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Lunch-time food choices in preschoolers: relationships between absolute and relative intake of different food categories, and appetitive characteristics and weight

S Carnell^a, K Pryor^b, LA Mais^{a,c}, S Warkentin^{a,c}, L Benson^a, and R Cheng^d

^a Division of Child & Adolescent Psychiatry, Department of Psychiatry & Behavioral Sciences, Johns Hopkins University School of Medicine, Baltimore, MD, USA, susan.carnell@jhmi.edu

^b Duke University School of Medicine, 201 Trent Drive, Durham, NC, 27710 USA

^c Discipline of Nutrology, Department of Pediatrics, Federal University of São Paulo (UNIFESP), São Paulo, SP, Brazil

^d St. George's University School of Medicine, 3500 Sunrise Highway, Building 300, Great River, NY 11739 USA, rcheng@sgu.edu

Abstract

Children's appetitive characteristics measured by parent-report questionnaires are reliably associated with body weight, as well as behavioral tests of appetite, but relatively little is known about relationships with food choice. As part of a larger preloading study, we served 4-5y olds from primary school classes five school lunches at which they were presented with the same standardized multi-item meal. Parents completed Child Eating Behavior Questionnaire (CEBQ) sub-scales assessing satiety responsiveness (CEBQ-SR), food responsiveness (CEBQ-FR) and enjoyment of food (CEBQ-EF), and children were weighed and measured. Despite differing preload conditions, children showed remarkable consistency of intake patterns across all five meals with day-to-day intra-class correlations in absolute and percentage intake of each food category ranging from .78 to .91. Higher CEBQ-SR was associated with lower mean intake of all food categories across all five meals, with the weakest association apparent for snack foods. Higher CEBQ-FR was associated with higher intake of white bread and fruits and vegetables, and higher CEBQ-EF was associated with greater intake of all categories, with the strongest association apparent for white bread. Analyses of intake of each food group as a percentage of total intake, treated here as an index of the child's choice to consume relatively more or relatively less of each different food category when composing their total lunch-time meal, further suggested that children who were higher in CEBQ-SR ate relatively *more* snack foods and relatively *less* fruits and vegetables, while children with higher CEBQ-EF ate relatively *less* snack foods and relatively *more* white bread. Higher absolute intakes of white bread and snack foods were

Corresponding author: Susan Carnell, Division of Child & Adolescent Psychiatry, Department of Psychiatry & Behavioral Sciences, Johns Hopkins University School of Medicine, Baltimore, MD, USA. susan.carnell@jhmi.edu.

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associated with higher BMI z score. CEBQ sub-scale associations with food intake variables were largely unchanged by controlling for daily metabolic needs. However, descriptive comparisons of lunch intakes with expected amounts based on metabolic needs suggested that overweight/obese boys were at particularly high risk of overeating. Parents' reports of children's appetitive characteristics on the CEBQ are associated with differential patterns of food choice as indexed by absolute and relative intake of various food categories assessed on multiple occasions in a naturalistic, school-based setting, without parents present.

Keywords

Macronutrient intake; ad libitum intake; test meal; meal-time; school meals; appetitive traits

Introduction

Children's appetitive characteristics appear to be relatively stable throughout early (Farrow & Blissett, 2012) and middle childhood (Ashcroft, Semmler, Carnell, van Jaarsveld, & Wardle, 2008), and associated with their weight. For example, we and others have reported consistent associations between greater body weight and higher scores on the food responsiveness (CEBQ-FR) and enjoyment of food (CEBQ-EF) sub-scales, and lower scores on the satiety responsiveness (CEBQ-SR) sub-scale of the Child Eating Behavior Questionnaire (Croker, Cooke, & Wardle, 2011; Domoff, Miller, Kaciroti, & Lumeng, 2015; Jahnke & Warschburger, 2008; Parkinson, Drewett, Le Couteur, Adamson, & Gateshead Millennium Study Core, 2010; Sleddens, Kremers, & Thijs, 2008; Viana, Sinde, & Saxton, 2008; Webber, Hill, Saxton, Van Jaarsveld, & Wardle, 2009; Carnell & Wardle, 2007), a parent-report questionnaire measuring children's appetitive characteristics (Carnell & Wardle, 2007; Wardle, Guthrie, Sanderson, & Rapoport, 2001). However, less is known about how these characteristics are associated with food choices. This is important, because food approach tendencies may not be obesogenic if the foods in question are low in calories, raising the possibility of intervening to redirect food approach characteristics to a healthier selection of foods.

Food choices may be defined and therefore measured in a number of ways. Perhaps the most common conception of food choice is where an individual chooses between two or more alternatives within a named food category (e.g. snack decision between high-fat vs. low-fat cookie, or between cookie vs. apple), with the choice normally followed by actual or theoretical consumption. However, food choice can also be construed more broadly, as an individual's decision to consume a particular absolute amount of a certain category of food, or to consume relatively more or relatively less of a certain food category, when presented with an array containing several different food categories. Food choices of this kind may be particularly relevant to obesity as they have a more direct effect on overall energy intake than selection between two types of food, which may or may not be followed by consumption of that food in its entirety. For this paper we therefore adopt the latter definition. Accordingly, below we review studies attempting to assess actual dietary *intake* in addition to classical studies of *choices* that may or may not predict intake, as well as

studies on food *preferences*, which may be considered as assessing individuals' relative likelihood of choosing different food categories.

