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More than Just a Pretty Face: The Relationship between Infant's Temperament, Food Acceptance, and Mothers' Perceptions of their Enjoyment of Food

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Abstract

The goal of the present study was to determine whether mothers' assessment of their infants' temperament is associated with objective measures of their infant's acceptance patterns and their judgments of their infants' liking of a green vegetable. To this end, infants (N=92) were video-recorded as their mothers fed them green beans. From these videos, we determined the frequency of facial distaste expressions made during the first two minutes of the feeding. Other measures included intake, maternal ratings of infants' enjoyment of this vegetable, and temperament. Infants who scored high on the approach dimension of the temperament questionnaire were less likely to express facial expressions of distaste, consumed more food, and were perceived by their mothers as enjoying the food more. Mediation analyses revealed that ratings of enjoyment were not directly related to the child's approach temperament, but rather the relationship between mothers' ratings and temperament was mediated by the amount of time infants spent eating the vegetable. Regression analyses suggested that in addition to the length of time children ate, mothers' ratings of their infants' enjoyment was predicted by the number of squints that the infant expressed during the meal. These findings suggest that although certain aspects of children's temperament are related to their food acceptance mothers attend to facial expressions and time spent eating independently of these temperamental characteristics when judging their infant's enjoyment of a food. Understanding how mothers use this information to decide which foods to feed their infants is an important area for future research.

Keywords

feeding; facial reactivity; FACS; temperament; green vegetables; nutrition; mother-infant interactions

During the past few decades, childhood obesity has more than tripled; rising from 6.5% in 1980 to almost 20% in 2004 (Ogden *et al.*, 2006). Obese children are more likely to suffer from adverse health conditions and are more likely to become overweight or obese adults, who are at increased risk for heart disease, type 2 diabetes, and various other health

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problems (Freedman, Zuguo, Srinivasan, Berenson, Dietz, 2007; Li, Ford, Zhao, Mokdad, 2009). As a result, the U.S. Surgeon General has identified the obesity epidemic as one of the greatest health problems facing the nation today. Because dietary patterns established in childhood track into adulthood (e.g., Mikkilä, Räsänen, Raitakari, Pietinen, & Viikari, 2005), understanding how food preferences are acquired in childhood will aid in the development of better evidence-based strategies for improving children's diets.

Past research has shown that infants can clearly discriminate the flavor of different types of vegetables and will initially prefer some vegetables more than others (e.g., Gerrish & Mennella, 2001; Mennella, Nicklaus, Jagolino, & Yourshaw, 2008; Mennella, Kennedy & Beauchamp, 2006). Although green vegetables offer vitamins and nutrients that are important for optimum health and growth throughout childhood, they are often rejected initially by infants because of their bitter taste that results from organic compounds such as phenols (Drewnowski & Gomez-Carneros, 2000, Sandell & Breslin, 2009). Although small amounts of these chemicals are beneficial to human health, they can be toxic in large doses.

Like adults, infants can control the muscles required to express primary emotions and are therefore well equipped to convey a wide range of emotional states and reactivity to tastes (Ekman & Oster, 1979). Early investigations that related facial reactivity to taste and feeding in human infants were pioneered by Steiner in the early 1970's In these studies, a drop of solution containing one of the basic tastes (i.e., sweet, sour, salty, bitter, or savory) was placed on the infants' tongues. When tasting sweet and umami, their faces relaxed and they began suckling and smiling, perhaps because mother's milk tastes sweet and is rich in umami (McDaniel, Barker, & Lederer, 1989; Ramirez, DeSantiago, Tovar, & Torres, 2001). In contrast, bitter tastes elicited gaping responses, while sour elicited squinting and lip pursing, suggesting that these tastes may be innately aversive. Interestingly, no facial responses were evident to salt taste before the age of 4 months, suggesting postnatal maturation for salt taste in humans (Beauchamp, Cowart, & Moran, 1986). It has been suggested that the facial expressions made while feeding provide caregivers with important information about the degree to which non-verbal infants like foods (Forestell & Mennella, 2007). Visually striking facial displays of gaping which often accompany rejections of foods, such as green vegetables, are readily identified by caregivers and thus provide preverbal infants with an efficient means to communicate their dislike of foods. (Rosenstein & Oster, 1988).

Throughout evolutionary history, facial expressions may have served as nonverbal signals to warn caregivers that their infants may be eating something harmful and have been used as cues to avoid feeding their infants poisonous substances (Babchuk, Hames, & Thompson, 1985), however today such negative reactions to bitter tasting foods such as green vegetables, may discourage mothers from feeding these foods to their children. This is of particular concern, given that that research shows that early experiences with flavors of fruits and vegetables play an important role in laying the foundation for healthy food preferences. For example, although infants may not initially like a particular food item, they will eventually learn to accept only after it is presented 8–12 times (Forestell & Mennella, 2007, Gerrish & Mennella, 2001, Sullivan & Birch, 1994). Awareness of this normal course of food acceptance is important because approximately one quarter of parents prematurely drew conclusions about their infant's liking of foods after two or fewer exposures (Carruth, Zeigler, Gordan & Barr, 2004). As a result, some infants may not learn to like bitter green vegetables because their caregivers are hesitant to continue offering foods that they believe their infants dislike.

