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Observed Infant Food Cue Responsivity: Associations with Maternal Report of Infant Eating Behavior, Breastfeeding, and Infant Weight Gain

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Abstract

Infant obesity and the rate of weight gain during infancy are significant public health concerns, but few studies have examined eating behaviors in infancy. Food cue responsivity has been described as a key contributor to obesity risk in school age children and adults, but has been rarely examined during infancy. The purpose of the current study was to test among 30 infants aged 6 to 12 months the hypotheses that infants would show greater interest in food versus nonfood stimuli, and that greater birth weight, greater rate of weight gain during infancy, greater mother-reported food responsiveness, being formula versus breastmilk fed, and higher maternal body mass index, would each be associated with greater interest in the food versus non-food stimulus. Results showed that overall infants showed a preference for the food versus non-food stimulus. Preference for the food versus non-food stimulus was predicted by greater infant rate of weight gain since birth, greater maternal-reported infant food responsiveness, and having been exclusively formula-fed, but not by any other factor tested. Results are discussed with regard to theoretical implications for the study of infant obesity and applied prevention implications.

Keywords

Infancy; Eating behaviors

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Obesity is a significant public health problem (Ogden, Carroll, Kit, & Flegal, 2014). Preventing obesity is much more effective than treating it (Epstein, Valoski, Wing, & McCurley, 1994; Epstein, Valoski, Wing, & McCurley, 1990) and once obesity is established it is very likely to persist throughout the lifespan (Freedman et al., 2005; Nader et al., 2006). Prevention is therefore critical. By age 2 years, 8.1% of children are already obese (Ogden et al., 2014). In addition, the rate of weight gain in the first year of life is a robust risk factor for obesity later in childhood and into adulthood, independent of prenatal factors or birth weight (Baird et al., 2005; Belfort, Rifas-Shiman, Rich-Edwards, Kleinman, & Gillman, 2007; Botton et al., 2008; Dennison, Edmunds, Stratton, & Pruzek, 2006; Ekelund et al., 2007; Larnkjaer et al., 2010; Ong & Loos, 2006; Sachdev et al., 2005; Stettler et al., 2005; Taveras et al., 2011). The mechanism of rapid weight gain in the first year of life is currently unknown. As a result, there has been a call for additional research on the contributors to the development of obesity in children younger than age 2 years (Lumeng, Taveras, Birch, & Yanovski, 2015).

A growing focus in obesity research across the lifespan has been the role of food cue responsivity in contributing to obesity risk. Food cue responsivity is defined as the degree to which external food cues, such as the sight of food, encourage an individual to eat, potentially to excess (Carnell, Susan, Benson, Pryor, & Driggin, 2013). This appetitive trait has commonly been assessed in a number of ways. One approach has been to give children the opportunity to eat to satiety and then choose between eating palatable snacks or playing with toys (Birch, Fisher, & Davison, 2003). Others have evaluated attentional bias for food using implicit assessments (Carnell et al., 2013). An additional related construct is the willingness to consciously work to obtain food (i.e., the reinforcing value of food) (Epstein, Leddy, Temple, & Faith, 2007). Food cue responsivity in children has also been measured by parental report of food responsiveness and enjoyment of food (Wardle, Guthrie, Sanderson, & Rapoport, 2001a). Greater food cue responsivity measured through a range of these approaches has been associated with greater rates of obesity or weight gain in school age children (Braet & Crombez, 2003; Carnell & Wardle, 2008; Fisher et al., 2007; Hill et al., 2008; Hill, Saxton, Webber, Blundell, & Wardle, 2009; Nederkoorn, Coelho, Guerrieri, Houben, & Jansen, 2012; Seeyave et al., 2009; Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008).