Appetitive characteristics and food choice in children

A handful of studies have related appetitive characteristics to indices of food *preferences* and *intake*. For example, one recent study using parent-report food preference questionnaires in samples of UK 16-month olds and Australian 3-4 year olds found that higher CEBQ-SR was associated with lower fruit and vegetable liking, CEBQ-FR was associated with greater liking for snack foods, and CEBQ-EF was associated with greater fruit and vegetable liking (Fildes et al., 2015). Another UK study using a 6-item Food Frequency Questionnaire (FFQ) found higher CEBQ-EF was associated with greater fruit and vegetable intake in pre-schoolers (Cooke et al., 2004) and a Dutch study using an FFQ to assess fruit and snack intake in 8-12 year olds found that higher CEBQ-SR was associated with less fruit intake and more snack intake, while higher CEBQ-FR was associated with greater fruit intake, and higher CEBQ-EF with greater fruit and snack intake (Rodenburg, Kremers, Oenema, & van de Mheen, 2012). Another study using CEBQ data obtained at 16 months of age and 3 day food diaries assessed at 21 months old demonstrated that whereas higher CEBQ-FR was associated with greater meal frequency but not meal size, higher CEBQ-SR was associated with a smaller meal size but not with meal frequency; the composition of the diet was not reported in this study (Syra, Johnson, Wardle, & Llewellyn, 2016).

Food choices and adiposity in children

Studies with relevance to the relationship between food choices and adiposity in children include those examining i) *free-living food intake* using child- or parent-report dietary measures such as food records, 24 hour dietary recalls and food frequency questionnaires, ii) *food choices* and *preferences* assessed via behavioral tests and questionnaires, and iii) *weighed food intake* as assessed at ad libitum multi-item meal tests conducted in the laboratory. Studies using (i) have tended to show that greater choice of and/or intake of high-fat, high-sugar foods is associated with greater weight (Lioy, Volatier, Lafay, Touvier, & Maire, 2009; Millar et al., 2014). However some observe no associations (Alexy, Libuda, Mersmann, & Kersting, 2011), perhaps because studies of self-reported free-living intake in older children (Baxter, Thompson, & Davis, 2000; Baxter, Thompson, Davis, & Johnson, 1997; Baxter, Thompson, Litaker, Frye, & Guinn, 2002; Baxter et al., 2003) and parent-reported free-living intake in younger children (Montgomery et al., 2005; Reilly, Montgomery, Jackson, MacRitchie, & Armstrong, 2001) are prone to recall bias, under- or over-reporting and social desirability bias. Fewer studies use (ii) and those that do have produced mixed results, with some studies finding that children who choose or report preferring high-fat and/or high-sugar foods are heavier or fatter (Lanfer et al., 2012; Fisher & Birch, 1995), but others reporting no association between liking for particular food categories and adiposity (Hill, Wardle, & Cooke, 2009), possibly due to the relative unimportance of stable 'liking' compared to in-the-moment 'wanting' in driving intake (Berridge, 2009). Laboratory tests of food group intake from standardized food selections are therefore a helpful third way to examine the relationship between food choice and weight. Although many studies use test meals to examine the effect of various food-related manipulations (e.g. macronutrient content, portion size) on calorie intake, surprisingly few

use this method as a way of examining characteristic food choices in a naturalistic environment. However, a recent study measuring 71 4-6 year olds' intake at two test meals – one baseline meal consisting of moderately palatable foods, and one highly palatable buffet including sweet, sweet-fat, and savory-fat foods – found that total energy intake at both meals and intake of savory-fat foods at the palatable buffet were positively associated with adiposity as assessed by DXA (Fearnbach, Thivel, Meyermann, & Keller, 2015); findings like this suggest that there could be a particular food choice profile that is characteristic of heavier children.

Consistency of eating behavior and food group intake

Although there is a sizeable literature using dietary recalls, records and food frequency questionnaires to investigate tracking of food group intake within childhood (Oellingrath, Svendsen, & Brantsaeter, 2011), from childhood to adolescence (Patterson, Warnberg, Kearney, & Sjostrom, 2009; Wang, Bentley, Zhai, & Popkin, 2002), and from childhood to adulthood (Mikkila, Rasanen, Raitakari, Pietinen, & Viikari, 2005) fewer studies have examined consistency of food group intake over a shorter period, using objective methods. One US study presented 36 adults with four laboratory meals consisting of either 15 chicken sandwich quarters, or a mix of chicken, ham and turkey quarters, and reported intra-class coefficients ICCs of .69 for females and .80 for males, independent of the variety of sandwiches presented (Martin et al., 2005). Other research in children has supported stability of intake over a daily time-span, but not necessarily from meal to meal, with one study of 6 days of weighed food intake in 15 2-5 y olds finding that while children's intake between individual meals was highly variable (33.6% mean coefficient of variation), total daily energy intake was relatively consistent (10.4% mean coefficient of variation) (Birch, Johnson, Andresen, Peters, & Schulte, 1991).

The current study

The primary aim of this study was to use data from a larger eating behavior protocol during which 4-5 year olds were presented with the same standardized multi-item lunch on 5 different occasions, following a variety of preloads, to investigate relationships between CEBQ sub-scale scores and intake of food categories with varying relationships to child obesity risk in a naturalistic, school-based setting outside the influence of parents, whose actual or even perceived monitoring can affect children's food choices (Klesges, Stein, Eck, Isbell, & Klesges, 1991). To fully characterize food choice patterns, *relative* as well as absolute intake of food categories was evaluated by calculating intake of each food group as a percentage of total food intake. Further, to rule out the possibility that CEBQ-intake relationships were primarily driven by differences in metabolic needs and to get a sense of the likely impact of a particular CEBQ sub-scale score on weight gain, we estimated daily and lunch-time metabolic needs for each child in order to conduct adjusted analyses, and to conduct descriptive comparisons of actual intake with estimated requirements for our various groups of interest. Secondary aims were to assess consistency of food group intake variables across multiple occasions (to strengthen confidence in observed CEBQ-intake relationships) and to test associations between food group intake variables and child weight.