Although infants generally tend to like some foods more than others, there is wide individual variability in both the types and frequency of facial expressions that they demonstrate to

foods (Forestell & Mennella, 2007). These individual differences may be, at least in part, a function of the temperamental characteristics of the child. Indeed, temperamental factors have been shown to be related to children's food acceptance. For example, research that has established links between temperament and eating behaviors in 3–8 year-old children have shown that shy and emotional children tend to be less willing to try new foods and exhibit more food avoidant behaviors (Haycraft, Farrow, Meyer, Powell, & Blissett, 2011; Pliner & Loewen, 1997). Infants who are perceived to have difficult or demanding temperaments are more likely to experience feeding difficulties, characterized by colic, and mealtime behaviors such as choking, gagging, emesis, and food refusals, (Feldman, Keren, Gross-Rozvel, & Tyano, 2004, Lindberg, Bohlin, & Hagekull, 1991). Moreover, interactions during feeding have been shown to be related to mothers' judgments of temperament over the long term. Mothers who switched their infants from a milk-based formula to a hydrolysate formula because of colic and intolerance to the former formula were more likely to indicate that their child had behavioral problems several years later (Forsyth & Canny, 1991).

Few studies have assessed infants without feeding problems to determine whether temperamental differences among infants relate to individual differences in food acceptance patterns during a meal and further, whether mothers' perceptions of their infants' temperament biased their judgments of food acceptance. There are two pathways through which this may occur; first, mothers may preferentially attend to those feeding behaviors that fit and conform to their perceptions of their infant's temperament. Second, a mother's perceptions of her infants' temperament may produce expectations that lead to a self-fulfilling prophecy; that is, her expectations may induce behavioral reactions in the infant that further confirm her beliefs (Pauli-Pott, Mertesacker, Bade, Haverkock, & Beckmann, 2003).

Therefore the present study aimed to investigate whether temperamental factors are related to measures of infants' acceptance of a green vegetable as well as mothers' judgments of their liking and enjoyment of this food. Specifically we measured infants' facial expressions while feeding, their total intake of the food, and the length of the feed to determine whether these objective measures of acceptance were related to infants' temperament. Secondly, we determined the degree to which mothers' ratings of their infants' enjoyment of the food was related to these objective measures of acceptance as well as dimensions of temperament. Finally, we assessed whether mothers' perceptions of their infants' temperament directly affected their judgments of their infants' enjoyment of the food, or whether the relationship between mothers' assessment of their infants' temperament and their enjoyment of the green vegetable was in fact mediated by the infants' acceptance patterns.

We hypothesized that infants who had easier temperaments (i.e., were less withdrawn and more approaching, exhibited less negative mood, and were more adaptable) would demonstrate more acceptance of green beans, by consuming more, eating longer, and showing fewer faces of distaste, and that their mothers' assessment of these temperamental dimensions would also correlate with their judgments of their infants' enjoyment of the food. Finally, we predicted that mothers' ratings of their infants' enjoyment of the food would primarily be a function of their observations of their infants' food acceptance patterns, and therefore would mediate the relationship between their ratings of their infants' food acceptance and temperament.

Methods

Participants

Mothers whose infants had recently started eating solid foods (N=108) between the ages of 4.0 and 9.2 months of age were recruited through advertisements in newspapers, breastfeeding support groups, and the Supplemental Nutrition Program for Women, Infants, and Children in Philadelphia, Pennsylvania. Only healthy infants who were born full-term, and had been eating solid food for at least 2 weeks with no feeding problems qualified for the study. Sixteen of these mother-infant dyads were excluded because the infants' face was partially or fully occluded during the feeding session, thereby preventing video analyses. Thus, the final sample was 92 dyads.

As indicated in Table 1, infants (N=92) were, on average, 6 (±0.1) months of age, which is the age that the American Dietetic Association recommends introducing solid foods into infants' diets (Duyff, 2006). Their weight-for-age was within one standard deviation of the mean and their racial background was 31.5% Caucasian, 44.6% African American, 2.2% Hispanic, and 21.7% either mixed race or "other." Their mothers were 29 years of age (±0.6, *C.I.*; 28.2 – 30.6), had an average BMI of 28.3 (±0.7, *C.I.*; 26.9 – 29.7) and 14.5 years of schooling (±0.3, *C.I.*; 13.9 – 15.1).

All mothers were paid for their participation in the study. The Office of Regulatory Affairs at the University of Pennsylvania approved all procedures, and informed consent was obtained from each mother prior to participation in the study.

Measures

Food Acceptance Measures—A range of acceptance measures were collected to determine infants' liking of green beans. Green beans were chosen as the test vegetable to extend previous research that used this vegetable (i.e., Birch & Sullivan, 1998, Forestell & Mennella, 2007). Measures of green been acceptance were intake (g), duration of feeding (min), mean acceptance latencies (s), the frequency of each facial expression of distaste per spoonful offered during the first two minutes of the meal, as determined through video analyses, and maternal ratings. Each of these measures is described below.

