoid “stocking-up” on tempting foods?
- Almost never
- Seldom
- Usually
- Almost always

How likely are you to shop for low calorie foods?
- Unlikely
- Slightly unlikely
- Moderately likely
- Very likely

I eat diet foods, even if they do not taste very good.
- True
- False

Please click the 'next page' button at the top of the page to continue with the questionnaire.
A diet would be too boring a way for me to lose weight.
- True
- False

I would rather skip a meal than stop eating in the middle of one.
- True
- False

I alternate between times when I diet strictly and times when I don’t pay much attention to what and how much I eat.
- True
- False

Please click the “next page” button at the top of the page to continue with the questionnaire.

Sometimes I skip meals to avoid gaining weight.
- True
- False

I avoid some foods on principle even though I like them.
- True
- False

I try to stick to a plan when I lose weight.
- True
- False

Please click the “next page” button at the top of the page to continue with the questionnaire.

Without a diet plan I wouldn’t know how to control my weight.
- True
- False

Quick success is most important to me during a diet.
- True
- False

Life is too short to worry about dieting.
- Yes
- No.

Please click the “next page” button at the top of the page to continue with the questionnaire.

I enjoy eating too much to stick to counting calories or watching my weight.
- Yes
- No

I often stop eating when I am not really full as a conscious means of limiting the amount that I eat.
- Yes
- No

I eat anything I want, any time I want.
- Yes
- No

Please click the “next page” button at the top of the page to continue with the questionnaire.

I do not eat some foods because they make me fat.
- Yes
- No

How likely are you to consciously eat slowly in order to cut down on how much you eat?
- Unlikely
- Slightly unlikely
- Moderately likely
- Very likely

On a scale of 0 to 5, where 0 means no restraint in eating (eating whatever you want, whenever you want it) and 5 means total restraint (constantly limiting food intake and never giving in), what number would you grade yourself?
- 0
- 1
- 2
- 3
- 4
- 5

Please click the “next page” button at the top of the page to continue with the questionnaire.
Do you usually eat breakfast?
- Yes
- No

Which of the following statements describes you?
- I am currently working on losing weight
- I am currently working on gaining weight
- I am actively working on maintaining my current weight
- I am not currently involved in any weight management effort

Please click the 'next page' button at the top of the page to continue with the questionnaire.

You have reached the end of the questionnaire. Your responses will be assessed, and we will be contacting you to let you know if you have qualified to attend a screening session. If you have any questions, please contact Melinda Kearsley at mkearsley@umw.edu
Appendix P: Photos of the dinner and breakfast bars
**Appendix Q**: Latin Square design for 22 participants that is balanced for carryover and position effects and blinding codes for the samples.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sample Order 1</th>
<th>Sample Order 2</th>
<th>Sample Order 3</th>
<th>Sample Order 4</th>
<th>Sample Order 5</th>
</tr>
</thead>
<tbody>
<tr>
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<td>5</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Blinding Codes:**

- Sample 1 – 137 (HPX Inulin, Orafti)
- Sample 2 – 319 (Promitor soluble Corn Fiber, Tate & Lyle)
- Sample 3 – 588 (Orafti P95 Oligofructose, Orafti)
- Sample 4 – 602 (Fibersym RW RS4 Resistant Wheat Starch, MGP Ingredients, Inc.)
- Sample 5 – 946 (Control)
**Appendix R: Low-fiber lead-in diet instructions for the day before study visits**

### Diet and Activity the Day Before your Study Visit

Please read the following instructions regarding the foods you eat and drink during the 24 hours before your visit at WICU Hall. Everyone in the study will follow the same menu plan. This will help us make sure your food choices the day before the study do not influence our study results.

If you have any questions or concerns about these instructions, please do not hesitate to contact Michelle Karako at mkarako@umich.edu or 734-936-5317.

#### Fiber Supplements

Please do not use any fiber supplements or tablets, such as Metamucil, Citrucel, Benecol, and others.