Limited research has examined food cue responsivity in children younger than age 2 years. Parent report that an infant has “a good appetite” (Wright, Parkinson, & Drewett, 2006) or greater enjoyment of food and food responsiveness (van Jaarsveld, Llewellyn, Johnson, & Wardle, 2011) at younger than age 3 months predicted greater rates of weight gain in later infancy. Vigorous sucking patterns in early infancy, which may reflect food cue responsivity, have been linked with greater rates of infant weight gain (Agras, Hammer, McNicholas, & Kraemer, 2004; Agras, Kraemer, Berkowitz, & Hammer, 1990; Agras, Kraemer, Berkowitz, Korner, & Hammer, 1987; Waterland, Berkowitz, Stunkard, & Stallings, 1998). Only recently have researchers begun to use experimental protocols to interrogate infant eating behaviors besides infant sucking. In experimental studies with 9- to 18-month old infants, greater relative reinforcing value of food was linked with higher infant weight status (Kong, Feda, Eiden, & Epstein, 2015). The need for additional approaches to examining infant

eating behavior in experimental settings has been noted, in particular the examination of differential attention between two objects when food and non-food alternatives are presented in a concurrent fashion (Kong et al., 2015).

Infant feeding history may be an important factor to consider as it relates to infant food responsiveness. Infants who are formula-fed have an increased risk for overweight and obesity compared to breastfed infants (Butte, Wong, Hopkinson, Smith, & Ellis, 2000; Li, Fein, & Grummer-Strawn, 2008; Owen, Martin, Whincup, Smith, & Cook, 2005). Hypothesized mechanisms include improved satiety responsiveness in breastfed infants (e.g. Brown & Lee, 2012), differences in protein composition of formula versus breastmilk (e.g., Koletzko et al., 2009), and a less controlling maternal feeding style with breastfeeding (Taveras, Rifas-Shiman, Scanlon, Gummer-Strawn, Sherry, & Gillman, 2006), allowing for greater infant satiety responsiveness (Ventura & Birch, 2008; DiSantis, Collins, Fisher, Davey, 2011). There is a relative gap in the literature relating to food responsivity during this developmental period, especially as it relates to mode of feeding. In one observational study, although infants who were breastfed longer were rated by their mothers as more satiety responsive at 18 to 24 months, mode of feeding was not related to food responsivity (Brown & Lee, 2012). Similarly, in another study there was no association of formula-feeding with food responsiveness at 3 to 6 years of age, but the formula-fed group was quite small, limiting the power to find group differences (DiSantis et al., 2011). Neither of the studies (Brown & Lee, 2012; DiSantis et al., 2011) reported on food responsivity during infancy. To our knowledge, no studies have investigated the association of mode of feeding with food responsivity during infancy. DiSantis and colleagues reported that higher food responsiveness was related to a history of rapid growth. Formula-fed infants are at higher risk for early rapid growth, which is a risk factor for future overweight and obesity (Koletzko, Akerblom, Dodds, & Ashwell, 2005; Koletzko et al., 2008). Higher food responsivity in formula versus breastfed infants may be a mechanism explaining the higher risk for overweight and obesity in this group.

The current study therefore sought to examine observed infant food cue responsivity among 30 infants aged 6 to 12 months in the context of a novel behavioral protocol pitting a food versus non-food stimulus against one another. We sought to test several hypotheses. First, given the primacy of food as a behavioral reinforcer beginning in infancy (Gentry & Aldrich, 1948; Rosenstein & Oster, 1988), we hypothesized that overall, infants would show greater interest in the food versus non-food stimuli. Second, we hypothesized based on prior research linking maternal report of better infant appetite with infant weight gain (van Jaarsveld et al., 2011), that infants with greater birth weight or greater rate of weight gain since birth would show greater interest in the food versus non-food stimuli. Third, based on previous findings of good cross-validation between maternal report of children's eating behaviors and child behavioral measures (Carnell & Wardle, 2007) we hypothesized that infants whose mothers described them as more food responsive would show more interest in the food versus non-food stimulus. Fourth, given findings that breastfeeding is associated with better satiety responsiveness (Brown & Lee, 2012), we hypothesized that breastfeeding would be associated with reduced food responsiveness, a related but distinct construct. Finally, given associations between maternal and child weight (Whitaker, Wright, Pepe,

Seidel, & Dietz, 1997), we hypothesized maternal higher body mass index would predict greater infant interest in the food, as compared to the non-food stimulus.