Method

Overview

Children participated in a five day school-based eating behavior testing protocol spanning five weeks and intake at a standardized multi-item lunch (see below for details) was recorded on each of the five test days. On the first day of the protocol, a standardized multi-item lunch was simply given during the normal school lunch break (Day A). In addition, children's heights and weights were measured by researchers, following standard procedures. Where children were absent, measurements were taken on the following test day. Parents were given the option to exclude their children from weighing and measuring prior to the beginning of the study but none did so. Also on Day A, parents completed questionnaires including basic demographic information (e.g. parent educational level and ethnicity), together with a selection of sub-scales drawn from the Child Eating Behaviour Questionnaire (CEBQ; Carnell & Wardle, 2007; Wardle, Guthrie, Sanderson, & Rapoport, 2001) (see below for details). Reminder questionnaires were sent to parents who did not return the questionnaire within a week. On the second and third days, the same standardized lunch was given 30 minutes following consumption of 200 mL of either a low calorie orange flavor liquid preload (Day B) or a high calorie orange flavor liquid preload (Day C) (counter-balanced), differing only in carbohydrate content. On the fourth and fifth days of the protocol, lunch followed consumption of 200 mL of either water (Day D), or milkshake (Day E). Full details of preload preparation and contents and lunch administration procedures are presented elsewhere (Carnell & Wardle, 2007).

Procedures

Lunches

Lunch on each of the five days consisted of: 5 chicken slices (Sainsbury's Chicken Slices, J Sainsbury plc, 299.30±66.32 g, 136.96±113.84 kcal), 4 cheese slices (Sainsbury's Medium Cheddar Slices, J Sainsbury plc, 253.40±51.34 g, 361.21±309.93 kcal), 3 halves of white bread roll (Tesco's Bridge Rolls, Tesco plc / Sainsbury's Hot Dog Rolls, J Sainsbury plc, 288.77±31.32 g, 394.95±256.74 kcal), approximately 35 g of mini cheese crackers (McVities Mini Cheddars, 183.33±8.99 g, 391.18±296.61 kcal), approximately 50g of mini chocolate cookies (McVities Mini Chocolate Digestives, 258.51±7.85 g, 979.02±357.08 kcal), and approximately 98 g of green grapes (489.09±9.83 g, 103.18±93.38 kcal). A portion of vegetables was also provided. For the first class studied this was 8 cherry tomatoes throughout (102.90±198.99 g, 0.94±4.94 kcal); the remaining four classes received approximately 225 g carrot sticks (225.39±103.32 g, 14.03±18.72 kcal), based on low liking reports for the tomatoes by many children in the first class. Water was provided and, to ensure that children could eat to satiety, extra pre-weighed portions of bread rolls were offered when staff observed that children had finished their servings. Lunch tray contents were weighed before and after lunch in order to calculate intake of each component.

Child Eating Behaviour Questionnaire

The Child Eating Behaviour Questionnaire (CEBQ; Carnell & Wardle, 2007; Wardle, Guthrie, Sanderson, & Rapoport, 2001) is a validated multi-dimensional, parent-report

questionnaire measuring children's eating behaviour. Parents were asked to complete three sub-scales from the CEBQ that show strong theoretical and empirically demonstrated relationships with body weight. The Satiety Responsiveness/Slowness in Eating (CEBQ-SR) sub-scale includes 4 items assessing satiety sensitivity, i.e. the degree to which a child stops eating or chooses not to initiate eating based on their perceived fullness (e.g. *My child gets full before his/her meal is finished*). In addition to these items, 5 further items assess speed of eating, which has been positively associated with body weight. Notably, despite the theoretical distinction between satiety responsiveness and speed of eating, all items loaded together in the original factor analysis for the CEBQ (Wardle, Guthrie, Sanderson, & Rapoport, 2001). For this study these items were therefore combined to form a 9-item scale, on which higher scores indicate greater satiety responsivity and faster eating. The Food Responsiveness (CEBQ-FR) and Enjoyment of Food (CEBQ-EF) sub-scales both assess children's general appetite for food or desire to eat, with higher scores indicating greater levels. However, while CEBQ-EF aims to capture normal variation in general appetite (e.g. *My child enjoys eating*), the CEBQ-FR sub-scale was designed to detect potentially maladaptive levels of appetite (e.g. *Given the choice, my child would eat most of the time*) and also includes items assessing the tendency to eat when prompted by external cues (e.g. *Even if my child is full up, he/she finds room for his/her favourite food*),