#### Diet

Please eat a low-fiber diet. The following are examples of high and low fiber foods:

**High fiber foods (avoid excessive amounts of these)**
- Whole grain/wheat bread
- Whole grain cereals (i.e., Total, All Bran, Raisin Bran, Fiber One)
- High fiber fruit and vegetables (i.e., apples, oranges, whole grains (i.e., brown rice, quinoa, barley, oats))
- Beans

**Low fiber foods (use these as substitutions for the high fiber foods)**
- White bread
- French bread
- White English muffin or bagel
- White rice
- Fruit juice
- Meat and dairy

### Low-Fiber, Lead-In Diet

<table>
<thead>
<tr>
<th>Break</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal</td>
<td>2 in cup blackberries</td>
</tr>
<tr>
<td>2 Bread</td>
<td>1 piece of white toast, or 1 white English muffin</td>
</tr>
<tr>
<td>1 tsp. butter or margarine</td>
<td></td>
</tr>
<tr>
<td>1 Dairy serving</td>
<td>1 cup of low-fat milk, or 1 cup of low-fat yogurt</td>
</tr>
<tr>
<td>1 tsp. juice</td>
<td>Orange, pineapple, or grape juice</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2 oz. Meat</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 oz. cheese</td>
<td>The cheese bar, ham or meatloaf</td>
</tr>
<tr>
<td>2 slices white bread</td>
<td>Light or white bread</td>
</tr>
<tr>
<td>1 tsp. mayonnaise</td>
<td>Light mayonnaise</td>
</tr>
<tr>
<td>1 Dairy serving</td>
<td>1 cup of low-fat milk, or 1 cup of low-fat yogurt, or 1 container of low-fat yogurt</td>
</tr>
</tbody>
</table>

| Side dish or pretzels | 1 oz. 2 ounce serving |
| Fruits | Various fruits and dried fruits (e.g., cranberries) |

<table>
<thead>
<tr>
<th>Mid-afternoon snack</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-fiber granola bar</td>
<td>Medium snack, orange, or banana</td>
</tr>
<tr>
<td>Breakfast</td>
<td>Example</td>
</tr>
<tr>
<td>2 oz. meat</td>
<td>Scrambled eggs, baked or grilled</td>
</tr>
<tr>
<td>1/2 cup cooked potato</td>
<td>Can substitute instant rice</td>
</tr>
<tr>
<td>1/2 cup cooked rice</td>
<td>1 cup of white rice, or French bread</td>
</tr>
<tr>
<td>Vegetables</td>
<td>Can add steamed broccoli, or 1 cup mixed vegetables</td>
</tr>
<tr>
<td>1 tsp. butter, margarine or olive oil</td>
<td>Can substitute non-fat yogurt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Eating snack</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit juice</td>
<td>Orange, pineapple, or grape juice</td>
</tr>
<tr>
<td>Debbie</td>
<td>1 medium or 2 small blue corn tortillas</td>
</tr>
</tbody>
</table>
Appendix S: Screen-shots of the questionnaire for the fiber study

Welcome to the Fiber Study!

During each session of this study you will be asked to do the following:

1. Collect a breath sample before breakfast
2. Answer a series of questions related to your hunger and fullness feelings before breakfast
3. Consume a provided breakfast in its entirety
4. Collect a breath sample at 15 min, 30 min, 45 min, 60 min, 90 min, 120 min, and 180 min after breakfast
5. Consume a provided lunch at 180 min after breakfast
6. Answer a final series of questions related to your hunger and fullness feelings
7. Take a food diary with you and record all foods and drinks that you consume during the next 24hr period

***Please pass your panelist ID card through the window before beginning the study.***

Please click the hand at the top of the page to continue.

Instructions

Each questionnaire that you will be asked to answer during this study will be made up of 3 types of scales. These 3 scales will be described below and on the following 2 pages.

Scale 1: For the majority of statements you will be making intensity ratings on a scale that ranges from NO SENSATION to STRONGEST IMAGINABLE SENSATION OF ANY KIND.

Please read through an example of scale 1 shown below:

![Example with Scale 1](image)

Please click the hand at the top of the page to continue.

The first breath sample should be collected now.

Once you have finished with the breath collection, please click the hand at the top of the page to continue.

Scale 2: For several of the statements you will be asked to make intensity ratings on a line scale with only anchor descriptions. An example of one of the scales you will see ranges from NONE to GREATEST POSSIBLE AMOUNT.

