Published in final edited form as:
Appetite. 2012 October ; 59(2): 541–549. doi:10.1016/j.appet.2012.07.001.

Eating Behavior Dimensions: Associations With Energy Intake And Body Weight: A Review

Simone A. French[1,*], **Leonard H Epstein**[2], **Robert W. Jeffery**[1], **John E. Blundell**[3], and **Jane Wardle**[4]

[1]Division of Epidemiology & Community Health, University of Minnesota, 1300 South 2nd St #300, Minneapolis, MN 55454, United States

[2]School of Medicine and Biomedical Sciences, State University of New York at Buffalo, United States

[3]Institute of Psychological Science, Leeds University, UK

[4]Cancer Research UK Health Behaviour Centre, University College of London, UK

Abstract

The purpose of this review is to spark integrative thinking in the area of eating behaviors by critically examining research on exemplary constructs in this area. The eating behaviors food responsiveness, enjoyment of eating, satiety responsiveness, eating in the absence of hunger, reinforcing value of food, eating disinhibition and impulsivity/self-control are reviewed in relation to energy intake, body mass index and weight gain over time. Each of these constructs has been developed independently, and little research has explored the extent to which they overlap or whether they differentially predict food choices, energy intake and weight gain in the naturalistic environment. Most available data show positive cross-sectional associations with body mass index, but fewer studies report associations with energy intake or food choices. Little prospective data are available to link measures of eating behaviors with weight gain. Disinhibition has the largest and most consistent body of empirical data that link it prospectively with weight gain. An overarching conceptual model to integrate the conceptual and empirical research base for the role of eating behavior dimensions in the field of obesity research would highlight potential patterns of interaction between individual differences in eating behaviors, specific aspects of the individual's food environment and individual variation in state levels of hunger and satiety.

Keywords

Food responsiveness; satiety responsiveness; disinhibition; food reinforcement; body mass index

Introduction

Obesity is a population epidemic that continues to expand globally across international boundaries and cultures (de Onis et al., 2010). There is general consensus that a permissive food environment is an important contributing factor (French et al., 2001). However, there is

Corresponding author. frenc001@umn,.edu (Simone A. French).

also wide individual variability in body weight and weight gain over time in all environments (French et al., 1995). Therefore, it is important to understand the characteristics of individuals that interact with the environment to either magnify or minimize environmental risks (Blundell et al., 2005). A better understanding of individual differences is important to illuminate the causes of obesity and identify potential solutions.

Ultimately, excess energy intake is the pathway through which a permissive food environment influences weight gain. Eating behaviors influence energy intake through choices about when and where to eat, and the types and amounts of foods chosen, including decisions about starting and stopping eating (Blundell et al., 2005; Blundell & Cooling, 2000). Individual differences in eating behaviors have been captured using several different independently developed measures and underlying conceptualizations, including food responsiveness (Wardle et al., 2001; Carnell & Wardle, 2008), food enjoyment (Wardle et al., 2001; Carnell & Wardle, 2008), satiety responsiveness (Wardle et al., 2001; Carnell & Wardle, 2008), eating in the absence of hunger (Birch et al., 2003; Fisher & Birch, 1999), reinforcing value of food (Epstein et al., 2007; Epstein & Saelens, 2000), and the capacity to voluntarily inhibit eating (Herman & Polivy, 1984; Herman & Mack, 1975; Stunkard & Messick, 1985). Dispositions toward impulsivity and self-control have also been empirically linked with eating behaviors and weight gain (Francis & Sussman, 2009; Nederkoorn et al., 2006).

The purpose of the present selective review is to promote integrative thought with respect to conceptualization of eating behavior dimensions in children and adults. Key guiding questions are: 1) What measures have been used to capture eating behavior dimensions? 2) Are eating behavior dimensions consistent across child and adult populations? 3) How well do eating behavior dimensions predict food choices, energy intake, body mass index or weight gain? 4) Is any theoretical integration possible, based on the presently available empirical evidence?

Methods

Seven eating behavior constructs were selected for inclusion in this review on the basis of available literature linking them with energy intake, food choice and weight gain. Major databases were searched (PubMed, Medline, Psychlit) using the seven terms food responsiveness, satiety responsiveness, eating in the absence of hunger, relative reinforcing value of food, eating disinhibition, impulsivity and self-control and minor variations in each term. Each was crossed with body mass index, energy intake, weight change and weight gain. Article titles were reviewed by the first author and followed-up if the title fit the purpose of the review. One hundred seven articles were reviewed for inclusion of which 66 met the specified criteria to be included the review (reported associations with energy intake, food choices, body weight or weight gain). These articles (see Table 1) include published work from countries worldwide and form the foundation for the integrative review below.

Conceptualization of eating behavior dimensions

Several conceptual models related to eating behavior dimensions have been described in the eating behavior and obesity literature. Some focus on hypothesized underlying biological and genetic processes that are outside the scope of this review and are only briefly described here. Some have focused on the starting of eating, the stopping of eating, or both, and have included both biological and environmental influences. Onset factors may be broadly conceptualized as those that influence craving, appetite, motivation to eat, hedonic responses to food, or food reward. Eating termination factors include those that influence satiety or fullness, or external cues to stop eating. Hunger and satiety mechanisms involve both homeostatic (energy balance) and hedonic (affective response to food) aspects, and *people may be at risk for overeating through either or both of these pathways* (Berridge, 1996; Berridge, 2007). If an individual's satiety response is weak following food consumption, then their risk for overconsumption is higher (homeostatic pathway). If their responsiveness to and or enjoyment of food are strong (hedonic pathway), then their risk of overconsumption is also higher (Blundell & Finlayson, 2004; Drapeau et al., 2007). Eating behavior is generally thought to have a genetic basis (Gluckman & Hanson, 2008; Wardle et al., 2008) and some of the possible biological mechanisms have been identified (Blundell et al., 2005; Blundell & Cooling, 2000).

Researchers have developed psychometric [self-report questionnaires] and behavioral [laboratory] measures to capture individual differences in eating behaviors, including the concepts of hyper-responsiveness to food stimuli (Wardle et al., 2001; Carnell & Wardle, 2008), eating in the absence of hunger (Birch et al., 2003; Fisher & Birch, 1999), the reinforcing value of food (Epstein et al., 2007; Epstein & Saelens, 2000), and the ability or desire to voluntarily inhibit eating (Herman & Polivy, 1984; Herman & Mack, 1985; Stunkard & Messick, 1985). Comprehensive, multi-level models of eating behavior include genetic, biological, behavioral, psychological and environmental variables. The focus of the present review is on the behavioral level. Connection with the food and social environment is noted where relevant, and integrated into the discussion. Biological and genetic variables that are hypothesized to underlie the observable eating behaviors are not reviewed here.

Food responsiveness, enjoyment of food & satiety responsiveness

Among children, eating behavior dimensions have been examined in a program of research by Wardle and colleagues (Wardle et al., 2001; Carnell & Wardle, 2008; Carnell & Wardle, 2007; Sleddens et al., 2008; Viana et al., 2008; Webber et al., 2009; see Table 1). The Children's Eating Behavior Questionnaire (CEBQ) was developed to capture the important dimensions of children's eating behavior that might contribute to overeating and excess weight gain over time. It was developed for preschool aged children (4–5 years), but has been examined in children up to age 12 years (Wardle et al., 2001; Carnell & Wardle 2008; Carnell & Wardle, 2007; Sleddens et al., 2008; Viana et al., 2009). The CEBQ consists of 8 subscales created by 35-items that are *parent-reported* endorsements of descriptions of the child's typical eating behavior. The dimensions that seem most central to the concept of motivation to eat and that have received the most research attention in relation to links with eating behaviors and obesity are food responsiveness, enjoyment of food, and satiety responsiveness. These dimensions map directly onto onset of eating (food responsiveness and food enjoyment) and offset of eating (satiety responsiveness). Food responsiveness refers to the extent to which a child indicates an interest in and desires to spend time eating food ("my child is always asking for food"). Food responsiveness provides an assessment of individual differences in response to food cues, and may indicate a vulnerability to the obesigenic environment. Enjoyment of food captures the extent to which a child finds eating pleasurable and desires to eat ("my child enjoys eating"). Satiety responsiveness indicates the extent to which a child becomes full easily and leaves food when finished eating ("my child leaves food on his or her plate at the end of a meal"). The subscales have good internal consistency, test-retest reliability and stability over time (Ashcroft et al, 2008). Among children across age groups that ranged from 3–7 years, older children showed higher food responsiveness and enjoyment of food, and lower satiety responsiveness and slowness in eating (Carnell & Wardle, 2008; Carnell & Wardle, 2007; Webber et al., 2009).