Data treatment and analysis

Data treatment—To estimate calorie intake of each individual food on each test day we used manufacturers' information and average calorie contents from McCance and Widdowson's *The Composition of Foods* (McCance & Widdowson, 2002). We then calculated caloric intakes for four different food categories posing different levels of obesity risk: Snack foods (chocolate cookies, cheese crackers), white bread, protein foods (chicken and cheese slices) and fruits and vegetables (tomatoes/carrots and grapes). The snack foods selected here represented highly-processed energy-dense items, which have been shown to be associated with higher weight (Drapeau et al., 2003; Newby et al., 2003), while fruits and vegetables have been shown to be protective against obesity, possibly by replacing more energy-dense foods in the diet (Epstein et al., 2001; Rolls, Ello-Martin, & Tohill, 2004). White bread and protein foods may be associated with obesity (Bazzano et al., 2005; Rolland-Cachera, Deheeger, Akrouit, & Bellisle, 1995; Warren, Henry, & Simonite, 2003) and over-consumption could certainly result in increased weight; high intake of these was therefore considered to confer an intermediate level of obesity risk. Caloric intake data from all five test days, representing children's lunch intake across a range of possible circumstances, was used to investigate consistency of intake, and to calculate summary variables for analyses of relationships with CEBQ sub-scales and BMI z score. Additionally, in order to create variables capturing children's preferences for particular food groups, we calculated mean intakes (kcal) for each designated food group on each test day. For example, snack food intake on each test day was calculated as the mean of the total chocolate cookie calories, and total cheese cracker calories consumed on that day. An averaging rather than a summing method was chosen in order to represent children's average preference for items within each food category, since a summing method could be distorted by heavy consumption of one item in the context of minimal consumption of the others. To represent total intake of each food category of interest in the context of total lunch intake we also,

though, calculated intake of each designated food group as a percentage of total lunch calories consumed; this additionally provided a specific index of *relative* food choices. Finally, for analyses of relationships with CEBQ sub-scales and BMI z score, we used the above variables to create mean intakes (kcal), and percentage intakes (% total kcal), for each food group, across all five test days. In order to maximize power to detect associations, we created these summary scores for participants who had five days of data (n=70), four days of data (n=31), three days of data (n=18), two days of data (n=2) or one day of data (n=2).

Data analysis—To test consistency of food group intake in kcal, and food group intake in kcal as a percentage of total lunch intake, we calculated intraclass correlations (ICC) as an indicator of overall consistency. In addition, to investigate differences by test day, we ran Friedman's tests for each food group using both kcal and percentage variables, including data for Days A-E, and to further explore differences between days we conducted post-hoc tests, using Tukey's Range Test. Next, to investigate relationships between CEBQ sub-scale scores, child BMI z scores, and both mean food group intake in kcal, and total food group intake in kcal as a percentage of total lunch intake, we ran Spearman's correlations, since intake variables were not normally distributed. Primarily for illustrative purposes, we also plotted mean food group intake in kcal, and food group intake in kcal as a percentage of total lunch intake, for the lowest, middle and highest tertiles of each CEBQ sub-scale, and for lower healthy-weight, higher healthy-weight and overweight/obese groups, and ran univariate ANOVAs to examine group differences with Tukey post-hoc tests to explore significant effects. CEBQ tertiles were generated based on being in the lowest vs. middle vs. highest tertile of the data distribution for each sub-scale (CEBQ-FR: lowest 0.00-1.00, middle 1.01-1.40, highest 1.41-4.00, respectively; CEBQ-SR: lowest 0.00-1.78, middle 1.79-2.33, highest 2.34-4.00; CEBQ-EF: lowest 0.00-2.00, middle 2.01-3.00, highest 3.01-4.00). Weight groups were based on having a BMI < 50th centile (lower healthy-weight), > 50th centile (higher healthy-weight), and overweight/obese as defined by World Obesity Clinical Care (formerly International Obesity Task Force) criteria (Cole & Lobstein, 2012). Finally, in order to explore the clinical significance of these findings, we calculated daily metabolic needs based on age, sex, body weight, height and physical activity levels (assumed to be low) for each individual child (Academies, 2005), as well as estimated daily lunch needs based on 35% of daily calories being consumed at the lunch meal (Galisa, Esperança, & Sá, 2008). We then repeated intake correlations controlling for daily metabolic needs. We also generated calorie values representing lunchtime metabolic needs for children in different CEBQ tertile groups and weight groups, so that we could conduct a descriptive comparison of actual total intakes and predicted total intakes based on differing metabolic needs. All analyses were conducted using SPSS, version 23.

Results

Participants

Five primary school reception classes taking children between 4 and 5 years of age were recruited into the study. All schools were located in the lowest quartile of deprivation for their borough, as indexed by free school meal eligibility. Together, the five reception classes contained 149 children, of whom 123 participated on at least one of the five experimental

days, while 70 participated on all five days. Of the 108 children who had BMI data available, 35.2% (n=38) had a BMI centile of 50 or under (lower healthy-weight), 44.4% (n=48) had a BMI centile of over 50 (higher healthy-weight), and 20.4% (n=22) were overweight or obese. One hundred and four children participated on at least one day, and had data available on either BMI or one of the CEBQ sub-scales. Of these children, 74.0% (n=77) were White British, 8.7% (n=9) were White European, 1% (n=1) was Indian, 8.7% (n=9) were Black African, 5.8% (n=6) were Black Caribbean, 1% (n=1) was other groups, and 1% (n=1) was missing (percentages do not add up to 100 due to rounding errors). Almost twenty-seven percent (n=28) of mothers reported their highest education to be General Certificate of Secondary Education (GCSE)/Ordinary Level (O-level)/National Vocational Qualification (NVQ)/General National Vocational Qualification (GNVQ), while 25% (n=26) reported attaining Advanced Level (A-level)/National Diploma, and 41% (n=43) a degree or further qualification. Only 1% (n=1) reported no and educational qualifications and 6% (n=6) had missing data.