The amount of food consumed was determined by weighing each jar before and after each feeding on a Mettler balance (Hightstown, NJ), which was accurate to 1.0 g. All food that spilled onto the tray or bib was placed in the jar before weighing. The length of feeding was determined by recording the amount of time between the first spoon offer and the last spoon in the session. Immediately after each feeding session, the mothers, who were not aware of the hypothesis being tested, rated on a 9-point scale how much they thought their infant liked the food; higher numbers reflected greater liking.

To objectively quantify infants' facial responses we used the Facial Action Coding System (FACS; Ekman & Friesen, 1978). This anatomically-based tool describes how the contraction of each facial muscle, individually or in combination with other muscles changes the appearance of the face through the use of a basic measurement called Action Units (AUs). By identifying facial movements that are associated with distaste, researchers have gleaned important information about infants' liking of foods. For example, FACS has been used to quantify infants' facial responses to basic tastes (Rosenstein & Oster, 1988) and odors (Soussignan, Schaal, Marlier, & Jiang, 1997), formula (Mennella, Griffin, & Beauchamp, 2004), cereal (Mennella, Forestell, Morgan & Beauchamp, 2009), and fruits and vegetables (Forestell & Mennella, 2007).

Orofacial responses were quantified by a trained rater, who was certified in Facial Action Coding System (FACS; Ekman, Friesen, & Hagar, 2002) and was unaware of the identity of the infants, using a frame-by-frame analysis by means of Observer™ (Noldus Information Technology, Heerlen, Netherlands). Consistent with previous studies in this area (e.g., Soussignan et al, 1997, Forestell & Mennella, 2007) scoring was limited to the first two minutes of the session to ensure that infants' facial expressions were not influenced by satiety. Facial responses at the beginning of feeding are thought to be reflective of hedonic responses in animals (Berridge, 1996) and pre-verbal human infants (Mennella, Jagnow, & Beauchamp, 2001; Rosenstein & Oster 1988; Soussignan *et al.*, 1997; Steiner, Glaser, Hawilo, & Berridge, 2001). Because facial expressions of distaste have been shown to be more discriminating than facial expressions of liking (e.g., smiling) in gauging infants' hedonic responsiveness (Forestell & Mennella, 2007; Mennella *et al.*, 2001; Mennella *et al.*, 2009), we analyzed the frequency of the following facial responses for each spoon of food offered, each of which are prototypical of distaste: inner brow raises (AU 1), brow lowerers (AU 4), squinting (AU 6 + AU 7), nose wrinkling (AU 9), upper lip raising (AU 10), and gaping (AU 26/27). For all of the analyses, each AU was considered separately. We also analyzed the amount of time the infants spent crying and not eating during the first two minutes of feeding. A second observer scored the number of spoon offers and the frequency of each of the facial expressions for 30 of the feeding sessions. The mean Pearson product-moment coefficient between the two raters' scores was 0.85, signifying good reliability between the raters.

Measurement of Feeding History—Mothers were interviewed about the feeding history of their child (e.g., whether or not they breastfed, for how long, and when they introduced and how often they fed various solid foods, including green beans) as well as aspects of their own eating habits, such as the frequency with which they ate various vegetables.

Infant Temperament Measure—All but two of the mothers completed the Infant Temperament Scale (Carey & McDevitt, 1978) at their leisure and returned it within one week of the testing session. Each of the 95 questions on the scale use a 6-point rating scale (ranging from "almost never" to "almost always") to measure mothers' perception of the frequency with which the infant displayed specific behaviors. Each of the temperament dimensions (with sample questions) are as follows: activity (e.g., The infant plays actively with parents - much movement of arms, legs, body), rhythmicity (e.g., The infant gets sleepy at about the same time each evening), approach/withdrawal (e.g., For the first few minutes in a new place or situation (new store or home) the infant is fretful), adaptability (e.g., The infant accepts his/her bath at any time of the day without resisting it), mood (e.g., The infant is fussy on waking up and going to sleep), persistence (e.g., The infant keeps trying to get a desired toy, which is out of reach, for two minutes or more), and distractibility (e.g., The infant stops play and watches when someone walks by). This questionnaire has been shown to have good internal consistency and test-retest reliability (Cary & McDevitt, 1978).

Procedures

Testing occurred in a well-ventilated comfortable room that was specifically designed for sensory testing. At the time of day the infants were typically fed a meal of puréed foods, we video-recorded them while their mother fed them commercially available Stage 2 puréed green beans (Gerber Products Company, Fremont, MI). The video camera was placed 1.5 meters in front of the highchair, and the camera lens was zoomed so that the video image contained the entire face of the infant as well as the backrest of the highchair. Mothers were instructed to offer each spoonful of food by placing the food in front of the child's mouth until the child voluntarily accepted. To not distract infants and mothers, the experimenter sat

out of the view of the dyad and observed the session on a television monitor. Feeding ended when the infants rejected at least three consecutive spoon offers. In this manner, infants determined the pacing and duration of the feeding session and how much they consumed. Two jars of food were available to each infant (~ 226 grams). Only 15% (n=16) of the infants finished the first jar and none finished the second jar of food. The methodologies used were developed and validated to evaluate infants' hedonic responses independently of the caregiver and experimenter (Gerrish & Mennella, 2001; Mennella & Beauchamp, 1997).