Enjoyment of food is inversely correlated with satiety responsiveness and slowness in eating and positively correlated with food responsiveness. However, the extent to which the correlated subscales represent distinct dimensions of child eating behavior or reflect a single underlying dimension has not yet been explored (Carnell & Wardle, 2007). To date, the dimensions have been examined as unique subscales, usually in separate analyses in relation to the outcome of interest (Carnell & Wardle, 2008; Carnell & Wardle, 2007; Webber et al., 2009), but the utility of conceptualizing them as distinct dimensions needs to be examined in further research.

In a series of validation studies using the "eating in the absence of hunger" paradigm (described further below), energy intake was inversely associated with satiety responsiveness, and was positively associated with enjoyment of food and with food responsiveness (Carnell & Wardle, 2007). In another validation study, associations between children's body mass index and eating behaviors were examined among children ages 3–5 years and ages 8–11 years (Carnell & Wardle, 2008). Among both 3–5 year olds and 8–11 year olds, body mass index was significantly inversely associated with satiety responsiveness and was positively associated with food responsiveness. Recently, an infant measure of the same scale has been developed, the Baby Eating Behavior Questionnaire (BEBQ), covering the period when infants are entirely milk-fed (Llewellyn et al., 2011; Llewellyn et al., 2010). Analyses using the BEBQ have shown cross-sectional and prospective associations with infant weight and weight gain (van Jaarsveld, et al., 2011).

Eating in the absence of hunger

The "eating in the absence of hunger" experimental paradigm is a measure of eating behavior among children that has been examined in the context of food choices, energy intake and weight gain (Birch et al., 2003). In this paradigm a child is first served a full meal and eats until satisfied. A short time later (e.g., 15 minutes), the child is given the opportunity to eat high-fat/energy snack foods ad libitum, usually under the pretext of a non-food related purpose (e.g., in the context of play). Energy intake from the snack foods is measured. The focal dependent variable is defined by the energy intake consumed "in the absence of hunger" during the second eating opportunity. The research paradigm is a direct measure of hedonic hunger, since the child has just consumed a meal to the point of satiety as part of the research procedure, and does not need energy to meet homeostatic needs. However, it also may be indicative of weak or rapidly fading satiety cues (Carnell & Wardle, 2007). In this paradigm, children who eat more snack food during the second eating opportunity score higher on measures of food responsiveness and enjoyment, and lower on measures of satiety responsiveness (Carnell & Wardle, 2007).

This research paradigm has been widely used to understand the eating behaviors of children and to examine differences between obese and normal weight children in their responses to food and eating opportunities (Birch et al., 2003; Fisher & Birch, 1999; Butte et al., 2007; Fisher & Birch, 2002; Hill et al., 2008; Kral et al., 2010; Shomaker et al., 2010; Shunk & Birch, 2004; Tanofsky-Kraff et al., 2008; Zocca et al., 2011) (six cross-sectional studies; two prospective studies; see Table 1). Typically, energy intake is higher among overweight children than normal weight children during the snacking opportunity following a meal. However, some studies have observed effects only among boys (Hill et al., 2008). In this case, the authors argued that the lack of effect in girls could be due to the measure being sensitive to socially desirable responding. One prospective study examined eating in the absence of hunger at age 5 and 7 years in 192 girls (Fisher & Birch, 2002). Cross-sectional associations were observed between overweight status and eating in the absence of hunger at both ages. Girls who consumed greater amounts of snack foods in the eating in the absence of hunger task at both ages 5 and 7 years had an odds ratio of 4.6 for likelihood of being overweight at both ages, compared with girls who consumed less snack food in the eating in the absence of hunger task. Unfortunately, the association between eating in the absence of hunger at age 5 years and later body mass index was not reported (Fisher & Birch, 2002). In a separate prospective analysis of this cohort, baseline eating in the absence of hunger was significantly associated with weight gain over a four-year period (Shunk & Birch, 2004).

Another prospective cohort study among 879 4–19 year olds found that eating in the absence of hunger was significantly predictive of weight gain one year later, but was no longer significant when child baseline body mass index was included in the model (Butte et al., 2007). This measurement paradigm has not examined differences by body mass index in energy intake during the initial meal, nor eating in the absence of hunger when the foods offered in the second eating task are not highly palatable, nor have associations with weight gain been shown to be stronger for eating measured in the absence of hunger as opposed to eating in any other context (such as when hungry).

In summary, among children, eating behavior dimensions have been explored using parent-reported psychometric measures of child eating behaviors, and laboratory-observed behavioral measures of eating in the absence of hunger. The parent-reported psychometric measures are reliably associated with child eating behaviors in a laboratory behavioral paradigm. Eating in the absence of hunger is higher among overweight children as young as 3 years (Carnell & Wardle, 2008). The pattern appears to be stable over time (Fisher & Birch, 2002). Stable dimensions of eating behaviors such as high food responsiveness and enjoyment of food are significantly associated with eating in the absence of hunger in experimental settings (Carnell & Wardle, 2008; Carnell & Wardle, 2007). Additional prospective research is needed to examine whether these measures are differentially related to patterns of energy intake and weight gain over time. Environmental influences that could moderate the child's responsiveness to food or tendencies toward eating in the absence of hunger need to be systematically measured. These include parent feeding behaviors and aspects of the home food environment that could affect the child's choice of food types and amounts, and alternative activities to eating. Exploration of the influence of alternative food and activity choices available is further discussed below with the consideration of the concept of relative reinforcing value of food.

Reinforcing value of food

The reinforcing value of food is a measure designed to assess the strength of a particular food [but not "food" in general] as a reinforcer of behavior. The conceptual model for food reinforcement is based on research on drug abuse liability (Richardson & Roberts, 1996) and uses a similar measurement approach. Epstein and colleagues have developed a measure of the reinforcing value of food to measure individual differences in food reinforcing value (Epstein et al., 2007; Epstein and Saelens, 2000; Epstein et al., 2011; Epstein et al., 2010; Epstein et al., 2007; Epstein et al., 2004; Giesen et al., 2010; Salens & Epstein, 1996; Hill et al., 2009; Temple, Legierski et al., 2008; see Table 1).

The reinforcing value of food can be measured in an absolute sense by providing only access to food, or in a relative sense, in which two or more alternatives are available to study how participants allocate time and effort for each alternative. In the most commonly used laboratory paradigm to measure the reinforcing value of food, the "work" for food involves using a computer task that offers individuals a choice to key press for either an attractive target food, or an attractive alternative reward, such as reading or playing a video game. It is also possible to study the relative reinforcing value of different types of foods, rather than a food versus an alternative. When absolute or relative reinforcing value is studied, the reinforcement schedules for the alternatives generally increase in a progressive manner. The extent to which the person continues to respond for the target food as the response requirements become increasingly high defines the reinforcing value of food for that person. It can be measured in one of two ways, either by the absolute value of the reinforcer (e.g., number of computer mouse clicks for the food); or by the relative reinforcing value (e.g., number of clicks for food compared with number of clicks for the alternative reinforcer). In many situations, it makes more sense to measure the relative reinforcing value of food, since in the naturalistic environment, people make choices about when, what and how much to eat. It is also possible to study how well one commodity or alternative can substitute for the alternative by having the schedule increase for one alternative and stay the same for the other alternative. For example, it may be interesting to study how substitutable is a healthy dessert (fruit) for a less healthy dessert (ice cream). In that scenario, the behavioral cost or schedule of reinforcement for the healthy food would stay the same, while the schedule for ice cream would increase. The value at which people switch to fruit from choosing ice cream is a measure of the substitutability of the commodities.