Food group intake across test days: differences and correlations between days

Differences and correlations between days for food group intake were calculated for the 70 children completing every day of the test protocol. **Figure 1a** shows mean intake (kcal) by food group for Day A (no preload), Day B (low calorie orange preload), Day C (high calorie orange preload), Day D (water preload) and Day E (milkshake preload), and **Figure 1b** shows mean percentage intakes (% total kcal) by food group for each day (see Carnell & Wardle (2007) for details on relationships between compensation for caloric content of preloads and CEBQ sub-scales). Intraclass correlations (ICCs) for the repeated intake assessments were .86 ($p<0.001$) for snack food intake in kcal and .87 ($p<0.001$) for snack food intake as a percentage of total intake. ICCs for white bread were .87 ($p<0.001$) for kcal intake and .78 ($p<0.001$) for percentage intake. ICCs for protein foods were 0.91 ($p<0.001$) for kcal intake and .91 ($p<0.001$) for percentage intake. ICCs for fruits and vegetables were 0.86 ($p<0.001$) for kcal and .84 ($p<0.001$) for percentage intake.

Relationships between CEBQ sub-scale scores and BMI z score, and food group intake

Relationships between CEBQ sub-scale scores and BMI z score, and food group intake were calculated using data from all subjects participating on at least one day of the study and having CEBQ-SR (n=115), CEBQ-FR (n=115), CEBQ-EF (n=116) or BMI data (n=108) available. **Table 1** presents the main analyses, which were bivariate correlations between CEBQ sub-scale scores and mean intake (kcal) (**Table 1a**) as well as percentage of total intake (**Table 1b**) by food group across all five test days. Additionally, primarily for illustration, **Figure 2a** shows mean intake (kcal) by food group for low, middle and high tertiles of each CEBQ sub-scale, while **Figure 2b** shows percentage intakes (% total kcal) by food group for each tertile.

CEBQ-SR scores showed the highest negative correlations with white bread and fruit and vegetable intake (both $r=-0.36$), followed by protein food intake ($r=-0.31$), with the lowest negative correlation for snack food intake ($r=-0.22$). Higher CEBQ-SR scores were also associated with lower total intake ($r=-0.44$). Correlations with percentage intakes revealed a different pattern of results, with fruits and vegetables ($r=-0.23$) showing a significant

negative correlation with CEBQ-SR, and a positive correlation emerging for snack foods ($r=0.23$).

CEBQ-FR scores showed a positive correlation with fruit and vegetable ($r=0.26$) and white bread intake ($r=0.24$), but relationships with snack food and protein food intake did not reach significance. Higher CEBQ-FR scores were also associated with greater total food intake ($r=0.28$). Correlations with percentage intake revealed no significant differences.

CEBQ-EF scores showed the strongest positive correlation with white bread intake ($r=0.36$), followed by fruit and vegetable intake ($r=0.28$), protein food intake ($r=0.25$), then snack food intake ($r=0.21$). Higher CEBQ-EF scores were also associated with greater total food intake ($r=0.40$). Correlations with percentage intakes revealed a different pattern of results, with a positive correlation emerging for white bread ($r=0.19$) and a negative correlation for snack foods ($r=-0.19$).

Correlations with intake adjusted for the daily metabolic needs of each child (**Supplementary Table 1**) were largely similar for all sub-scales and food groups except that the correlation between snack food intake and CEBQ-EF decreased to non-significant levels.

Table 1 presents bivariate correlations between BMI z score scores and mean intake (kcal) (**Table 1a**) as well as percentage of total intake (**Table 1b**) by food group, while **Figure 3a** and **Figure 3b** show mean intake and percentage intake by food group for different weight groups. Snack food intake ($r=0.25$) and bread intake ($r=0.37$) were positively correlated with BMI z score but smaller BMI z correlations for protein food intake and fruit and vegetable intake did not reach statistical significance. Greater total food intake was associated with higher BMI z score ($r=0.38$). Correlations with percentage intake revealed no significant differences.

Discussion

This study of young children's lunch intake objectively assessed over multiple occasions revealed that different parent-report dimensions of child appetite are associated with differing profiles of food choice, defined here as a child's decision to consume a particular absolute amount of a certain category of food, or to consume relatively more or relatively less of a certain food category, when presented with an array containing several different food categories. More specifically, higher CEBQ-SR scores were significantly associated with lesser intake within both lower and higher-ED food categories, and higher CEBQ-EF with greater intake of all food categories, while higher CEBQ-FR was associated with greater intake of white bread and fruits and vegetables. As well as suggesting that these sub-scales are sensitive to different profiles of eating behaviors relating to type as well as amount of food in children, these associations could be substantively important, because differing profiles of food choice could be differentially associated with longitudinal BMI trajectories, and mediate longitudinal relationships between appetitive characteristics and child weight trajectories. Certainly, in addition to relationships with CEBQ, the current dataset also revealed a relationship between greater intake of sweet and savory snack-foods and white bread and higher child BMI z scores. These food groups each exemplify food types that have

been associated with greater adiposity (Nicklas, Yang, Baranowski, Zakeri, & Berenson, 2003).