Method

Participants and Recruitment

Thirty healthy, full term 6-, 9-, and 12-month old infants recruited from the community participated. Mothers were told that the researchers were interested in “learning about infant preferences and infant behaviors relating to those preferences.” Inclusion criteria were that the infant was born at full term (≥ 37 weeks gestation), following an uncomplicated pregnancy without perinatal or neonatal complications, with a birth weight appropriate for gestational age (10th and 90th percentile for gestational age and sex), without any current developmental delays, food allergies or intolerances or significant medical problems, and from a home where English was the primary language spoken. The sample was comprised of ten 6-month olds (6 boys, $M_{\text{age}} = 6.04$; $SD = 0.42$), ten 9-month olds (7 boys, $M_{\text{age}} = 9.24$; $SD = 0.43$), and ten 12-month olds (6 boys, $M_{\text{age}} = 12.25$; $SD = 0.23$), 82.8% of whom were White (one participant did not have race data reported, therefore $N = 29$). Average gestational age was 39.63 weeks ($SD = 1.25$). Mothers ranged in age from 23 to 41 years ($M = 31.17$, $SD = 5.09$), 86.2% were White, and 65.6% had completed a 4-year degree or more. Average infant birthweight was 3.45 kg ($SD = 0.41$).

Procedures

During the experiment, infants sat on their mothers' laps, centered in front of a tray (18"×14") that was clipped onto a table, with the experimenter sitting directly across from the infant. Mothers were instructed to adjust the height of the chair so that the infant was able to reach the most distal part of the tray. Mothers were also asked to wear a blindfold and to limit interactions with the infant to prevent unintentionally influencing the infants' reactions and choices. In order to reduce distraction for the infant, the experimenter wore a dark colored visor and lowered her head to cover her eyes during the tasks. All parts of the experiment were videotaped.

Infants were presented with six pairs of small clear plastic containers, which were sealed on all four sides with clips. Each pair included a food item and a visually similar toy item (See Fig. 1). The pairs were comprised of (A) Two golden Oreos stacked together and a pine-wood yo-yo, (B) six green beans and six green crayons, (C) five butter crackers of varying shape and 5 puzzle pieces painted yellow, (D) 100 green peas and 100 small green buttons, (E) three strawberries with their tops cut off and three 1-inch red porcupine balls, and (F) three broccoli florets and three cubes formed from green play foam. All stimuli pairs were presented starting with the experimenter's right hand, with initial toy and food containers counterbalanced across participants. The order of presentation for the stimuli pairs was randomized prior to the study visit, in order to eliminate order effects. The protocol was videotaped for later coding of infant behavior. These codes, as described below, were converted to create the binary outcome variable in the following analyses, reflecting whether the infants touched the food or non-food container.

After a script was finalized and approved by all authors, one lead researcher trained three research assistants in the correct administration of the protocol. All experimenters were female and instructed to use a similar tone and volume of voice. At each step of the protocol, instructions were given relating to the angle at which the containers should be held and shown to the infants, the number of seconds they should be shown, and how far apart they should be held. Experimenters memorized the script and protocol. A lead researcher met with the other experimenters individually to calibrate tone and volume and to assure correct administration of the script. Videos were reviewed and approved in meetings with all authors before each experimenter administered the protocol to participants.