Two questionnaire versions of the relative reinforcing value of food have been developed (Epstein et al., 2010; Goldfield et al., 2005) and one has been used in naturalistic settings with children (Hill et al., 2009). One questionnaire presents a series of choices to individuals that are similar to those used in the computer choice task. The other questionnaire is based on behavioral economic notions of elasticity of demand, and it asks participants to report the number of portions of food they would purchase when the price changes (Epstein et al, 2010). The correlation between the computer-based task and the questionnaire measure is modest in adults. The questionnaire measure may have lower validity in school-aged children, because it is premised on a logical hierarchy of ordered choices that may be difficult for younger children to understand (Hill et al., 2009).

In cross-sectional studies, findings generally support the association between relative reinforcing value of food and weight status among children and adults. A study of 8–12 year old children found that compared to normal weight children, overweight children scored higher on a laboratory measure of relative reinforcing value of food (Temple et al., 2008). Among adults, some studies found higher relative reinforcing value of food (RRVF) scores among overweight compared with normal weight adults (Epstein et al., 2010; Epstein et al., 2007). In a novel finding in one study, body mass index was related to the degree to which food reinforcement increased over a 2-week period of regular consumption of the food using the relative reinforcing value task. Those who showed an increase in the reinforcing value of food had greater body mass index values than those who did not increase the reinforcing value of food (Temple & Epstein, 2011). Four studies reported higher energy intake in the laboratory setting among those with higher RRVF compared to those with lower RRVF (Epstein et al., 2011; Epstein et al., 2010; Epstein et al., 2007; Epstein et al., 2004). In addition, food reinforcement is positively associated with energy intake measured by repeated 24-hour recalls and food frequency questionnaires, and is associated with sugar intake (Epstein, Carr, Lin, Fletcher, 2011). In one study, energy intake mediated the relationship between high food reinforcement and obesity (Epstein, Carr, Lin, Fletcher, Roemmich, in press). In the only prospective study published to date, reinforcing value of food was not associated with body mass index at baseline, but was significantly associated with measured weight gain over a one-year period among 316 children ages 7–10 years (Hill et al., 2009).

A unique aspect of the relative reinforcement paradigm is its use of a structured choice between a well-liked food and a non-food reinforcer or other food. Motivation to eat depends not only on the food choices available, but also the availability of alternative activities that are more reinforcing than food. Evaluation of a choice situation in the laboratory paradigm can provide information about substitution of reinforcers (e.g. which activities or foods can be used to substitute for choosing to work for the target food) (Lappalainen & Epstein, 1990). One study that used snack food versus fruit and vegetable reinforcers found no significant differences among obese and normal weight in RRVF snack choices (Giesen et al., 2010). Other studies have found no weight-related differences in preference for nonfood reinforcers (in children: Bonato & Boland, 1983; Johnson et al., 1978; Sobhany & Rogers, 1985; Geller et al., 1981). One hypothesis that is derived from the relative reinforcing value paradigm is that some people may be motivated to eat because they have an absence of alternative reinforcers (Temple, Legierski, Giacomelli, Salvy, Epstein, 2008). This hypothesis is supported in the finding that children who were low in the relative reinforcing value of food and high in access to alternative reinforcers experienced the most positive effects on body mass index in a family-based treatment program (Best, Theim, Gredysa, Stein, Welch, Saelens et al, in press). This raises the possibility that increasing the reinforcing value of alternatives to food may be an important treatment goal in pediatric obesity treatment programs.

Several variations in the reinforcing value of food paradigm are relevant to the measurement of the construct and its relationship to theoretical conceptions of eating behavior dimensions. First, one variation of the measurement procedure includes having the person consume food prior to engaging in the computer work-choice task. Reinforcement theory suggests that individual differences are best captured when people are not deprived of the reinforcer (Epstein et al., 2007; Epstein & Saelens, 2000; Lappalainen & Epstein, 1990). In this case, consuming a food preload will ensure that people are not hungry while engaged in the food reinforcer task, and thus individual differences in reinforcing value of the food will be more easily observed. Thus, responding under non-food-deprived conditions allows hedonic-based hunger to be measured. Second, the experimental procedure can be organized so that the person consumes the food earned while progressing through the task, or it can be organized so that the person consumes the food following the task completion. If food reinforcers are consumed during the task, satiety processes may contribute to the pattern of response captured during the task.

Food reinforcement has been related to both the disinhibition and impulsivity constructs reviewed below. The results suggest that food reinforcement may interact with dispositional impulsivity to heighten risk for excess energy intake and weight gain (Epstein et al., 2011). A limitation of the food reinforcement measure is that the reinforcing value is food-specific, and thus it is impractical to generalize across foods. The measure is also specific to the experimental setting in which the participant works for the food or a particular nonfood alternative reinforcer. It is not clear how the motivation to work for the particular food is affected by the nonfood alternative choice, or whether the measure would generalize to predict food choice or eating behavior in a naturalistic setting. The experimental and questionnaire measures may or may not assess the same eating behavior dimension. Data from the most recent studies described above begin to address these issues, and additional systematic research will continue to inform the questions of whether reinforcing value of food predicts food choices and energy intake in settings in which the choice is between liked foods and less liked foods, liked foods and engaging in alternative behaviors, and less liked foods and engaging in alternative behaviors.

Eating disinhibition

The concept of eating disinhibition has been examined in a broad range of adult studies, primarily community-based surveys and clinical weight loss interventions (see Table 1; Barkeling et al., 2007; Bellisle et al., 2004; Chambers & Yeomans, 2011; Dykes et al., 2004; Hainer et al., 2006; Harden et al., 2009; Hays et al., 2002; Lindroos et al., 1997; Ouwens et al., 2003; Provencher et al., 2003; Schubert & Randler, 2008; Borg et al., 2004; Chaput et al., 2009; Drapeau et al., 2003; Levine et al., 2007; McGuire et al., 1999; Savage et al., 2009; Teixeira et al., 2010; Vogels et al., 2005; Wing et al., 2008]). The main instrument used to measure eating disinhibition is the Three Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985). Originally developed in an attempt to address the conceptual and measurement problems associated with the Restraint Scale (Herman & Polivy, 1984; Herman & Mack, 1975), the TFEQ identified three distinct eating behavior components: Restraint, Disinhibition and Hunger. The Disinhibition subscale measures responsiveness to food stimuli such as the sight or smell of food, and eating in response to positive and negative emotional states. Subsequent research has identified the Disinhibition subscale as most consistently correlated with obesity and higher energy intake (Bryant et al., 2007). Example Disinhibition scale items include “I usually eat too much at social occasions, like parties or picnics;” “Sometimes things just taste so good that I keep on eating even when I am no longer hungry”; “Sometimes when I start eating, I just can’t seem to stop;” “When I feel lonely, I console myself by eating” (Stunkard & Messick, 1985). Recently, some researchers have conceptualized disinhibition as internal and external control of eating (Karlsson et al., 2000; Bond et al., 2001). Most of the existing research retains the three-scale configuration of the questionnaire, and that configuration is reviewed here.