CEBQ-SR associations

One notable feature of our CEBQ association findings was that the relationship between snack food intake and CEBQ-SR was weaker than for some of the other food groups. One potential explanation for this might be the fact that intake of snack foods was very high among all children; however there was still substantial variance available to detect relationships with sub-scale scores and scatter plots were consistent with this observation. In addition, we did not see this pattern with other sub-scales, suggesting that, more likely, CEBQ-SR is not quite as strong a driver of snack intake as of intake of other food categories. Another striking observation was that, in analyses of food group intakes as a *percentage* of total intake, higher CEBQ-SR was associated with relatively *greater*, rather than lesser, intake of snack foods, as well as relatively *lesser* intake of fruits and vegetables. This suggests that, while children with high CEBQ-SR may eat less overall, they tend to preferentially choose relatively *more* unhealthy foods when these are made available in a relatively non-monitored situation, potentially indicating a risk for poor nutrition choices. Further, although correlations between CEBQ-SR and food group intakes were largely unchanged by adjusting for daily metabolic needs, and those scoring high on CEBQ-SR (highest tertile within sample) ate relatively little compared to those with lower scores (lowest tertile within sample), children in all tertiles were consuming *less* than their estimated needs, and in fact less than the estimated needs of children in all weight groups, including overweight and obese. These conclusions should of course be treated with caution, since we did not measure children's intakes post-lunch, and children could have compensated for a relative deficit in lunch calories by consuming relatively more calories over the rest of the day.

CEBQ-FR associations

We were also interested to see that, although CEBQ-FR was not significantly associated with protein or snack food intake, scores were positively associated with greater white bread and fruit and vegetable intake. Although we did not anticipate the significant relationship with fruit and vegetable intake, this relationship is consistent with the purpose of the scale, which was to tap potentially maladaptive appetitive characteristics including a strong drive to snack, and to eat beyond fullness when offered their favorite foods, which may include fruits. In support of fruits rather than vegetables driving the CEBQ-FR finding, we indeed found in a follow-up exploratory analysis that associations were more apparent for fruits ($r=.20$, $p=0.032$) than for vegetables ($r=.01$, $p=0.884$). It was also notable that, although those scoring high on CEBQ-FR were consuming an amount of calories closer to their estimated metabolic needs than children in the other tertiles (high FR: 506 kcal actual intake vs. 549 kcal expected intake, mid FR: 458 vs 543 kcal, low FR: 444 vs 560 kcal), all groups were generally consuming less than their estimated metabolic needs. Another interesting observation was that analyses of *percentage* intakes showed no associations with CEBQ-FR; this suggests that although higher CEBQ-FR may be associated with greater intake of various food groups, this variable does not substantially influence *relative* choice and intake of different foods at a multi-item meal.

CEBQ-EF associations

Another observation of interest in our data was that relationships with greater intake were more consistent across food groups for CEBQ-EF than for CEBQ-FR, suggesting that the former may be a slightly more robust indicator of heightened overall intake. With this in mind it was also interesting that the strongest association with CEBQ-EF that we observed was for white bread – this was often compiled by children into sandwiches, which might be considered the main part of their lunch meal. This suggests that the enjoyment scale may be especially reflective of mealtime consumption. Adjusting for metabolic needs made no substantive difference to associations with food group intake, with all relationships remaining significant and positive (except the association with snack food intake which remained positive but became non-significant). In addition, as was the case with CEBQ-FR, those scoring high on CEBQ-EF were consuming an amount of calories closer to their estimated metabolic needs than children in the other tertiles (high EF: 544 kcal actual intake vs. 547 kcal expected intake, mid EF: 482 vs 542 kcal, low EF: 395 vs 524 kcal), but all groups were consuming less than their estimated metabolic needs. Analysis of percentage intakes, though, revealed an interesting deviation from the absolute intake results, with greater food enjoyment being associated with *lesser* relative intake of snack foods, as well as greater relative intake of white bread. Together these findings confirm that the CEBQ-EF scale reflects mealtime consumption and further suggest that higher scores could predict a healthier overall consumption profile with snack foods making up a relatively smaller proportion of total intake.

Consistency of food group intake patterns

A secondary finding of this study was that, despite differing preload conditions, children who completed all five days of the protocol showed remarkable consistency of food choice across all five meals, with strong day-to-day intra-class correlations for both intake in kcal, and percentage intakes, across all food categories. Interestingly, the lowest ICC observed was for percentage intake of white bread, suggesting that this food choice index may be the most variable and potentially elastic in the sense of varying in response to the different preload conditions. However, on the whole our data suggest that food choice patterns may indeed be stable. This not only gives confidence in our reported associations with CEBQ sub-scale scores, but argues strongly for the development of measures of food preference or choice traits, or characteristics, as well as appetitive characteristics.

Food intake and child weight

Another secondary aim of our study was to explore associations between food choices and BMI z score, and we found here that greater intake of sweet and savory snack foods and white bread were associated with higher child BMI z scores. Importantly, the majority of these associations remained even when controlling for differing metabolic needs based on age, sex, height, weight and physical activity. One partial exception to this pattern was the relationship with snack foods, for which the direction remained positive but the r value became non-significant, dropping from .25 to .15. This change was small and should not be over-interpreted but could suggest that lunch-time energy intake from categories such as white bread is a more robust indicator of obesogenic food preferences independent of

metabolic need, than energy intake from snack foods, which have the potential to inspire bouts of excessive eating in all children. Another interesting observation was that only overweight boys, not leaner boys, or girls of any weight group, were consuming more than the mean estimated lunch-time metabolic needs for their weight group (666 kcal intake vs. 582 kcal needs). Limitations to our estimation methods notwithstanding, this observation suggests that overweight boys could be at particular risk of overeating at a multi-item meal such as the one we presented.