To ensure that the infants' facial expressions during the feeding were a reflection of their hedonic responses to the food rather than imitation of the mother's facial expressions (Meltzoff & Moore, 1983), mothers wore a face mask that covered the mouth and nose throughout the feeding session. To accustom infants to these procedures, each mother was sent a bib, spoon, and mask to use while feeding her infant at home for three days before the test session. Mothers also refrained from talking while feeding the infant during the test to eliminate any influence of verbal responses on the infants' facial expressions or acceptance of the food (Gunnar & Stone, 1984; Hornik, Risenhoover, & Gunnar, 1987). Analyses of the videotapes revealed that all of the mothers complied.

We asked mothers not to feed their infants for 1–2 hours before their appointment so that they would be tested approximately 0.5–1 hour before their next scheduled feeding. This was done to ensure that intake and facial responses during the test session were not affected by extreme hunger or satiation (Berridge, 1991), but rather reflected infants' hedonic responses to the food. Analyses of the mothers' feeding logs indicated that on average infants were last fed 3.0 h (±0.2) before the beginning of the test meal.

Results

Participant Characteristics

All infants (N=92) had been eating cereal for a mean of 2.2 ± 0.1 months at the time of the study. Over half of the infants (i.e., 57%) had been introduced to vegetables, and 32% of the infants were eating green beans prior to study participation (see Table 1), though none had been exposed to green beans more than 10 times (9.5 ± 2.4 times). Forty-three (47%) of the infants had been breastfed exclusively (i.e., never fed formula) for at least the first two months of life, 26 (28%) were formula fed and had fewer than seven days of experience with breastfeeding, and 23 infants (25%) had been both breastfed and formula fed. At the time of the study, 45 infants (49%) were still receiving breast milk (40 of these infants were exclusively breastfed) on a regular basis, and the remaining infants were still feeding formula. Infants who were breastfeeding did not significantly differ from formula-fed infants in mean age, weight-for-age percentile, or age at which they were introduced to vegetables.

Determinants of Infants' Acceptance of Green Beans

Analyses of infants' consumption of the green beans indicated that they consumed approximately 55 grams of green beans during the test meal (see Table 2). There were no differences in the amount of green beans consumed nor in the frequency of facial responses (all ps>0.30) expressed between breastfed and formula-fed infants in the current study. Because previous research has demonstrated that the flavors of mothers' diets are transmitted through their breast milk (Mennella, 2007) and as a result, breastfed infants more readily accept foods that their mothers frequently consume (e.g., Forestell & Mennella, 2007; Mennella *et al.*, 2001, Sullivan & Birch, 1994), we additionally analyzed mothers' consumption of vegetables. These analyses indicated that breastfeeding and formula feeding

mothers consumed, on average, 14 vegetables per week; only four of which were green vegetables.

Because infants who had previously been introduced to vegetables were less likely to gape (35% *vs.* 17%; $\chi^2(1) = 3.8$, $p = 0.05$, $\varphi = 0.2$) and spent less time crying (8.4 ± 3.8 s *vs.* 1.5 ± 0.6 s, $F(1, 90) = 4.0$, $p < 0.05$, $\eta^2 = 0.04$) while eating the green beans, we controlled for past exposure to vegetables using partial correlation analyses. These analyses revealed that infants who scored higher on the approach dimension on the temperament scale ate significantly more food ($r(90) = 0.26$, $p < 0.02$), for a longer time ($r(90) = 0.26$, $p < 0.02$), and expressed fewer lip raises ($r(89) = 0.24$, $p < 0.03$), and nose wrinkles ($r(89) = 0.23$, $p < 0.04$) during the feeding session.

Mothers' Perceptions of Infants' Liking

Maternal ratings of infants' enjoyment of the food were not related to characteristics of the mother (i.e., socioeconomic status, BMI, or their consumption of green vegetables) or the infants' past feeding history. However, their ratings were lower for infants who displayed more brow lowerers ($r(90) = -0.3$, $p < 0.01$), squints ($r(90) = -0.4$, $p < 0.001$), and nose wrinkles ($r(90) = -0.3$, $p < 0.02$) per spoon offer over the first two minutes of feeding, ate less food ($r(91) = 0.4$, $p < 0.001$) for a shorter period of time ($r(91) = 0.5$, $p < 0.001$), and were lower in approach temperament ($r(91) = 0.28$, $p < 0.01$).

Acceptance as a Mediator of the Relationship between Approach/Withdrawal Dimension of Temperament and Mothers' Perceptions of Liking

To determine whether infants' temperament was directly associated with mothers' ratings of the infants' enjoyment of the food, or whether this was an indirect relationship that was mediated by infants' acceptance behaviors during feeding, mediation analyses were conducted following Baron & Kenny (1986). These analyses involve meeting the following four criteria: 1) the temperament subscales (predictor) and children's acceptance (mediator) as measured by facial expressions, consumption, and time spent eating, should be associated, 2) the mediator and criterion variables (i.e., mothers' ratings) should be associated, 3) the predictor should be associated with the criterion, and 4) the association between the predictor and criterion decreases when the mediator is controlled.