Disinhibition may be most closely related to food sensitivity or factors that influence the onset of eating. However, the failure to inhibit eating, once started, could be related to weak satiety processes or to weaker volitional controls (cognitive or motivational) on eating behavior. The research on the TFEQ Disinhibition measure provided the largest number of studies, including nine prospective designs. The consistency of results of these multi-country, prospective and cross-sectional studies is striking. Ten of 11 cross-sectional studies and seven of nine prospective studies showed positive associations between body mass index or weight gain and disinhibition scores. Disinhibition, as measured by the TFEQ subscale, appears to include components of food responsiveness, weak satiety response and emotion-based eating. Less experimental laboratory research is available using the Disinhibition scale. It is not known whether similar patterns of associations between Disinhibition and laboratory-based eating behaviors exist as those found for other measures of motivation to eat, such as satiety responsiveness, eating in the absence of hunger and relative reinforcement of food. It is hypothesized that Disinhibition would be highly correlated with eating in the absence of hunger, low satiety responsiveness and high reinforcing value of food.

Impulsivity and self-control

Self-control and behavioral impulsivity have been studied extensively in children (Mischel et al., 1989) and adults (Reynolds et al., 2006)(see Table 1: in children (Duckworth et al., 2010; Tsukayama et al., 2010; Francis & Sussman, 2009; Nederkoorn et al., 2006; Bonato & Boland, 1983; Johnson et al., 1978; Sobhany & Rogers, 1985; Geller et al., 1981; Batterink et al., 2010; Wills et al., 2007; in adults (Appelhans et al., 2011; Epstein et al., 2003; Hofman et al., 2009; Nederkoorn et al., 2010; Nederkoorn et al., 2006; Rollins et al., 2010; Sproesser et al., 2010; Weller et al., 2008; Yeomans et al., 2008). Impulsivity is defined as the tendency to act without forethought, an inability to inhibit inappropriate behaviors, an inability to wait, and insensitivity to consequences (Spinrad et al., 2007; Rothbart et al., 2001). Individuals who are highly impulsive are more sensitive to immediate rewards and less sensitive to punishment. Effortful control has been called self-control, self-regulation, and “executive function”. Self-control processes modulate reactivity by controlling attention and inhibiting responses. Measures of each of these dispositions include both laboratory tasks (such as a delay of gratification task [children]; delay discounting; and reaction-time tasks) and multi-item self-report scales (e.g. Barratt Impulsiveness Scale [Patton et al., 1995]; Child Behavior Questionnaire [Rothbart et al., 2001]). Impulsivity and self-control may be distinct dimensions or opposite ends on a single continuum. This issue is outside the scope of the present review for practical reasons (see Neef et al., 2001). Most studies included one or more different measures of either self-control, impulsivity, or both, and measures of these constructs varied from study to study.

Impulsivity is of interest in relation to eating behavior because of the predisposition of highly impulsive individuals to favor immediate rewards and discount the value of delayed rewards, and their lower ability to inhibit immediate responses. Related to food intake, impulsive individuals would be expected to prefer energy dense foods now, rather than the delayed consequence of weight control later. Impulsive individuals would be expected to have greater difficulty inhibiting their eating once started, and therefore be susceptible to overeating when stimulated by an opportunity to eat, or by large portion sizes or a variety of highly palatable foods.

A consistent body of empirical work has demonstrated a positive association between obesity and measures of impulsivity and an inverse association with measures of self-control. Nine cross-sectional studies among children reported positive associations between measures of impulsivity and body mass index or obesity (see Table 1). Four prospective cohort studies were located that examined self-regulation and delay of gratification measures in relation to weight gain over time. In one study, children who scored low on self-regulation and delay of gratification measures at ages 3 years and 5 years gained significantly more weight (BMI z-score change) over time compared to those who were higher on either or both measures (Francis & Sussman, 2009). One prospective study found an inverse relationship between impulsivity and body mass index change: impulsivity was associated with less body mass index gain over time (Pauli-Pott et al., 2010). Several earlier studies examined differences among obese and normal weight children in measures of self-control and found that obese children were more likely than non-obese children to choose an immediate food reward (versus a larger, delayed food reward) (Bonato & Boland, 1983; Johnson et al., 1978; Sobhany & Rogers, 1985; Geller et al., 1981). However, no obese-normal weight differences in delay were observed for non-food rewards.

Studies among adults have reported mixed or null findings regarding associations between obesity and measures of impulsivity (Weller et al., 2008; Yeomans et al., 2008; Epstein et al., 2003; Hofman et al., 2009; Nederkoorn et al., 2010; Nederkoorn et al., 2006). For example, Weller et al. (2008) found that among a sample of 95 college students, obese participants scored higher on a laboratory measure of delay discounting (for money) compared to normal weight participants. Delay discounting measures the extent to which a person chooses a smaller, immediate outcome (e.g. $10 now) in preference to a larger, distal outcome (e.g. $50 a month from now). Preference for the immediate, smaller reward is an index of impulsivity. By contrast, Nederkoorn et al (2006) found few differences on several different measures of impulsivity. Among a normal weight sample of 147 women college students, scores on the Disinhibition scale were significantly associated with a computer-based delay discounting measure and questionnaire measures of impulsivity (Yeomans et al., 2008).

Research suggests that impulsivity may interact with hunger to influence food intake, as greatest intake in an ad libitum eating task was observed for those who were hungry and impulsive (Nederkoorn, Guerrieri, Havermans, Roefs, Jansen, 2009). In addition, impulsivity may interact with food reinforcement to predict energy intake in non-obese adults (Rollins, Dearing & Epstein, 2010) and response to weight loss in children (Best, Theim, Gredysa, Stein, Welch, Saelens et al, in press). In both studies, good impulse control reduced the effects of high food reinforcement on eating or weight loss.

These results suggest that children who are relatively more impulsive may be more susceptible to overeating, although by adulthood, the patterns are less clear. It is not known whether impulsive individuals are more motivated to eat in the first place. Available studies are primarily cross-sectional or experimental comparisons of obese and normal weight children or adults, and therefore cannot establish whether there is a causal link for impulsivity in promoting higher energy intake or excess weight gain. The one prospective study in adults found no evidence that impulsivity was associated with weight gain (Nederkoorn et al., 2010). It is possible that individuals who are highly food motivated and highly impulsive are at greatest risk for overeating and weight gain. Impulsivity may moderate the effects of motivation to eat on food choices and eating behaviors. Studies are needed to clarify whether impulsivity confers its own independent risk for overeating and weight gain, or whether its risk is only conferred among those who are highly motivated by food.

Discussion

Seven eating behavior dimensions and their association with energy intake and weight gain were reviewed here. They have all been shown to be stable and higher among overweight compared with normal weight children and adults (Ashcroft, Semmler, Carnell, van Jaarsveld & Wardle, 2008). Most available studies are cross-sectional in design, but there are a limited number of prospective studies that show positive associations between some of the eating behavior dimensions and weight gain. However, most of the available research does not examine simultaneously more than one eating behavior measure in relation to the focal outcome variable.

Little research has explored whether these different eating behavior constructs are conceptually unique or overlapping. For example, food responsiveness and disinhibition both involve sensitivity to food cues. It is not clear whether these are the same or different concepts, or whether they vary developmentally. There has been very little research on whether these constructs interact to predict energy intake and risk for excess weight gain. For example, a person who is hyper-responsive to food cues, but has normal satiety mechanisms might be at risk for excess energy intake and obesity primarily in environments with high availability of palatable foods and snacks, through consumption of normal sized meals but frequent snacks. Another may not be over-responsive to food cues, and show good control over when they initiate eating, but show lower control over stopping eating. Hence, meal size is likely to be larger, but not meal frequency. Others may be vulnerable on both fronts, being food responsive and thus frequently eating, and having low control over stopping and thus large meal sizes. High food reinforcement and slow food habituation (which may be a reflection of satiety) have been shown to additively predict energy intake (Epstein et al., 2009; Carr & Epstein, 2011). Other studies have shown interactive effects on energy intake and body mass index (Epstein et al., 2009; Carr & Epstein, 2011).