Familiarization—Each of the six stimuli set trials started with a familiarization period during which both stimuli within a set (e.g., green beans and crayons) were presented to the infant. Therefore, there were six total familiarization trials, preceding the test phase for each of the six stimulus pairs. For each of the six trials, the experimenter placed the first container, without its top, on the table approximately 45 degrees to her right and out of the infant's reach. The experimenter then said “[infant's name], what's this?” in an animated tone. If the stimulus was food, the experimenter then took a small bite and said “Yum!”, then took another small bite and said “Yum!” again. If the stimulus was a toy, the experimenter demonstrated its function (e.g., drawing a line on a piece of paper with the crayon, fitting puzzle pieces together then taking them apart) to the infant and said “Wow!”, then repeated herself again. After this presentation, the container was removed from the table and the second stimulus of the pair was presented in the same manner on the experimenter's left side. At the end of this presentation, the container was removed from the table. Duration of the familiarization task was approximately 20 to 30 seconds.

Primary Tasks—Following each familiarization trial, infants were presented with each stimulus separately (i.e., show separately) and then shown both containers together (i.e., show together). The containers were uncovered, but out of reach. Finally, the tops were securely replaced on the containers and the infants were allowed to touch and play with the stimuli, one set at a time (i.e., direct contact). The following procedures were repeated for each of the six stimuli pairs. Duration of the primary tasks was approximately 10 to 12 minutes.

Show separately: Following the familiarization trial, both open containers were placed in the experimenter's lap, out of the infant's view. After a short pause, using her right hand for the first stimulus, the experimenter extended her arm with the container tilted downward such that the infant could visually examine the contents, but could not reach them. This motion occurred simultaneously with the experimenter saying “look!” in an animated tone to draw the infant's attention to the container. When the infant oriented toward the container, the experimenter looked down in order to avoid eye contact with the baby and began timing. After five seconds, she pulled the container back onto her lap, out of the infant's view, and followed the same procedure with the second stimulus in her left hand.

Show together: With one container in each hand, the experimenter extended her arms, saying “here” in a welcoming tone while holding each container tilted downward toward the

infant, out of reach. Once the infant oriented his/her attention to the experimenter she looked down with her arms still extended for 20 seconds. At the end of the 20 seconds, the experimenter retracted her arms, and said “wait” in a friendly tone while securely placing the lids back on the containers.

Direct contact: Once containers were securely sealed, the experimenter said “here” while placing the two containers approximately 12 inches apart on the tray in front of the infant. When placing them down, she gently tapped the containers on the tray to draw attention to their presence, making sure to avoid contact with the infant's hands and arms. Once the containers were placed down, the infant was allowed to interact with the stimuli set for 60 seconds. At the end of the 60 seconds, the experimenter reached over and said “all done, my turn”, while removing the two containers from the tray. This method of measuring infant preference through preferential reaching has long been used in the field of developmental psychology (e.g., Spelke, 1985) assessing concepts both related (Shutts et al., 2009) and unrelated (Hamlin & Wynn, 2011) to food-based stimuli.

Three independent raters coded the ‘Direct Contact’ portion of the videos for infants touching the food or toy container during each 10-second interval of each 60-second trial. Prior to coding, a research assistant viewed each video and recorded the precise start time of each of the six stimulus-pair trials for each infant, as well as the start times for each of the 10-second intervals. Coders then watched videos in the same viewing software (VLC Media Player), using the precise start points and paused at each established 10-second interval to record the appropriate code. Slow motion was used when necessary to identify behaviors that occurred close to the end of the interval. Initially, videos were coded on an ordinal scale (0 = no touching, 1 = ‘passive’ touching [e.g., holding but not manipulating container], 2 = ‘active’ touching [e.g., pushing, banging moving container]); however, these coded variables were collapsed into dichotomous categories for analysis. The infants' touches of the food and toy containers were coded separately; therefore, an infant could be coded for touching the food container and the toy container in the same 10-second interval. A code of 0 or 1 was given for each interval. A code of 0 signified that the infant never purposefully touched the container during the 10-second interval. A code of 1 signified that the infant purposefully touched the container at any point during the 10-second interval.

The three coders were trained to reliability (intraclass correlation coefficient [ICC] = .82 [touch food], ICC = .81 [touch toy]) on the coding scheme prior to initiating coding. Double-coding for 20% of the videos showed excellent inter-rater reliability throughout the coding period (ICC = .96).