Accordingly, we examined the associations among each of the temperament subscales, the children's acceptance measures, and mothers' ratings. As reported above, only the approach/withdrawal dimension of the Infant Temperament Scale correlated significantly with mother's ratings. This dimension also correlated with the mediator variable (i.e., time spent eating, $r = -0.26$, $p < 0.01$). Therefore, only approach dimension, time spent eating, and mothers' ratings were included in the mediation analyses. To determine whether time spent eating mediated the relationship between children's approach/withdrawal and mothers' ratings, infants' acceptance measures were regressed with approach/withdrawal on mothers' ratings. These analyses revealed a significant effect of time spent eating on mothers' ratings ($t(88) = 4.7$, $p < 0.001$) when approach/withdrawal was controlled. However, the association between approach/withdrawal and mother's ratings failed to reach significance ($t(88) = 1.7$, $p > 0.09$) when time spent eating was controlled. This was further supported by a bootstrap analyses (Preacher & Hayes, 2004) which indicated with 95% confidence that the indirect effect was estimated to lie between −0.70 and −0.10. Because zero is not in the 95% confidence interval, we concluded that the relationship between mothers' ratings and approach/withdrawal was mediated by the amount of time infants spent eating.

To determine whether additional acceptance cues influenced mothers' ratings of their infants' enjoyment of the foods, a linear regression analysis was conducted which included

consumption, time spent eating, each of the facial expressions of distaste, and the amount of time spent crying during the first two minutes of the feeding session as predictor variables, mothers' ratings as the criterion variable, and frequency of vegetable consumption and length of time breastfed as covariates. Mothers' ratings of infants' enjoyment of green beans at the end of the feeding were related to the number of squints ($\beta = -0.28$, $p < 0.01$) and how long the infant ate ($\beta = 0.44$, $p < 0.001$). These variables accounted for 33% of the variance in mothers' ratings ($F(2, 86) = 20.29$, $p < 0.001$).

Discussion

The goal of the present study was to elucidate whether dimensions of temperament are related to infants' acceptance, as determined by the infants' facial reactivity and intake of a green vegetable and their mothers' judgments of their liking of this food. Consistent with previous research (Forestell & Mennella, 2007; Mennella et al, 2009), we found that there was a great deal of individual variation in the infants' acceptance of a green vegetable. This variation was related to (1) infants' food exposure; those who had been eating vegetables over the previous weeks displayed fewer facial expressions of distaste and (2) their temperament; children who were more approaching ate more of the green beans for a longer time and showed fewer facial expressions of distaste. We also found that mothers were sensitive to certain facial behaviors expressed during feeding, which affected their judgments of their infants' liking of the food.

With respect to past feeding experiences, research has shown that breastfed infants whose mothers' diets included particular foods were more accepting than formula-fed infants (Forestell & Mennella, 2007). The present study found no difference between breastfed and formula-fed infants in green bean acceptance. This was likely due to the infrequent consumption of green vegetables by the lactating mothers in the present study and the lack of the flavors of vegetables in breast milk (Mennella, 2007; Mennella *et al.*, 2001). However, consistent with previous research (Mennella, Nicklaus, Jagolino, & Yourshaw, 2008), green bean acceptance was related to previous vegetables exposure.

This study is the first to report that the temperamental dimension of approach/withdrawal is related to infants' acceptance of foods. Those infants who were rated higher on approach by their mothers ate more food for a longer time and exhibited fewer faces of distaste. These findings are consistent with previous work that has shown that older children who score low on approach tend to withdraw from unfamiliar stimuli, are more fearful, shy, and timid, and are more neophobic with respect to food (Pliner & Loewen, 1997). Therefore parents of children who are withdrawn and less approaching should be aware that their children may be less accepting of certain foods than other children. Future research which assesses how temperament interacts with early feeding experience to affect subsequent food acceptance will improve our understanding of individual differences in the development of food acceptance patterns in children.

We found that maternal ratings of infants' approach/withdrawal were also correlated with mothers' judgments of infants' liking of the food. However this relationship was mediated by the length of time spent eating. Thus, whether infants were high on approach or withdrawn did not directly affect how much their mothers thought they enjoyed the food. Although, it is possible that the infants' responses to vegetables during past feedings affected maternal judgments, the degree to which maternal judgments are based on past rather than on current responses to a food is an area of research with important implications. For example, mothers who remember infants' negative responses during prior feedings may not notice improvements in the acceptance of the food over time (e.g., increased consumption, fewer negative facial expressions).

Although the number of squints infants displayed while feeding did not mediate the relationship between the infants' temperament and the maternal ratings of enjoyment, we believe that mothers may have considered this facial response when rating their infants' enjoyment. This contention is supported by our regression analyses which suggest that in combination with the length of the meal, squints predicted 33% of the variance in mothers' ratings. However, the present study revealed that while the number of squints that infants displayed during the first two minutes of a feeding significantly predicted how much food infants would ultimately consume, squints did not account for a large proportion of the variance in intake. These findings, combined with previous research (e.g., Forestell & Mennella, 2007), suggest that mothers should focus on infants' willingness to continue eating a food. Following repeated exposure, distaste expressions will decrease as intake increases (see also Mennella, Jagnow, & Beauchamp, 2001).