Individuals differ in their state of biological hunger or satiety at any given time in the naturalistic setting. In developed societies, most people, most of the time, regardless of economic circumstances, are not at the extremes of the hunger/satiety dimension. Individuals also vary in their responsiveness to food in their environment, the types of environments that they find themselves in or actively choose to spend time in, and their satiety responses or the speed with which they stop eating once started. The typical food environment is one in which food access is high and the types of foods available are a mixture of high calorie, highly reinforcing foods to lower energy, less reinforcing foods. Each of these dimensions [hunger/satiety and the individual's food environment] needs to be systematically defined and examined to better understand the importance of the individual differences in eating behaviors and their common and unique features in interaction with food environment exposures and selections. Of the measures reviewed above, Disinhibition might identify those who are fast to respond to food and eating opportunities in the environment, and slower to stop eating once started. Eating in the absence of hunger and satiety responsiveness may identify those who are slow to stop eating once started, but may not measure as clearly those who are highly responsive to food. The results of the present review suggest that few empirical data are available to understand this multi-dimensional space of individual differences in eating behaviors. Some data are available that support the interactive role of food reinforcement, impulsivity, and hunger/satiety (Best, Theim, Gredysa, Stein, Welch, Saelens, et al. in press; Nederkoorn, Guerrieri, Havermans, Roefs, Jansen et al, 2009 ; Rollins, Dearing & Epstein, 2010).

Two important areas of research could help move the field forward. The first is research to distill the variety of constructs and measures currently available in the eating behaviors area into the key elements. Studies that include several different measures of the same eating behavior and measure several different eating behaviors would be instrumental in this regard. Analytic techniques such as factor analysis and cluster analysis could then be used to distill the underlying elements that cross-cut the available measures of eating behaviors.

The second area of research involves examination of the interaction between these eating behavior individual differences and different food environments. Since sensitivity to food cues is clearly a risky phenotype for overeating and weight gain, creative ways are needed to test individual-environmental interactions. Laboratory experimental paradigms and naturalistic settings could be used to examine how individuals choose among foods and eating situations under conditions of hunger and satiety. For example, are there differences among people who are more or less food responsive in the types of eating opportunities or foods chosen, or in whether an eating opportunity or a non-eating opportunity is chosen? Is this difference magnified under conditions of satiety? Research is needed that is able to examine the individual differences in choice of activities (to eat or not to eat), in addition to types of foods chosen once an eating setting is entered. Exploration of how people who are highly food motivated make choices between foods (e.g., high-calorie snack foods versus fruits and vegetables) and between food and nonfood activities will be informative for theory development, understanding the etiology of obesity and designing interventions.

Three of the constructs reviewed use questionnaires to assess the relevant eating behavior dimensions, while the other two use laboratory behavioral tasks. Additional validation data are needed to further clarify the constructs measured and to provide convergent and discriminant validation (Cronbach & Meehl, 1955). For example, many of the studies reviewed did not assess energy intake or food choices (see Table 1). Standard psychometric concepts are relevant for questionnaire and laboratory measures, and further work is needed to provide data on sensitivity and specificity of measurement and classification. Assessment of eating in the absence of hunger and food reinforcement incorporate eating food prior to engaging in the measurement task and thus may share common measurement variance in predicting eating behavior. An additional concern for both laboratory and questionnaire measures is that of social desirability in responding. In public settings, and particularly among some groups (e.g. overweight people; females), social desirability may bias the results observed because people are trying to present themselves in a positive light and will therefore avoid or minimize eating in front of the experimenter (Eck et al., 1996; Mori et al., 1987).

Eating behaviors in both children and adults were included in this review. For some of them, almost all the work has been done in children (food responsiveness, food enjoyment, satiety responsiveness, eating in the absence of hunger); others have been investigated primarily in adults (disinhibited eating), and some have been applied in both adults and children (reinforcing value of food; impulsivity; self control). An argument can be made for continuing efforts to integrate concepts and measures across child and adult populations. Food choices, eating behavior, hunger and satiety are biologically-based processes with underlying genetic components, but all are likely to be developmentally shaped by the social and physical environment, including foods available and parent feeding behaviors, cultural norms and other complex social factors. Understanding eating behaviors early in childhood is essential to develop effective obesity prevention interventions and policies. Comparable measures across age groups will make developmental approaches more accessible and make it possible to examine interactions between individuals' eating behaviors and their environmental exposures across the lifecourse.

References

Appelhans BM, Woolf K, Pagoto SL, Schneider KL, Whited MC, Liebman R. Inhibiting food reward: Delay discounting, food reward sensitivity, and palatable food intake in overweight and obese women. Obesity. 2011; 19:2175–2182. [PubMed: 21475139]

Ashcroft J, Semmler C, Carnell S, van Jaarsveld CH, Wardle J. Continuity and stability of eating behaviour traits in children. Eur J Clin Nutr. 2008; 62(8):985–990. [PubMed: 17684526]

Barkeling B, King NA, Naslund E, Blundell JE. Characterization of obese individuals who claim to detect no relationship between their eating pattern and sensations of hunger and fullness. International Journal of Obesity. 2007; 31:435–439. [PubMed: 16953260]

Batterink L, Yokum S, Stice E. Body mass correlates inversely with inhibitory control in response to food among adolescent girls: An fMRI study. NeuroImage. 2010; 52:1696–1703. [PubMed: 20510377]

Bellisle F, Clement K, Le Barzic ML, Le Gall A, Guy-Grand B, Basdevant A. The eating inventory and body adiposity from leanness to massive obesity: a study of 2509 adults. Obesity Research. 2004; 12:2023–2030. [PubMed: 15687404]

Berridge KC. Food reward: Brain substrates of wanting and liking. Neuroscience and Biobehavioral Reviews. 1996; 20:1–25. [PubMed: 8622814]

Berridge, KC. Brain reward systems for food incentives and hedonics in normal appetite and eating disorders. In: Kirkham, TC.; Cooper, SJ., editors. Progress in brain research: Appetite and body weight. Academic Press; 2007. p. 191-216.

Best JR, Theim KR, Gredysa DM, Stein RI, Welch RR, Saelens BE, et al. Behavioral economic predictors of overweight children's weight loss. J Consult Clin Psychol. (in press).

Birch LL, Fisher JO, Davison KK. Learning to overeat: Maternal use of restrictive feeding practices promotes girls' eating in the absence of hunger. American Journal of Clinical Nutrition. 2003; 78:215–220. [PubMed: 12885700]

Blundell JE, Cooling J. Routes to obesity: Phenotypes, food choices and activity. British Journal of Nutrition. 2000; 83:S33–S38. [PubMed: 10889790]

Blundell JE, Finlayson G. Is susceptibility to weight gain characterized by homeostatic or hedonic risk factors for overconsumption? Physiology & Behavior. 2004; 82:21–25. [PubMed: 15234585]

Blundell JE, Stubbs RJ, Golding C, Croden F, Alam R, Whybrow S, et al. Resistance and susceptibility to weight gain: Individual variability in response to a high-fat diet. Physiology and Behavior. 2005; 86:614–622. [PubMed: 16225895]

Bonato DP, Boland FJ. Delay of gratification in obese children. Addictive Behaviors. 1983; 8:71–74. [PubMed: 6880927]

Bond MJ, McDowell AJ, Wilkinson JY. The measurement of dietary restraint, disinhibition and hunger: An examination of the factor structure of the Three Factor Eating Questionnaire (TFEQ). International Journal of Obesity and Related Metabolic Disorders. 2001; 25:900–906. [PubMed: 11439306]

Borg P, Fogelholm M, Kukkonen-Harjula K. Food selection and eating behaviour during weight maintenance intervention and 2-year follow-up in obese men. International Journal of Obesity & Related Metabolic Disorders. 2004; 28:1548–1554. [PubMed: 15543160]