Measures

Mothers reported maternal age and education, and the child's gestational age, sex, birthdate and race/ethnicity at recruitment. All other measures were obtained following the behavioral protocol described above. For each food and non-food stimulus (12 items), mothers indicated if the item had ever been in the family's home for the infant to see (i.e., familiarity with the stimuli; yes vs. no).

Mothers completed the Baby Eating Behaviour Questionnaire (BEBQ; Llewellyn, van Jaarsveld, Johnson, Carnell, & Wardle, 2011), an adapted version of the Children's Eating Behaviour Questionnaire (Wardle, Guthrie, Sanderson, & Rapoport, 2001b). The BEBQ is an 18-item parent-report psychometric measure of infant appetite. It encompasses four appetitive measurement scales, one of which was used for the present study: food responsiveness (6 items, Cronbach's $\alpha = .67$). All questions in each subscale were scored on a 5-point Likert scale as never (1), rarely (2), sometimes (3), often (4), or always (5), and mean scores for each subscale were then calculated (range: 1–5). Refer to Table 1 for the sample's descriptive statistics.

Mothers completed an infant diet questionnaire (Fein, Labiner-Wolfe, Shealy, Li, Chen, & Grummer-Strawn, 2008) in which they provided information regarding their infants' breastfeeding history. Infant breastfeeding history was categorized as either (1) 'currently breastfeeding', (2) breastfed, but had completely stopped by the time of the office visit ('previously breastfed'), or (3) 'never breastfed'. Mothers also provided information about their infants' complimentary food intake. All but one of the infants had started complimentary foods at the time of the office visit.

Infants were weighed on a Seca 334 digital scale (Seca, Hamburg, Germany) and length measured on a portable Seca 417 infantometer (Seca, Hamburg, Germany) wearing only a clean diaper, using standardized procedures by staff trained in infant anthropometry. Infant age/sex-specific weight-for-age *z*-scores were calculated using reference data from the World Health Organization (WHO). We computed the change in weight-for-sex-and-age *z*-score from birth to the time of the study visit. Mothers were weighed and measured with a calibrated Detecto 550C digital scale (Detecto Scale Co., Webb City, MO) and portable Seca 213/217 stadiometer (Seca, Hamburg, Germany). Maternal BMI was calculated by dividing weight in kilograms by the squared height in meters (kg/m^2).

Statistical Analyses

Using SPSS (version 22.0, SPSS Inc, Chicago, IL), analyses were carried out using the Generalized Estimating Equations (GEE; Liang & Zeger, 1986; Ziegler, 2011) with a logistic regression model and an exchangeable working correlation matrix structure to account for within-subject correlations that occurred within the 36 coded intervals (six 10-second intervals * 6 stimuli sets) for each infant. The benefit of using the GEE analysis is that it is able to account not only for the correlations within child for each separate stimulus set, but also within the 36 total intervals across stimulus sets for each infant. All logistic regressions modeled the odds of 'touch food' as the response, versus 'touch non-food' as the alternative. Analyses focused on the six 1-minute trials during which container touching was recorded in 10 second intervals, for a total of 36 intervals per child. With 30 participants, this resulted in a total of 1080 intervals. Because we were interested in infants' preference between food and non-food stimuli, intervals during which the infant touched both the food and non-food stimuli, and intervals in which the infant touched neither container (a combined total of 6.9% intervals) were not included in the analysis. Thus the binary outcome of interest was created by combining the 'touch food' and 'touch non-food' codes, such that a code of '1' was assigned if an infant touched the food container and a code of '0'

was assigned if an infant touched the non-food container. Data were complete for 93.1% of the 1080 intervals.

We first evaluated the unadjusted associations between each covariate and the outcome (touching the food versus non-food container) using univariate GEE models. Next we included all significant predictors ($p = .05$) from the univariate analysis in a multivariate model to estimate the independent effect of each predictor on the outcome adjusting for the others.