Please read through an example of scale 2 shown below:

![Example with Scale 2](image)

Please click the hand at the top of the page to continue.
The following first 4 questions are the **Slavin** VAS questions that are asked at baseline before breakfast (0min), 15 min after breakfast (25min), 30 min after breakfast (40min), 45 min after breakfast (55min), 1 hour after breakfast (70min), 1.5 hours after breakfast (100min), 2 hours after breakfast (130min) and 3 hours after breakfast (140min). The remaining questions were asked at baseline before breakfast (0min), immediately after breakfast (10min), 1 hour after breakfast (70min), 2 hours after breakfast (130min), and 3 hours after breakfast (190min).

**Part 1: Before Breakfast Questionnaire**

Please answer the questions on the following pages before being served your breakfast.

Remember to please base your ratings on your "**feelings right now***

**How hungry do you feel?**

- I am not hungry at all
- I have not been more hungry

**How satisfied do you feel?**

- I am completely hungry
- I cannot eat another bite

**How full do you feel?**

- Not at all
- Totally full

**How much do you think you can eat?**

- Nothing at all
- A lot

Please click the hand at the top of the page to continue.
Rate your overall liking of the food you last ate

Rate your liking of the flavor of the food you last ate

Rate your liking of the appearance of the food you last ate

Rate your liking of the texture of the food you last ate

Rate your liking of the odor of the food you last ate

Rate the enjoyment you had from the food you last ate

Rate your appetite satisfaction from the food you last ate

Rate your contentedness with the food you last ate

Rate your satisfaction with the food you last ate

Please click the hand at the top of the page to continue.
Rate your current appetite for a meal

Rate the extent to which you are currently thinking of food

Rate your current willingness to eat

Rate the extent to which your stomach currently feels empty

Rate your current feeling of weakness with hunger

Rate your current rate of salivation

Please click the hand at the top of the page to continue.

Rate your current desire to eat your next meal

Rate your current feeling of fullness

Rate your current desire to eat something savory

Please click the hand at the top of the page to continue.
Rate your current appetite

<table>
<thead>
<tr>
<th>None</th>
<th>Barelydetectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible</th>
</tr>
</thead>
</table>

Rate your current feeling of hunger

<table>
<thead>
<tr>
<th>None</th>
<th>Barely detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible of any kind</th>
</tr>
</thead>
</table>

Rate the extent to which you currently feel nauseated

<table>
<thead>
<tr>
<th>None</th>
<th>Barely detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible</th>
</tr>
</thead>
</table>

Rate the extent to which you currently have stomach cramps

<table>
<thead>
<tr>
<th>None</th>
<th>Barely detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible</th>
</tr>
</thead>
</table>

Rate the extent to which you currently feel stomach pain

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<th>None</th>
<th>Barely detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible</th>
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</thead>
</table>

Rate your current stomach muscle spasms

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<tr>
<th>None</th>
<th>Barely detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible of any kind</th>
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</thead>
</table>

Rate your current feeling of nausea

<table>
<thead>
<tr>
<th>None</th>
<th>Barely detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible</th>
</tr>
</thead>
</table>

Rate the extent to which your stomach currently aches

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<th>None</th>
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<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible</th>
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</thead>
</table>

Rate the extent to which your stomach currently feels bloated

<table>
<thead>
<tr>
<th>None</th>
<th>Barely detectable</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very Strong</th>
<th>Stomach impossible</th>
</tr>
</thead>
</table>

Please click the hand at the top of the page to continue.
Rate the extent to which your stomach feels like it is currently bursting

Rate your current feeling of indigestion

Rate the extent to which your stomach currently feels stuffed

Please click the hand at the top of the page to continue.

Rate your current feeling of gastric tightness

Rate the amount of food you currently desire

Rate the current amount of food you could eat

Please click the hand at the top of the page to continue.

Part 2: With Breakfast Questionnaire

Please Note: You will need to answer the question below before beginning to eat your breakfast, but after being served your breakfast.

Please pass your BREAKFAST CARD through the window to indicate you are ready to be served your breakfast.

After being served your breakfast, but before beginning to consume your breakfast, please answer the following question.