The present study used methodology specifically designed to objectively measure the infants' behavioral responses to a food. For example, the feeding situation was infant-led such that infants determined the pace, duration, and the amount consumed during the meal. Because infants were familiarized with their mothers wearing a mask during feeding, we could be confident to conclude that the infants' facial responses revealed their reactivity to the flavor of green beans rather than merely an imitation of their mother's facial reactivity (Melzoff & Moore, 1983). As a result, we can conclude that the infants' hedonic responses during the beginning of the meal predicted their overall intake and maternal perceptions. Although this manipulation may be construed as a limitation because it does not reflect the daily feeding environment experienced by the child, we caution that testing procedures that allow mothers to freely interact and display emotional expressions while feeding are potentially biased. First, because infants are sensitive to and mimic the facial expressions of their mothers (Gunnar & Stone, 1984), their facial expressions to the foods are skewed. Second, testing procedures that allow mothers to determine when to end the feeding session do not provide a measurement of infants' food acceptance because some mothers (e.g., those concerned about their own and their infant's eating and weight) may either under- or over-feed their infants by not attending to the satiation cues displayed by their infants (e.g., Blissett, Meyer, & Haycraft, 2006; Crow, Fawcett, & Wright, 1980, Li, Fein, & Grummer-Strawn, 2010). Due to the rigorous testing methods employed herein which controlled for these variables, this study provides an important first step in understanding how mothers interpret their infants' behavioral cues during feeding.

Future research that measures not only facial reactivity but also a wider range of nonverbal responses, and how long the infant displays these responses during the *entire* feed would provide further insight into the important questions addressed in the current study as well as insights into factors mediating infant satiety and satiation. Research is also needed to investigate whether mothers' emotional responses during feeding bias their infants' responses to foods. Such investigations that assess mothers' facial expressions, or lack thereof, during feeding and how they impact infant behavior and food acceptance will require the mothers' emotional responses to be controlled, objectively quantified, and analyzed in addition to those of their infants. These studies will provide important information about parent-child feeding interactions, and how parents' attitudes and feeding styles affect infants' acceptance of foods.

Conclusions

Feeding interactions are considered to be one of the most important domains of the mother-infant relationship during the first year because they influence the development of various socio-emotional capacities, such as self-regulation and social control (Speltz, Goodell, Endriga, & Clarren, 1994). In addition, these early feeding experiences establish later patterns of flavor preferences and food choices that affect children's health and growth

patterns. Thus, it is important to understand which factors influence parents' decisions to continue to provide their infants with opportunities to taste healthful foods such as green vegetables, which infants may not initially like.

Facial expressions made by infants during feeding provides caregivers with important information about whether the child is content or distressed or whether they like or reject the taste of a food (Forestell & Mennella, 2007), a basic biological commodity. Given the evolutionary significance of facial responses in response to tastes, it is not surprising that mothers focus on facial displays, such as squints, as a signal of how much their infant likes a food. However, findings from the present study suggest that they should focus on their infants' willingness to continue feeding and provide infants with multiple opportunities to taste the food. Previous findings (Forestell & Mennella, 2007) have indicated that over repeated exposures, facial expressions will eventually become less negative, although they may take longer to change than intake. By encouraging parents to repeatedly offer healthful foods, despite their perception that their infants dislike some of these foods, they are setting the stage for healthful eating patterns that will be carried into adulthood. Such an approach could have profound implications for improving eating habits in children thereby improving nutrition and reducing obesity.

1. We investigated the relationship between infants' temperament and food acceptance.
2. Infants high in approach temperament were more accepting of a green vegetable.
3. Mothers' ratings of these infants' enjoyment of the vegetable was also higher.
4. However mothers' ratings of enjoyment were not directly affected by temperament.
5. Ratings were affected bythe number of squints and the length of the feeding.

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References

Altman, DG. Practical Statistics for Medical Research. London: Chapman and Hall; 1991.

Babchuk WA, Hames RB, Thompson RA. Sex differences in the recognition of infant facial expressions of emotion: The primary caretaker hypothesis. Ethology and Sociobiology. 1985; 6(2): 89–101.

Baron RM, Kenny DA. The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. Journal of Personality and Social Psychology. 1986; 51:1173–1182. [PubMed: 3806354]

Beauchamp GK, Cowart BJ, Moran M. Developmental changes in salt acceptability in human infants. Developmental Psychobiology. 1986; 19(1):17–25. [PubMed: 3699249]

Berridge KC. Modulation of taste affect by hunger, caloric satiety, and sensory-specific satiety in the rat. Appetite. 1991; 16:103–120. [PubMed: 2064389]

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

Blissett J, Meyer C, Haycraft E. Maternal and paternal controlling feeding practices with male and female children. Appetite. 2006; 47:212–219. [PubMed: 16735080]

Carey WB, McDevitt SC. Revision of the Infant Temperament Questionnaire. Pediatrics. 1978; 61:735–739. [PubMed: 662513]

Carruth BR, Ziegler P, Gordon A, Barr SI. Prevalence of picky eaters among infants and toddlers and their caregiver's decisions about offering a Food. Journal of the American Dietetic Association. 2004; 104:S57–S64. [PubMed: 14702019]

Crow RA, Fawcett JN, Wright P. Maternal behavior during breast- and bottle-feeding. Journal of Behavioral Medicine. 1980; 3:259–277. [PubMed: 7441727]

Drewnowski A, Gomez-Carneros C. Bitter taste, phytonutrients, and the consumer: A review. American Journal of Clinical Nutrition. 2000; 72(6):1424–1435. [PubMed: 11101467]

Duyff, RL. American Dietetic Association Complete Food and Nutrition Guide. New Jersey: JohnWiley & Sons, Inc.; 2006. p. 388-389.