Results

Overall, we found a statistically significant preference for touching the food (65.6%) versus the non-food stimulus (34.4%; Wald $\chi^2(1)=12.34$, $p < .001$) across the 36 intervals. There was no effect of age group (6, 9, 12 months) on preference for food versus non-food (Wald $\chi^2(1)=.29$, $p = .87$). Therefore, data were collapsed across age group for all subsequent analyses. Preliminary analyses revealed that neither infant age, familiarity with the stimuli, nor which experimenter administered the protocol was associated with the outcome variable; therefore, subsequent analyses did not control for these variables.

Unadjusted univariate associations

Infant birth weight z -score was not associated with the odds of touching the food versus the non-food stimulus (OR 1.12 [95% CI: 0.85-1.47]). The change in weight z -score from birth to the time of study was associated with the likelihood of touching the food versus non-food stimuli. Specifically, infants in the top quartile of weight-for-age z -score change from birth to the age of study participation were more likely to touch the food vs. non-food stimuli as compared to infants in the bottom three quartiles: OR 2.29 (95% CI: 1.09-4.79).

Higher BEBQ Food Responsiveness subscale score was associated with greater odds of touching the food versus non-food stimulus: OR 2.04 (95% CI: 1.12-3.75). There was no association of maternal BMI with the infant showing a preference for the food versus non-food stimuli (OR 1.02 (95% CI: 0.98-1.06).

Infants who were formula-fed, and had never been breastfed (i.e., 'never breastfed'), were more likely than those who were currently being breastfed (i.e., 'currently breastfed') to touch the food versus the non-food stimulus: OR 3.05 (95% CI: 1.39-6.70). Similarly, the 'never breastfed' infants were more likely than infants who were breastfed, but had stopped completely ('previously breastfed'), to touch the food versus the non-food stimulus: OR 2.84 (95% CI: 1.24- 6.55). The odds of touching the food versus non-food stimulus did not differ between the 'currently breastfed' and 'previously breastfed' (OR: 0.93 [95% CI: .45-1.94]). Additionally, there were statistically significant mean group differences on the BEBQ-FR scale, with the 'never breastfed' infants ($M=2.25$, $SD=.43$) having higher scores on the food responsivity scale than those who were 'previously breastfed' ($M=2.09$, $SD=.55$; $t(1042)=-4.11$, $p < .001$).

Multivariate Associations

The adjusted GEE logistic regression model included only the significant predictors from the individual models, which included the change in weight-for-age-z-score, BEBQ-FR, and breastfeeding history. Because the two groups who had been breastfed did not differ from one another in terms of predicting preference for food versus the non-food stimulus, we collapsed these groups to create a binary breastfeeding history variable (i.e., ever breastfed vs. never breastfed) to be parsimonious and save degrees of freedom. When all three predictors of interest were included in a single model, the effect of the change in weight-for-age-z-score was significantly attenuated, such that it was no longer a significant predictor of choosing the food over the non-food stimulus. See Table 2 for results of the final adjusted logistic regression model.

Discussion

This study had six main findings. First, overall, infants showed a preference for the food versus the non-food stimulus. Second, while infant birth weight was not associated with preference for the food versus non-food stimuli, greater rate of weight gain from birth associated with preference for the food stimulus in unadjusted analyses. Third, mother's report that the infant had higher food responsiveness was associated with preference for the food stimulus in unadjusted analyses. Fourth, those in the 'never breastfed' group were more likely to touch the food stimuli over the non-food stimuli and also had higher scores on the BEBQ food responsivity subscale than the 'previously breastfed' and 'currently breastfed' groups. Fifth, maternal BMI did not predict an infant preference for the food versus non-food stimuli. Lastly, in the final multivariate model, the effect of change in weight-for-age-z-score from birth to the time of the office visit was attenuated when breastfeeding history and BEBQ-FR were included in the model.