Remember to please base your rating on your ***feeling right now***

Did you receive <CURRENT_SAMPLE_DESCRIPTION_INTERNAL>?

- Yes
- No - If you answer NO, please let the staff know

Rate how full you expect to be (Please look at the breakfast to determine your answer)

Please click the END button at the top of the page to go on to the next portion of the study and start a 10 min timer. You will need to consume all of the breakfast during this 10 min.

Please take the next 10 minutes to consume the entire breakfast and drink that you have been served.

Try to pace your meal to fill the 10 minutes.
Appendix T: Pizza lunch served during the fiber study
Appendix U: Breath hydrogen equipment instructions and photos

Instructions below were taken from QuinTron Instrument Company (QuinTron, 2006).

“Assembly
The mouthpiece is attached to one end of the Tee-piece in line with the discard bag, which is attached to the other end.

The one-way flutter valve is inserted into the sidearm of the tee-piece, which is then attached to the large port of the collection bag. A 1-way stopcock is inserted into the luer port of the collection bag before a sample is collected.

Collecting a Sample
1. Instruct the patient to inhale normally.
2. Place the mouthpiece in the patient’s mouth. Instruct the patient to close lips tightly around the mouthpiece.
3. The patient should exhale slowly through the mouthpiece and stop when both bags are full.
4. When you have collected an adequate sample, take the devise from the patient, remove the collection bag from the tee-piece, and seal the bag with the port cap.
5. If the sample is inadequate, flatten the discard bag and repeat the procedures.

Evaluation of sample
1. Before beginning the sample analysis, the Quintron machine is calibrated following the equipment Manuel.
2. Once the machine is calibrated, the sample is removed from the bag through the luer port by inserting a syringe with attached stopcock into the 1-way stopcock. Both stopcocks are opened to withdraw a 30ml sample.
3. The 30ml sample is then injected into the machine and evaluated for hydrogen (H₂) and methane content (CH₄).
4. This procedure is repeated to obtain a replicate sample.”

QuinTron’s GaSampler™ System

Discard Bag
Tee-Piece
Flutter Valve
Mouthpiece
Collection Bag
Stopcock
Appendix V: Twenty-four hour food log using in the fiber study

FOOD DIARY INSTRUCTIONS
In order to calculate your nutrient intake for the 24 hours following your visit, you must keep a detailed record of your food and beverage consumption.

The following are some guidelines that will help you provide accurate intake data:
1. All meals and snacks (including beverages) MUST be recorded, whether they were eaten at home or away.
2. Be as specific as possible in recording food items. If whole and name of the product is available, please include it.
3. Measure food items when measurable or estimate quantities broadly. You should estimate portions where in weight, such as grams or ounces, or in volume, such as teaspoons, tablespoons, etc. The abbreviations used for food measurements are as follows:
   - teaspoon
   - tbsp = tablespoon
   - oz = ounce
   - ml = milliliter
4. Be sure to specify the method of preparation for each food item. Additional products are used in preparation, such as oil or mayonnaise, be sure they are included.
5. Make sure that all condiments, such as ketchup, gravy, or saucers, are recorded.
6. Please refer to the following pages for examples of portion sizes.

PORTION GUIDELINES

- 1 ounce: size of a matchbox
- 2.5 oz: size of a deck of playing cards
- 3 oz: fing of a clenched fist
- 1 oz: end of a marker pen
- 1 oz: end of a pen
- 1 oz: size of a computer mouse
- 2 Tbsp: size of a ping pong ball
- 1/2 cup: size of a hockey puck

COMMON SERVING SIZES

- 1/4 cup: 4 oz
- 1/2 cup: 8 oz
- 1 cup: 1 pt
- 1 pt: 1 qt
- 1 qt: 1 gal
- 1 gal: 1 gal
<table>
<thead>
<tr>
<th>Time</th>
<th>Foods and Beverages</th>
<th>Preparation</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: If you don’t know exact measurements, compare to common terms like ½ cup, 1 tsp, table. Use ½ cup, 1 tsp, etc.*
Appendix W: Gastrointestinal Tolerance Questionnaire used in the Fiber Study