Our results extend the small body of previous findings on the relationship between food choice and appetitive characteristics in children in a number of ways. First, the broad pattern of associations we observed between greater scores of food approach sub-scales (CEBQ-FR, CEBQ-EF) and greater intake, and between greater scores on our food avoidance sub-scale (CEBQ-SR), are consistent with previous parent- and child-reported intake and preference data from the UK (Fildes et al., 2015; Cooke et al., 2004), Australia (Fildes et al., 2015), and the Netherlands (Rodenburg, Kremers, Oenema, & van de Mheen, 2012). Notably, none of the preceding studies evaluated intake of food categories as a percentage of total intake as an index of food choice. Since many food decisions in modern, food-abundant environments involve selecting relative amounts of foods from within a broad array containing both healthy and less healthy options, we believe this to be a helpful way of investigating relative food choices. Our finding that children who were higher in CEBQ-SR ate relatively *less* fruits and vegetables but relatively *more* snack foods, is consistent with Rodenburg et al's reported association between higher CEBQ-SR and *less* fruit intake but *more* snack intake. Our observation that children with higher food enjoyment ate relatively *less* snack foods and relatively *more* white bread was novel and particularly interesting in its implications regarding the overall health of the dietary profile. The current study also extended previous work on the CEBQ by evaluating results in the context of estimated metabolic needs. The robustness of our findings despite adjustment for needs suggests that caloric intake and food choices are not simply driven by homeostatic mechanisms to maintain current weight among children displaying a certain appetitive characteristic, but instead reflect behavioral tendencies that could lead to excess weight gain in the future.

Our study had a number of strengths, the primary one being that we measured objective food intake at a standardized, multi-item meal over multiple occasions, giving us more confidence in our estimates of relationships with CEBQ sub-scales and adiposity than would be obtained if we used reported data, or data from one meal occasion alone. In so doing, we were able not only to conduct a novel investigation of associations between objectively measured intake and CEBQ sub-scale scores, but also to add to a fairly limited body of research exploring associations between BMI and food intake assessed under controlled conditions in the preschool population. Another advantage is that intake was measured in a naturalistic, ecological setting outside of the influence of parents, whose actual or even perceived monitoring is known to affect children's food choices (Klesges et al., 1991). Certainly children were not completely unobserved – teachers and researchers were present at all of the meals. However it would be very unusual for children of this age to be unsupervised, so their behavior in these meals is likely to be fairly reflective of normal eating behavior. One might also argue that the majority of meals at this age are consumed in the home, making meals eaten at school less representative of overall intake. However, food

consumed outside of the home, including at school, is also a significant contributor to intake and is associated with increased caloric intake (Briefel, Crepinsek, Cabili, Wilson, & Gleason, 2009; Poti & Popkin, 2011), poorer diet quality (Briefel et al., 2009; Poti & Popkin, 2011), and increased BMI (Fox, Dodd, Wilson, & Gleason, 2009).

The variable preceding preloads could be seen as a limitation, as could our analysis approach of including data from children with a varying number of days of complete data when averaging meals across all preloading conditions. However, children do sometimes consume something before lunch, making it useful to look at food choice (consistency and relationships with other variables) over a variety of different conditions of prior intake. In addition, the majority of children ($n=119$, 96.75%) had complete data for at least 3 days of the protocol, and relationships with CEBQ sub-scales and BMI z score were also apparent when data from each day were analyzed separately, suggesting that our approach of averaging across days to maximize power to detect associations with our outcomes of interest did not affect the results. The selection of foods we offered was limited compared to that sometimes offered in ad libitum eating tests in the laboratory. However, the foods we selected were common lunch-time foods for UK children, and the robust intakes we obtained, as well as the enthusiasm for the meal that we observed, suggest that intake was not unduly curtailed. Our sample was large for an eating behaviour study of this type. However, examination of confidence intervals demonstrated significant overlap in CEBQ-correlations between each sub-scale, suggesting that any differences in intake associations between sub-scales should be treated with caution and replicated in other studies.

To conclude, our results support the potential existence of stable 'food choice' traits or characteristics in children that are partly captured by sub-scales within the CEBQ, as well as highlighting relationships between certain food choice patterns and child weight. As such, they highlight potential targets for intervention in the prevention or treatment of child obesity. For example, since snack food intake was associated with higher adiposity, intake of these foods could be specifically targeted for reduction through education or environmental controls. Since white bread showed a similar association and highly-processed, high-glycemic index carbohydrates have also been associated with overeating and higher adiposity in other studies (Ludwig et al., 1999), another potential intervention might be to replace this type of bread with a more satiating, whole-grain version in children's meals. Since CEBQ sub-scales predict intake, as well as weight, it might also be advisable to develop interventions to either change appetitive characteristics (e.g. Daniels et al., 2014) or if not then at least ameliorate the effects of these characteristics on weight by changing the immediate food environment (e.g. limit availability and accessibility of higher-ED foods). Scientifically, these results argue for further research into how specific CEBQ values predict intake of different food groups and, in turn, weight trajectories; this enterprise may help to establish behavioral profiles that could be targeted in the aforementioned interventions. Since the CEBQ, which was designed to assess appetite rather than food choice, does not entirely capture variation in food intake profiles, our results also argue for the development and validation of alternative characteristic/trait measures to directly assess stable, weight-predictive food preferences and intake patterns, preferably using similarly simple, parent-report techniques.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Children showed high consistency of food intake patterns over five lunch meals
- CEBQ-SR, FR and EF showed differential associations with absolute and relative intake of different food categories
- Absolute intakes of white bread and snacks were associated with higher BMI z