Bryant EJ, King NA, Blundell JE. Disinhibition: its effects on appetite and weight regulation. Obesity Reviews. 2007; 9:409–419. [PubMed: 18179615]

Butte NF, Cai G, Cole SA, Wilson TA, Fisher JO, Zakeri IF, et al. Metabolic and behavioral predictors of weight gain in Hispanic children: the Viva la Familia Study. American Journal of Clinical Nutrition. 2007; 85:1478–1485. [PubMed: 17556682]

Carnell S, Wardle J. Measuring behavioral susceptibility to obesity: validation of the child eating behavior questionnaire. Appetite. 2007; 48:104–113. [PubMed: 16962207]

Carnell S, Wardle J. Appetite and adiposity in children: Evidence for a behavioral susceptibility theory of obesity. American Journal of Clinical Nutrition. 2008; 88:22–29. [PubMed: 18614720]

Carr KA, Epstein LH. Relationship between food habituation and reinforcing efficacy of food. Learning and Motivation. 2011; 42:165–172. [PubMed: 21423567]

Chambers L, Yeomans MR. Individual differences in satiety response to carbohydrate and fat: Predictions from the Three Factor Eating Questionnaire (TFEQ). Appetite. 2011; 56:316–323. [PubMed: 21219950]

Chaput JP, Leblanc L, Perusse L, Despres JP, Bouchard C, Tremblay A. Risk factors for adult overweight and obesity in the Quebec Family Study: Have we been barking up the wrong tree? Obesity. 2009; 17:1964–1970. [PubMed: 19360005]

Cronbach LJ, Meehl PE. Construct validity in psychological tests. Psychological Bulletin. 1955; 52:281–302. [PubMed: 13245896]

de Onis M, Blossner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. American Journal of Clinical Nutrition. 2010; 92:1257–1264. [PubMed: 20861173]

Drapeau V, Provencher V, Lemieux S, Despres JP, Bouchard C, Tremblay A. Do 6-year changes in eating behaviors predict change in body weight? Results from the Quebec Family Study. International Journal of Obesity. 2003; 27:808–814. [PubMed: 12821966]

Drapeau V, King N, Hetherington M, Doucet E, Blundell JE, Tremblay A. Appetite sensations and satiety quotient: Predictors of energy intake and weight loss. Appetite. 2007; 48:159–166. [PubMed: 17045700]

Duckworth AL, Tsukayama E, Geier AB. Self-controlled children stay leaner in the transition to adolescence. Appetite. 2010; 54:304–308. [PubMed: 20004223]

Dykes J, Brunner EJ, Martikainen PT, Wardle J. Socioeconomic gradient in body size and obesity among women: the role of dietary restraint, disinhibition and hunger in the Whitehall II study. International Journal of Obesity. 2004; 28:262–268. [PubMed: 14647173]

Eck LH, Klesges LM, Klesges RC. Precision and estimated accuracy of two short-term food frequency questionnaires compared with recalls and records. Journal of Clinical Epidemiology. 1996; 49:1195–1200. [PubMed: 8827001]

Epstein, LH.; Saelens, BE. Behavioral economics of obesity: Food intake and energy expenditure. In: Bickel, WK.; Vuchinich, RE., editors. Reframing health behavior change with behavioral economics. Mahwah, NJ: Erlbaum; 2000. p. 293-311.

Epstein LH, Richards JB, Saad FG, Paluch RA, Roemmich JN, Lerman C. Comparison between two measures of delay discounting in smokers. Experimental Clinical Psychopharmacology. 2003; 11:131–138.

Epstein LH, Wright SM, Paluch RA, Leddy J, Hawk LW Jr, Jaroni JL, et al. Food hedonics and reinforcement as determinants of laboratory intake in smokers. Physiology and Behavior. 2004; 81:511–517. [PubMed: 15135024]

Epstein LH, Leddy JJ, Temple J, Faith M. Food reinforcement: A multilevel analysis. Psychological Bulletin. 2007; 133:884–906. [PubMed: 17723034]

Epstein LH, Temple JL, Neaderhiser BJ, Salis RJ, Erbe RW, Leddy JJ. Food reinforcement, the dopamine D2 receptor genotype and energy intake in obese and nonobese humans. Behavioral Neuroscience. 2007; 121:877–886. [PubMed: 17907820]

Epstein LH, Robinson JL, Temple JL, Roemmich JN, Marusewski AL, Nadbrzuch RL. Variety influences habituation of motivated behavior for food and energy intake in children. American Journal of Clinical Nutrition. 2009; 89:746–754. [PubMed: 19176724]

Epstein LH, Dearing KK, Roba LG. A questionnaire approach to measuring the relative reinforcing efficacy of snack foods. Eating Behaviors. 2010; 11:67–73. [PubMed: 20188288]

Epstein LH, Carr KA, Lin H, Fletcher KD. Food reinforcement, energy intake and macronutrient choice. American Journal of Clinical Nutrition. 2011; 94:12–18. [PubMed: 21543545]

Epstein LH, Carr KA, Lin H, Fletcher KD, Roemmich JN. Usual energy intake mediates the relationship between food reinforcement and BMI. Obesity. (in press).

Fisher JO, Birch L. Restricting access to foods and children's eating. Appetite. 1999; 32:405–419. [PubMed: 10336797]

Fisher JO, Birch LL. Eating in the absence of hunger and overweight in girls from 5 to 7 yr of age. American Journal of Clinical Nutrition. 2002; 76:226–231. [PubMed: 12081839]

Francis LA, Sussman EJ. Self-regulation and rapid weight gain in children from age 3 to 12 years. Archives of Pediatrics & Adolescent Medicine. 2009; 163:297–302. [PubMed: 19349557]

French SA, Jeffery RW, Folsom AR, Williamson DF, Byers T. Weight variability in a population-based sample of older women: Intercorrelation and reliability of measures. International Journal of Obesity. 1995; 19:22–29. [PubMed: 7719387]

French SA, Story M, Jeffery RW. Environmental influences on eating and physical activity. Annual Review of Public Health. 2001; 22:309–335.

Geller SE, Keane TM, Scheirer CJ. Delay of gratification, locus of control, and eating patterns in obese and nonobese children. Addictive Behaviors. 1981; 6:9–14. [PubMed: 7257923]

Giesen JCAH, Remco RC, Douven A, Tekelenburg M, Jansen A. Will work for snack food: the association of BMI and snack reinforcement. Obesity. 2010; 18:966–970. [PubMed: 20150901]

Gluckman PD, Hanson MA. Developmental and epigenetic pathways to obesity: an evolutionary-developmental perspective. International Journal of Obesity. 2008; 32:S62–S71. [PubMed: 19136993]

Goldfield GS, Epstein LH, Davidson M, Saad F. Validation of a questionnaire measure of the relative reinforcing value of food. Eating Behaviors. 2005; 6:283–292. [PubMed: 15854874]

Hainer V, Kunesova M, Bellisle F, Parizkova J, Braunerova R, Wagenknecht M, et al. The Eating Inventory, body adiposity and prevalence of diseases in a quota sample of Czech adults. International Journal of Obesity. 2006; 30:830–836. [PubMed: 16418762]

Harden CJ, Corfe BM, Richardson JC, Dettmar PW, Paxman JR. Body mass index and age affect Three Factor Eating Questionnaire scores in male subjects. Nutrition Research. 2009; 29:379–382. [PubMed: 19628103]

Hays NP, Bathalon GP, McCrory MA, Roubenoff R, Lipman R, Roberts SB. Eating behavior correlates of adult weight gain and obesity in healthy women aged 55–65 years. American Journal of Clinical Nutrition. 2002; 75:476–483. [PubMed: 11864852]

Herman CP, Mack D. Restrained and unrestrained eating. Journal of Personality. 1975; 43:647–660. [PubMed: 1206453]

Herman, CP.; Polivy, J. A boundary model for the regulation of eating. In: Stunkard, AJ.; Stellar, E., editors. Eating and Its Disorders. New York, NY: Raven Press; 1984. p. 141-156.