Our results align very closely with recent work examining food cue responsivity among 9- to 18-month old infants using a slightly different approach (Kong et al., 2015). Specifically, Kong et al. used a protocol in which infants needed to work to gain access to a food versus a non-food stimulus, thus measuring the relative reinforcing value of foods versus non-food. We found, just as did Kong et al., that infant rate of weight gain since birth, but not birth weight, was associated with the infant's food cue responsivity. The attenuation of this effect in the multivariate model suggests the importance of history of breastfeeding in level of early food responsivity, with infants who were formula-fed showing greater interest in food versus nonfood stimuli, even at these young ages of 6 to 12 months. This finding extends the current literature by showing the association of mode of feeding with appetite regulation at even younger ages than previously reported (Brown & Lee, 2012; DiSantis et al., 2011). Our findings also add to the literature in showing an association between mode of feeding and level of food responsivity during infancy, as measured by both behavioral observation and maternal report, whereas others have reported no associations between early feeding mode and food responsivity (Brown & Lee, 2012; DiSantis et al., 2011).

The finding that birth weight, as an individual predictor, was not related to observed infant food cue responsivity in either the work by Kong et al. or the present study suggests that infant birth weight does not predict eating behavior. This observation is consistent with prior

work also finding the same temporal directionality to the association in infants from 3 to 15 months of age (van Jaarsveld et al., 2011).

Our results also align with the findings in prior work that mother-reported infant food responsiveness is associated with food cue responsivity, as measured by a relative reinforcing value task (Kong et al., 2015). Prior studies in childhood have demonstrated good cross-validation between maternal report of children's eating behaviors on the Children's Eating Behaviour Questionnaire and behavioral measures (Carnell & Wardle, 2007). To our knowledge, this is only the second study, including the work by Kong et al., to provide validation of the Baby Eating Behaviour Questionnaire using observed behavioral measures.

Very few studies have been published examining maternal body mass index as a predictor of infant, rather than child, food cue responsivity. Milstein (1980) reported that 1 to 3 day old infants of overweight parents sucked more in response to higher glucose solutions than infants born to normal weight parents, and a study assessing infant feeding in 3 month olds found higher intake, total number of sucks, and sucking rates in infants of obese, compared to infants of normal weight mothers (Stunkard, Berkowitz, Stallings, & Schoeller, 1999). While these studies support an association between maternal BMI and infant food cue responsivity, the way in which infant behavior was measured differed greatly from our own behavioral task. It is possible that if the infants in our study were given the opportunity to consume the foods that were in the containers, we may have seen results that more closely approximated those of Milstein and Stunkard et al. Additionally, our ability to detect associations may have been limited by our small sample size and additional work in larger samples would be valuable.

Prior work has described continuity of food cue responsivity across childhood (Ashcroft, Semmler, Carnell, van Jaarsveld, & Wardle, 2008) and links between these types of eating behaviors and obesity risk have been well-documented (Carnell & Wardle, 2008; French, Epstein, Jeffery, Blundell, & Wardle, 2012). Folk wisdom in infant feeding, as well as recommendations from professional societies, convey to parents that one signal that an infant is ready to be offered solid foods (i.e., foods besides breastmilk or formula) is that the infant demonstrates an interest in solid food. A growing body of literature suggests that infants who are more interested in solid food (i.e., who demonstrate more food cue responsivity), may be at higher risk for the development of obesity. As this area of research evolves, parents and health care providers for infants may want to carefully consider the implications of these findings for understanding infant feeding cues, how those cues may signal elevated obesity risk, and therefore how environmental or other parenting strategies might moderate that risk. At least one study to date has shown that infant food cue responsivity can be modified by an intervention that supports the development of infants' interest in non-food stimuli (Kong et al., 2016).