Ekman, P.; Friesen, WV. Facial action coding system: A technique for the measurement of facial movement. Palo Alto, CA: Consulting Psychologists Press; 1978.

Ekman P, Oster H. Facial expressions of emotions. Annual Review of Psychology. 1979; 30:527–554.

Ekman, P.; Friesen, WV.; Hagar, JC. Facial Action Coding System on CD-ROM. Salt Lake City, UT: Network Information Research; 2002.

Esposito L, Fisher JO, Mennella JA, Hoelscher DM, Huang TT. Developmental perspectives on nutrition and obesity from gestation to adolescence. Preventing Chronic Disease. 2009; 6(3) http://www.cdc.gov/ped/issues/2009/jul/09_0014.htm.

Feldman R, Keren M, Gross-Rozvel O, Tyano S. Mother–Child Touch Patterns in Infant Feeding Disorders: Relation to Maternal, Child, and Environmental Factors. Journal of the American Academy of Child & Adolescent Psychiatry. 2004; 43(9):1089–1097. [PubMed: 15322412]

Forestell CA, Mennella JA. Early determinants of fruit and vegetable acceptance. Pediatrics. 2007; 120:1247–1254. [PubMed: 18055673]

Forsyth BWC, Canny PF. Perceptions of vulnerability 3½ years after problems of feeding and crying behavior in early infancy. Pediatrics. 1991; 88(4):757–763. [PubMed: 1896279]

Freedman DS, Zuguo M, Srinivasan SR, Berenson GS, Dietz WH. Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. Journal of Pediatrics. 2007; 150(1):12–17. [PubMed: 17188605]

Gerrish CJ, Mennella JA. Flavor variety enhances food acceptance in formula-fed infants. American Journal of Clinical Nutrition. 2001; 73:1080–1085. [PubMed: 11382663]

Glendinning JI. Is the bitter rejection response always adaptive? Physiology & Behavior. 1994; 56(6): 1217–1227. [PubMed: 7878094]

Gunnar MR, Stone C. The effects of positive maternal affect on infant response to pleasant, ambiguous, and fear-provoking toys. Child Development. 1984; 55:1231–1236.

Hornik R, Risenhoover N, Gunnar M. The effects of maternal positive, neutral, and negative affective communications on infant responses to new toys. Child Development. 1987; 58(4):937–944.

Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977; 33(1):159–174. [PubMed: 843571]

Li R, Fein SB, Grummer-Strawn LM. Do infants fed from bottles lack self-regulation of milk intake compared with directly breastfed infants? Pediatrics. 2010; 125:e1386–e1393. [PubMed: 20457676]

Li C, Ford ES, Zhao G, Mokdad AH. Prevalence of pre-diabetes and its association with clustering of cardiometabolic risk factors and hyperinsulinemia among US adolescents: NHANES 2005–2006. Diabetes Care. 2009; 32:342–347. [PubMed: 18957533]

Lindberg L, Bohlin G, Hagekull B. Early feeding problems in a normal population. International Journal of Eating Disorders. 1991; 4:395–405.

McDaniel MR, Barker E, Lederer CL. Sensory characterization of human milk. Journal of Dairy Science. 1989; 72:1149–1158. [PubMed: 2745823]

Meltzoff AN, Moore MK. Newborn infants imitate facial gestures. Child Development. 1983; 54(3): 702–709. [PubMed: 6851717]

Mennella, JA. The chemical senses and the development of flavor preferences in humans. In: Hale, T.; Hartmann, PE., editors. Textbook on Human Lactation. Texas: Hale Publishing; 2007. p. 403-413.

Mennella JA, Beauchamp GK. Mother's milk enhances the acceptance of cereal during weaning. Pediatric Research. 1997; 41:188–192. [PubMed: 9029637]

Mennella JA, Griffin CE, Beauchamp GK. Flavor programming during infancy. Pediatrics. 2004; 113(4):840–845. [PubMed: 15060236]

Mennella JA, Kennedy J, Beauchamp GK. The type of formula fed to infants modifies vegetable acceptance. Early Human Development. 2006; 82:263–268.