Figure 1a. Mean intake (kcal) by food group on Days A-E of protocol

Figure 1b. Mean percentage intake (% total kcal) of each food group on Days A-E of protocol

Figure 2a. Mean intake (kcal) by food group of children in low, mid and high tertiles for CEBQ-SR, CEBQ-FR and CEBQ-EF scores

Exploratory univariate ANOVAs with Tukey post-hoc tests revealed CEBQ-SR group differences for white bread ($F[2,120]=5.06$, $p=0.008$; low vs. mid $p=0.023$, low vs. high $p=0.014$); fruits and vegetables ($F[2,120]=7.48$, $p=0.001$; low vs. mid $p=0.003$, low vs. high $p=0.003$) and total intake ($F[2,120]=7.03$, $p=0.001$; low vs. mid $p=0.049$, low vs. high $p=0.001$); CEBQ-FR group difference for fruits and vegetables ($F[2,120]=3.27$, $p=0.042$; low vs. high $p=0.032$); and CEBQ-EF group differences for snack foods ($F[2,120]=3.55$, $p=0.032$; low vs. mid $p=0.024$), white bread ($F[2,120]=9.10$, $p<0.001$; low vs. high $p<0.001$, mid vs. high $p=0.004$), protein foods ($F[2,120]=5.31$, $p=0.006$; low vs. high $p=0.006$, mid vs. high $p=0.031$), fruits and vegetables ($F[2,120]=5.48$, $p=0.005$, low vs. high $p=0.004$); and total intake ($F[2,120]=8.48$, $p<0.001$; low vs. mid $p=0.015$, low vs. high $p<0.001$).

Figure 2b. Mean percentage intake (% total kcal) of each food group for children in low, mid and high tertiles for CEBQ-SR, CEBQ-FR and CEBQ-EF scores

Exploratory univariate ANOVAs with Tukey post-hoc tests demonstrated CEBQ-SR group difference for fruits and vegetables ($F[2,120]=3.78$, $p=0.026$; low vs. high $p=0.045$); and CEBQ-EF group difference for snack foods ($F[2,120]=5.85$, $p=0.004$; low vs. high $p=0.024$, mid vs. high $p=0.003$), and white bread ($F[2,120]=3.87$, $p=0.024$; mid vs. high $p=0.018$).

Figure 3a. Mean intake (kcal) by food group of children in lower healthy-weight, higher healthy-weight, and overweight/obese weight groups

Exploratory univariate ANOVAs with Tukey post-hoc tests revealed weight group differences for snack foods ($F[2,102]=5.85$, $p=0.004$; 50th centile vs. overweight/obese $p=0.003$), white bread ($F[2,102]=9.10$, $p<0.001$; 50th centile vs. overweight/obese $p<0.001$, > 50th centile vs. overweight/obese $p=0.001$), and total intake ($F[2,102]=9.07$, $p<0.001$; 50th centile vs. overweight/obese $p<0.001$, > 50th centile vs. overweight/obese $p=0.005$).

Figure 3b. Mean percentage intake (% total kcal) of each food group for children in lower healthy-weight, higher healthy-weight, and overweight/obese weight groups

Exploratory univariate ANOVAs with Tukey post-hoc tests revealed no weight group differences.

Table 1a

Correlations between CEBQ sub-scale scores, BMI z score and mean intake (kcal) by food group.

	Snack foods	White bread	Protein foods	Fruits & vegetables	Total intake
rho (95% CI)					
CEBQ-SR	-0.22 (-0.39;-0.04) *	-0.36 (-0.51;-0.19) ***	-0.31 (-0.47;-0.13) **	-0.36 (-0.51;0.19) ***	-0.44 (-0.581;-0.028) ***
CEBQ-FR	0.18 (-0.01;0.36)	0.24 (-0.06;0.41) *	0.12 (-0.70;0.30)	0.26 (0.08;0.43) *	0.28 (.10;0.44) *
CEBQ-EF	0.21 (0.03;0.38) *	0.36 (0.19;0.51) ***	0.25 (0.07;0.42) *	0.28 (0.10;0.44) *	0.40 (.23;0.55) ***
BMI z score	0.25 (0.06;0.42) *	0.37 (0.19;0.52) ***	0.19 (-0.00;0.37)	0.12 (-0.07;0.30)	0.38 (.20;0.53) ***

rho: Spearman's rho; CI: confidence interval.

*
p<0.05;**
p=0.001;***
p<0.001.

Table 1b

Correlations between CEBQ sub-scale scores, BMI z score and mean percentage intake (% total kcal) by food group.

	Snack foods	White bread	Protein foods	Fruits & vegetables
rho (95% CI)				
CEBQ-SR	0.23 (0.05;0.40)*	-0.12 (-0.30;0.07)	-0.15 (-0.33;0.04)	-0.23 (-0.40;-0.05)*
CEBQ-FR	-0.02 (-0.21;0.17)	0.01 (-0.18;0.20)	-0.01 (-0.20;0.18)	0.14 (-0.05;0.32)
CEBQ-EF	-0.19 (-0.36;0.00)*	0.19 (0.00;0.36)*	0.12 (-0.07;0.30)	0.17 (-0.02;0.35)
BMI z score	-0.04 (-0.23;0.15)	0.09 (-0.10;0.28)	0.01 (-0.18;0.20)	-0.05 (-0.24;0.14)

rho: Spearman's rho; CI: confidence interval.

* p<0.05.