Hill C, Llewellyn CH, Saxton J, Webber L, Semmler C, Carnell S, et al. Adiposity and "eating in the absence of hunger" in children. International Journal of Obesity. 2008; 32:1499–1505. [PubMed: 18645573]

Hill C, Saxton J, Webber L, Blundell J, Wardle J. The relative reinforcing value of food predicts weight gain in a longitudinal study of 7–10 yr old children. American Journal of Clinical Nutrition. 2009; 90:276–281. [PubMed: 19535428]

Hofman W, Friese M, Roefs A. Three ways to resist temptation: the independent contributions of executive attention, inhibitory control, and affect regulation to the impulse control of eating behavior. Journal of Experimental Social Psychology. 2009; 45:431–435.

Johnson F, Pratt M, Wardle J. Dietary restraint and self-regulation in eating behaviour. International Journal of Obesity. 2011 Epub 2011. 10.1038/ijo.2011.156

Johnson WG, Parry W, Drabman RS. The performance of obese and normal size children on a delay of gratification task. Addictive Behaviors. 1978; 3:205–208. [PubMed: 735906]

Karlsson J, Persson LO, Sjostrom L, Sullivan M. Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. International Journal of Obesity and Related Metabolic Disorders. 2000; 24:1715–1725. [PubMed: 11126230]

Kral TV, Moore RH, Stunkard AJ, Berkowitz RI, Stettler N, Stallings VA, et al. Adolescent eating in the absence of hunger and relation to discretionary calorie allowance. Journal of the American Dietetic Association. 2010; 110:1896–1900. [PubMed: 21111097]

Lappalainen R, Epstein LH. A behavioral economics analysis of food choice in humans. Appetite. 1990; 14:81–93. [PubMed: 2337342]

Levine MD, Klem ML, Kalarchian MA, Wing RR, Weissfeld L, Qin L, et al. Weight gain prevention among women. Obesity. 2007; 15:1267–1277. [PubMed: 17495203]

Lindroos A, Lissner L, Mathiassen ME, Karlsson J, Sullivan M, Bengtsson C, et al. Dietary intake in relation to restrained eating, disinhibition and hunger in obese and nonobese Swedish women. Obesity Research. 1997; 5:175–182. [PubMed: 9192390]

Llewellyn CH, van Jaarsveld CHM, Johnson L, Carnell S, Wardle J. Nature and nurture in infant appetite: analysis of the Gemini twin birth cohort. American Journal of Clinical Nutrition. 2010; 91:1172–1179. [PubMed: 20335548]

Llewellyn CH, van Jaarsveld CHM, Johnson L, Carnell S, Wardle J. Development and factor structure of the Baby Eating Behaviour Questionnaire. Appetite. 2011; 57:388–396. [PubMed: 21672566]

McGuire MT, Wing RR, Klem ML, Lang W, Hill JO. What predicts weight regain in a group of successful weight losers? Journal of Consulting and Clinical Psychology. 1999; 67:177–185. [PubMed: 10224727]

Mischel W, Shoda Y, Rodriguez ML. Delay of gratification in children. Science. 1989; 244:933–938. [PubMed: 2658056]

Mori D, Chaiken S, Pliner P. "Eating lightly" and the self-presentation of femininity. Journal Personality and Social Psychology. 1987; 53:693–702.

Nederkoorn C, Braet C, Van Eijs Y, Tanghe A, Jansen A. Why obese children cannot resist food: the role of impulsivity. Eating Behaviors. 2006; 7:315–322. [PubMed: 17056407]

Nederkoorn C, Smulders FTY, Havermans RC, Roefs A, Jansen A. Impulsivity in obese women. Appetite. 2006; 47:253–256. [PubMed: 16782231]

Nederkoorn C, Guerrieri R, Havermans RC, Roefs A, Jansen A. The interactive effect of hunger and impulsivity on food intake and purchase in a virtual supermarket. Int J Obes (Lond). 2009; 33:905–912. [PubMed: 19546869]

Nederkoorn C, Houben K, Hofmann W, Roefs A, Jansen A. Control yourself or just eat what you want? Weight gain over a year is predicted by an interactive effect of response inhibition ad implicit preference for snack foods. Health Psychology. 2010; 29:389–393. [PubMed: 20658826]

Neef NA, Bicard DF, Endo S. Assessment of impulsivity and the development of self-control in students with attention deficit hyperactivity disorder. Journal of Applied Behavior Analysis. 2001; 34:397–408. [PubMed: 11800181]

Ouwens MA, van Strien T, van der Staak CPF. Tendency toward overeating and restraint as predictors of food consumption. Appetite. 2003; 40:291–298. [PubMed: 12798787]

Patton JH, Stanford MS, Barratt ES. Factor structure of the Barratt Impulsiveness Scale. Journal of Clinical Psychology. 1995; 51:768–774. [PubMed: 8778124]

Pauli-Pott U, Albayrak O, Hebebrand J, Pott W. Does inhibitory control capacity in overweight and obese children and adolescents predict success in a weight-reduction program? European Child & Adolescent Psychiatry. 2010; 19:135–141. [PubMed: 19644731]

Peake PK, Hebl M, Mischel W. Strategic attention deployment for delay of gratification in working and waiting situations. Developmental Psychology. 2002; 38:313–326. [PubMed: 11881765]

Provencher V, Drapeau V, Tremblay A, Despres J, Lemieux S. Eating behaviors and indexes of body composition in men and women from the Quebec Family Study. Obesity Research. 2003; 11:783–792. [PubMed: 12805400]

Reynolds B, Ortengren A, Richards JB, de Wit H. Dimensions of impulsive behavior: Personality and behavioral measures. Personality and Individual Differences. 2006; 40:305–315.

Richardson NR, Roberts DCS. Progressive ratio schedules in drug self-administration studies in rats: A method to evaluate reinforcing efficacy. Journal of Neuroscience Methods. 1996; 66:1–11. [PubMed: 8794935]

Rollins BY, Dearing KK, Epstein LH. Delay discounting moderates the effect of food reinforcement on energy intake among nonobese women. Appetite. 2010; 55:420–425. [PubMed: 20678532]

Rothbart MK, Ahadi SA, Hershey KL, Fisher P. Investigations of temperament at three to seven years: the Children's Behavior Questionnaire. Child Development. 2001; 72:1394–1408. [PubMed: 11699677]

Saelens BE, Epstein LH. Reinforcing value of food in obese and nonobese women. Appetite. 1996; 27:41–50. [PubMed: 8879418]

Savage JS, Hoffman L, Birch LL. Dieting, restraint and disinhibition predict women's weight change over 6 yrs. American Journal of Clinical Nutrition. 2009; 90:33–40. [PubMed: 19439461]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Schubert E, Randler C. Association between chronotype and the constructs of the Three Factor Eating Questionnaire. Appetite. 2008; 51:501–505. [PubMed: 18479778]

Shomaker LB, Tanofsky-Kraff M, Zocca JM, Courville A, Kozlosky M, Columbo KM, et al. Eating in the absence of hunger in adolescents: Intake after a large-array meal compared with that after a standardized meal. American Journal of Clinical Nutrition. 2010; 92:697–703. [PubMed: 20720255]

Shunk JA, Birch LL. Girls at risk for overweight at age 5 are at risk for dietary restraint, disinhibited overeating, weight concerns, and greater weight gain from 5 to 9 years. Journal of the American Dietetic Association. 2004; 104:1120–1126. [PubMed: 15215771]

Sleddens EFC, Kremers SPJ, Thijs C. The Children's Eating Behaviour Questionnaire: factorial validity and association with Body Mass Index in Dutch children aged 6–7. International Journal of Behavior Nutrition and Physical Activity. 2008; 5:49.10.1186/1479-5868-5-49