GI Tolerance Questionnaire

Subject ID _______________ Treatment _______________ Visit _______________

Please fill out the following questionnaire as accurately as possible. Question a should be answered as a number. For questions b-d, make a small vertical line in the location that most represents the average of your experience over the 24 hours.

a. Stool Frequency: _______ (number of stools in last 24 hours)

b. Stool Consistency

Diarrhea ____________________________ Hard stool/constipation

C. Degree of intestinal bloating

Minimal ____________________________ Excessive

d. Degree of flatulence

Minimal ____________________________ Excessive
Appendix X: SAS code for the retrospective power calculation

To calculate the power for the comparison between the area under the curves for oligofructose and control, I first set up a data file with a row for each judge and a column for the area under the curve score for each food (4 fiber treatments and the control) at each factor. Then I used PROC CORR to compute a correlation matrix from this file. The correlation between 2 measures (e.g. area under the curve for oligofructose and area under the curve for the control), the pooled standard deviation of the 2 measures and the number of pairs (N = 22) was run through PROC POWER to determine the power (probability that the test will reject the null hypothesis when the null hypothesis is false).

"Power calculation for Mental Hunger factor AUC Oligo vs. Control"
proc corr data = corr;
  var _oligofac1_AUC _controlfac1_AUC;
run;

proc power;
  pairedmeans test=diff
  meandiff = 8.00
  corr = 0.59163
  stddev = 46.11399
  npairs = 22
  power = .;
run;

"Power calculation for Physical Hunger factor AUC Oligo vs. Control"
proc corr data = corr;
  var _oligoffac2_AUC _controlfac2_AUC;
run;

proc power;
  pairedmeans test=diff
  meandiff = 3.83474
  corr = 0.65102
  stddev = 21.13691
  npairs = 22
  power = .;
run;

"Power calculation for Physical Fullness factor AUC Oligo vs. Control"
proc corr data = corr;
  var _oligofac8_AUC _controlfac8_AUC;
run;

proc power;
  pairedmeans test=diff
  meandiff = 11.72635
  corr = 0.36612
  stddev = 33.13548
  npairs = 22
  power = .;
run;
To determine the number of subjects and the mean difference that I could have found with 80% power, additional PROC POWER procedures were run. To determine the number of subjects, a ‘.’ was put in the ‘n_pairs’ and the power was set to 0.8. To determine what mean difference I could have found with the same variability and same number of pairs (N=22) and at an 80% power level, a second PROC POWER calculation was run with the ‘meandiff’ set to ‘8 to 40 by1’ and the power set to 0.8. This allowed me to see what mean difference could have been found with 22 subjects and the same variability with 80% power.

"N_pairs calculation for Mental Hunger factor AUC Oligo vs. Control"

```plaintext
proc power;
   pairedmeans test=diff
   meandiff = 8.00
   corr = 0.59163
   stddev = 46.11399
   n_pairs = .
   power = .8;
run;
```

"Mean difference calculation for Mental Hunger factor AUC Oligo vs. Control"

```plaintext
proc power;
   pairedmeans test=diff
   meandiff = 8 to 40 by 1
   corr = 0.59163
   stddev = 46.11399
   n_pairs = 22
   power = .8;
run;
```

"N_pairs calculation for Physical Hunger factor AUC Oligo vs. Control"

```plaintext
proc power;
   pairedmeans test=diff
   meandiff = 3.83474
   corr = 0.65102
   stddev = 21.13691
   n_pairs = .
   power = .8;
run;
```

"Mean difference calculation for Physical Hunger factor AUC Oligo vs. Control"

```plaintext
proc power;
   pairedmeans test=diff
   meandiff = 8 to 40 by 1
   corr = 0.65102
   stddev = 21.13691
   n_pairs = 22
   power = .8;
run;
```
"Npairs calculation for Physical Fullness factor AUC Oligo vs. Control"

```
proc power;
  pairedmeans test=diff
  meandiff = 11.72635
  corr = 0.36612
  stddev = 33.13548
  npairs = .
  power = .8;
run;
```

"Mean difference calculation for Physical Fullness factor AUC Oligo vs. Control"

```
proc power;
  pairedmeans test=diff
  meandiff = 8 to 40 by 1
  corr = 0.36612
  stddev = 33.13548
  npairs = 22
  power = .8;
run;
```