Mennella JA, Jagnow CP, Beauchamp GK. Prenatal and postnatal flavor learning by human infants. Pediatrics. 2001; 107(6):E88. [PubMed: 11389286]

Mennella JA, Forestell CA, Morgan LK, Beauchamp GK. Early milk feeding influences taste acceptance and liking during infancy. American Journal of Clinical Nutrition. 2009; 90:780S–788S. [PubMed: 19605570]

Mennella JA, Nicklaus S, Jagolino AL, Yourshaw LM. Variety is the spice of life: Strategies for promoting fruit and vegetable acceptance in infants. Physiology & Behavior. 2008; 94:29–38. [PubMed: 18222499]

Mikkilä V, Räsänen L, Raitakari OT, Pietinen P, Viikari J. Consistent dietary patterns identified from childhood to adulthood: The Cardiovascular Risk in Young Finns Study. British Journal of Nutrition. 2005; 93:923–931. [PubMed: 16022763]

Ogden CL, Carrroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. Journal of the American Medical Association. 2006; 295:1549–1555. [PubMed: 16595758]

Pauli-Pott U, Mertesacker B, Bade U, Haverkock A, Beckmann D. Parental perceptions and infant temperament development. Infant Behavior and Development. 2003; 26:27–48.

Pliner P, Loewen ER. Temperament and food neophobia in children and their mothers. Appetite. 1997; 28(3):239–254. [PubMed: 9218097]

Preacher KJ, Hayes AF. SPSS and SAS procedures for estimating indirect effects in simple mediation models. Behavior Research Methods, Instruments, & Computers. 2004; 36:717–731.

Ramirez I, DeSantiago S, Tovar AR, Torres N. Amino acid intake during lactation and amino acids of plasma and human milk. Advances in Experimental Medicine and Biology. 2001; 501:415–421. [PubMed: 11787711]

Rosenstein D, Oster H. Differential facial responses to four basic tastes in newborns. Child Development. 1988; 59:1555–1568. [PubMed: 3208567]

Sandell MA, Breslin PA. Variability in a taste-receptor gene determines whether we taste toxins in food. Current Biology. 2006; 16(18):R792–R794. [PubMed: 16979544]

Skinner JD, Carruth BR, Bounds W, Ziegler PJ. Children's food preferences: A longitudinal analysis. Journal of the American Dietetic Association. 2002; 102:1638–1647. [PubMed: 12449287]

Soussignan R, Schaal B, Marlier L, Jiang T. Facial and autonomic responses to biological and artificial olfactory stimuli in human neonates: re-examining early hedonic discrimination of odors. Physiology & Behavior. 1997; 62:745–758. [PubMed: 9284493]

Speltz ML, Goodell EW, Endriga MC, Clarren SK. Feeding interactions of infants with unrepaired cleft lip and/or palate. Infant Behavior and Development. 1994; 17:131–139.

Sullivan SA, Birch LL. Infant dietary experience and acceptance of solid food. Pediatrics. 1994; 93:271–277. [PubMed: 8121740]

Steiner JE, Glaser D, Hawilo ME, Berridge KC. Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. Neuroscience and Biobehavioral Reviews. 2001; 25:53–74. [PubMed: 11166078]

Table 1

Infant Characteristics (N=92)

Variable	% or *Mean (s.e.m.)*	95% *C.I.*
Age, mo	6.3 (0.1)	6.1 – 6.5
Gender, % female	47.8%	
Weight for age z-scores	0.4 (0.1)	0.3 – 0.5
Feeding history		
% Breast fed[a]	46.7%	
% Formula fed	28.3%	
Age of cereal intro., mo	4.0 (0.1)	0.3 – 0.5
% Eating vegetables	56.5%	
% Eating green beans	31.5%	
Infant Temperament (Range of scores is 1.0–6.0)		
Activity	4.2 (0.1)	2.9 – 5.3
Rhythmicity	2.7 (0.1)	2.6 – 2.8
Approach/withdrawal	2.7 (0.1)	2.5 – 2.9
Adaptability	2.5 (0.1)	2.4 – 2.6
Intensity	3.5 (0.1)	3.4 – 3.6
Mood	3.0 (0.1)	2.9 – 3.1
Persistence	3.1 (0.1)	3.0 – 3.2
Distractibility	2.5 (0.1)	2.4 – 2.6

[a]Breastfed children were exclusively fed breast milk for at least two months. Formula fed children were given <7 days exposure to breast milk. The remaining 25% were both breast and formula fed.

Table 2

Infants' Green Bean Acceptance

	M (s.e.m.)	95% *C.I.*	%[a]
Overall Consumption			
Intake (g)	54.6 (4.8)	45.1 – 64.1	--
Time spent eating (min)	12.1 (0.7)	10.7 – 13.5	--
Mean acceptance latency (s)	3.8 (0.3)	3.2 – 4.4	--
Frequency of facial expressions per spoon offer over first 2 minutes of feeding			
Brow lowerers (AU 4)	2.0 (0.2)	1.6 – 2.4	90.2%
Inner brow raises (AU 1)	1.4 (0.2)	1.0 – 1.8	75.0%
Squints (AU 6, AU 7)	2.8 (0.2)	2.4 – 3.2	97.8%
Nose wrinkles (AU 9)	0.6 (0.1)	0.4 – 0.8	59.8%
Lip raises (AU 10)	2.0 (0.2)	1.6 – 2.4	96.7%
Gapes (AU 26, AU 27)	0.2 (0.03)	0.1 – 0.3	25.0%
Time spent crying (s)	2.2 (0.7)	0.8 – 3.6	20.6%
Mothers' ratings of enjoyment (1 = extreme dislike, 9 = extreme like)	6.1 (0.2)	5.6 – 6.6	--

[a]Percentage of children who expressed the behavior