Sobhany MS, Rogers CS. External responsiveness to food and non-food cues among obese and nonobese children. International Journal of Obesity. 1985; 9:99–106. [PubMed: 4030200]

Spinrad RL, Eisenberg N, Gaertner BM. Measures of effortful regulation for children. Infant Mental Health Journal. 2007; 28:606–626. [PubMed: 18066395]

Sproesser G, Strohbach S, Schupp H, Renner B. Candy or apple? How self-control resources and motives impact dietary healthiness in women. Appetite. 2010; 56:784–787. [PubMed: 21296115]

Stunkard A, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. Journal of Psychosomatic Research. 1985; 29:71–83. [PubMed: 3981480]

Tanofsky-Kraff M, Ranzenhofer LM, Yanovski SZ, Schvey MA, Faith M, Gustafson J, et al. Psychometric properties of a new questionnaire to assess eating in the absence of hunger in children and adolescents. Appetite. 2008; 51:148–155. [PubMed: 18342988]

Teixeira PJ, Silva MN, Coutinho SR, Palmeira AL, Mata J, Vieira PN, et al. Mediators of weight loss and weight loss maintenance in middle-aged women. Obesity. 2010; 18:725–735. [PubMed: 19696752]

Temple JL, Legierski CM, Giacomelli AM, Salvy S, Epstein LH. Overweight children find food more reinforcing and consume more energy than do nonoverweight children. American Journal of Clinical Nutrition. 2008; 87:1121–1127. [PubMed: 18469229]

Temple JL, Epstein LH. Sensitization of food reinforcement is related to weight status and baseline food reinforcement. Int J Obes (Lond). 2011 Nov 1.201110.1038/ijo.2011.210

Tsukayama E, Toomey SL, Faith MS, Duckworth AL. Self-control as a protective factor against overweight status in the transition from childhood to adolescence. Archives of Pediatrics & Adolescent Medicine. 2010; 164:631–635. [PubMed: 20603463]

van Jaarsveld CHM, Llewellyn CH, Johnson L, Wardle J. Prospective associations between appetitive traits and weight gain in infancy. American Journal of Clinical Nutrition. 2011; 94:1562–1567. [PubMed: 22071702]

Viana V, Sinde S, Saxton JC. Children's Eating Behaviour Questionnaire: Associations with BMI in Portuguese children. British Journal of Nutrition. 2008; 100:445–450. [PubMed: 18275626]

Vogels N, Diepvens K, Westerterp-Plantenga S. Predictors of long- term weight maintenance. Obesity Research. 2005; 13:2162–2168. [PubMed: 16421351]

Wardle J, Guthrie CA, Sanderson S, Rapoport L. Development of the Children's Eating Behaviour Questionnaire. Journal of Child Psychology. 2001; 42:963–970.

Wardle J, Carnell S, Haworth CMA, Farooqi IS, O'Rahilly S, Plomin R. Obesity associated genetic variation in FTO is associated with diminished satiety. Journal of Clinical Endocrinology & Metabolism. 2008; 93:3640–3643. [PubMed: 18583465]

Webber L, Hill C, Saxton J, van Jaarsveld CHM, Wardle J. Eating behavior and weight in children. International Journal of Obesity. 2009; 33:21–28. [PubMed: 19002146]

Weller RE, Cook EW, Avsar KB, Cox JE. Obese women show greater delay discounting than healthy weight women. Appetite. 2008; 51:563–569. [PubMed: 18513828]

Wills TA, Isasi CR, Mendoza D, Ainette MG. Self-control constructs related to measures of dietary intake and physical activity in adolescents. Journal of Adolescent Health. 2007; 41:551–558. [PubMed: 18023783]

Wing RR, Fava JL, Phelan S, McCaffery J, Papandonatos G, Gorin AA, Tate DF. Maintaining large weight losses: The role of behavioral and psychological factors. Journal of Consulting and Clinical Psychology. 2008; 76:1015–1021. [PubMed: 19045969]

Yeomans MR, Leitch M, Mobini S. Impulsivity is associated with the disinhibition but not restraint factor from the Three Factor Eating Questionnaire. Appetite. 2008; 50:469–476. [PubMed: 18069081]

Zocca JM, Shomaker LB, Tanofsky-Kraff M, Columbo KM, Raciti GR, Brady SM, et al. Links between mothers' and children's disinhibited eating and children's adiposity. Appetite. 2011; 56:324–331. [PubMed: 21182882]

Highlights

- The purpose of this review is to spark integrative thinking in the area of eating behaviors by critically examining research on exemplary constructs in this area.
- The eating behaviors food responsiveness, enjoyment of eating, satiety responsiveness, eating in the absence of hunger, reinforcing value of food, eating disinhibition and impulsivity/self-control are reviewed in relation to energy intake, body mass index and weight gain over time.
- Most available data show positive cross-sectional associations with body mass index, but fewer studies report associations with energy intake or food choices.
- Little prospective data are available to link measures of eating behaviors with weight gain.
- An overarching conceptual model to integrate the conceptual and empirical research base for the role of eating behavior dimensions in the field of obesity research would highlight potential patterns of interaction between individual differences in eating behaviors, specific aspects of the individual's food environment and individual variation in state levels of hunger and satiety.

Table 1

Eating Behavior Constructs: Summary of Studies

Construct Name	Prospective studies	Cross-sectional studies	Associations with BMI	Food/Energy
Food Responsiveness Food Liking Satiety Responsiveness	No studies	5 studies Carnell & Wardle 2007; 2008 Sleddens et al 2008 Viana et al 2008 Webber et al 2009	4+ 1 not reported	1+ 4 not reported
Eating in the Absence of Hunger	2+ studies Butte et al 2007 Shunk & Birch 2004	6 studies Fisher & Birch 2002 Hill et al 2008 Kral et al 2010 Shomaker et al 2010 Tanofsky-Kraff et al 2008 Zocca et al 2011	7+ 1 not reported	8 not reported
Relative Reinforcing Value of Food				
Children	1+ study Hill et al 2009	1+study Temple et al 2008	1+ 1 NS	1+ 1 not reported
Adults	No studies	6 studies Epstein et al 2010; 2011; 2007; 2004 Giesen et al 2010; Saelens et al 1996	2+ 1 NS 2 not reported	4+ 1 not reported
Disinhibition	7+ studies 2 NS studies Borg et al 2004; Chaput et al 2009 Drapeau et al 2003 Levine et al 2007 McGuire et al 1999 Savage et al 2009 Teixeira et al 2010 Vogels et al 2005 Wing et al 2008	13 studies Barkeling et al 2007 Bellisle et al 2004 Chambers et al 2011 Chaput et al 2009 Dykes et al 2004 Finlayson et al in press Hainer et al 2006 Harden et al 2009 Hays et al 2002 Lindroos et al 1997 Ouwens et al 2003 Provencher et al 2003 Schubert et al 2008	10+ 1 NS	4+ 1 NS 16 not reported
Impulsivity/Self-Control				
Children	2+ studies 2− studies Francis & Sussman 2009 Duckworth et al 2010 Pauli-Pott et al 2010 Tsukayama et al 2010	9 studies Nederkoorn et al 2006 Bonato & Boland 1983 Johnson et al 1978 Sobhany & Rogers 1985 Geller et al 1981 Batterink et al 2010 Pauli-Pott et al 2010 Verdejo-Garcia et al 2010 Wills et al 2007	7+ 1 NS 5 not reported	1+ 12 not reported
Adults	1 NS study Nederkoorn et al 2010	8 studies Appelhans et al 2011 Epstein et al 2003 Hofman et al 2009 Nederkoorn et al 2006 Rollins et al 2010 Sproesser et al 2011 Weller et al 2008 Yeomans et al 2008	2+ 3 NS 4 not reported 2 mixed results	4+ 1 NS 5 not reported

NS = not significant; + = positive association; − = negative association