There are several limitations to our study. Our sample size was small, which may have limited our power to detect small and medium associations, in particular age group differences. Our study population was also primarily white with relatively well-educated parents. Future work should include samples of more diverse socioeconomic status. Despite

our best efforts, the food versus non-food stimuli may not have been well-matched in all stimulus sets, leading to an artificial bias of the infants for the food stimuli. However, the observation that the effect was consistent across stimulus sets lessens this concern.

Conclusions

In summary, this study found that infants from ages 6- to 12-months demonstrated a preference for food vs. non-food stimuli, and that this preference was associated with higher rates of weight gain during infancy, maternal report of greater food responsiveness, and a history of being exclusively formula fed. In order to evaluate developmental differences between 6- to 12-months of age, future studies would benefit from a larger sample size in order to provide the ability to test for smaller effect sizes. Future work should consider the potential biological predictors of these infant eating behaviors. In addition, future work should consider how this measure of food cue responsivity is or is not associated with other traditional measures of infant eating behavior such as infant sucking pressure. Future studies may also benefit from modifying the behavioral protocol in order to allow the infants to eat the foods, and play with the toys presented. This may map more precisely onto the construct of food cue responsivity, and would allow for an assessment of amount of food eaten in response to these cues. Infant food cue responsivity should be considered as a potential target for behavioral intervention to prevent obesity very early in the lifespan.

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Fig. 1.

Food and non-food stimulus pairs. (A) Two golden Oreos stacked together and a pine-wood yo-yo, (B) six green beans and six green crayons, (C) five butter crackers of varying shape and 5 puzzle pieces painted yellow, (D) 100 green peas and 100 small green buttons, (E) three strawberries with their tops cut off and three 1-inch red porcupine balls, and (F) three broccoli florets and three cubes formed from green play foam.

Table 1
Means and Standard Deviations of Predictors of Interest

Predictor	<i>M (SD)/%</i>
<i>Infant</i>	
Birthweight-for-age-and-sex-z-score	0.10 (0.98)
Change in weight Z-score from birth to study visit	0.27 (0.84)
BEBQ Food Responsiveness	2.10 (0.55)
Never breastfed (%)	24.1
Previously breastfed (%)	13.8
Currently breastfed (%)	62.1
<i>Mother</i>	
BMI at study visit	28.00 (8.20)

Note. BEBQ: Baby Eating Behaviour Questionnaire;
 BMI: Body Mass Index

Table 2
Unadjusted and Multivariate Associations of Each Covariate with Touching Food vs. Non-Food Stimuli

	Wald χ^2	df	p-value	OR	95% CI
Unadjusted associations					
Birthweight z-score	0.63	1	.43	1.12	0.85-1.47
Change in weight z-score ^a	4.83	1	.03	2.29	1.09-4.79
BEBQ-FR	5.25	1	.02	2.04	1.11-3.75
Maternal BMI	0.76	1	.38	1.02	0.98-1.06
Breastfeeding history- Previously breastfed vs Never breastfed	6.03	1	.01	2.84	1.24-6.55
Breastfeeding history- Currently breastfed vs Never breastfed	7.73	1	.005	3.05	1.39-6.70
Breastfeeding history- Previously breastfed vs Currently breastfed	0.04	1	.85	0.93	0.45-1.94
Breastfeeding history-binary ^b	8.45	1	.004	3.01	1.43-6.33
Multivariate associations					
Change in weight z-score ^a	1.01	1	.32	1.46	0.70-3.07
Breastfeeding history-binary ^b	5.34	1	.02	2.43	1.14-5.16
BEBQ-FR	5.67	1	.02	1.61	1.09-2.37

Note.

^a Binary variable with top quartile vs bottom three quartiles for change in weight-for-age z-score from birth to time of office visit. Bottom three quartiles were the referent.

^b Binary variable with 'never breastfed' versus 'ever breastfed' (collapsed 'currently breastfed' and 'previously breastfed'). 'Ever breastfed' was the referent in this model. BEBQ-FR: Baby Eating Behaviour Questionnaire-Food Responsivity subscale.