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Infant temperament and feeding history predict infants' responses to novel foods[☆]

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Abstract

The purpose of the present study was to investigate whether infant temperament and previous feeding history were associated with infants' acceptance and rejection of a novel food at 12 months of age. Mother–infant dyads ($n = 89$) were video-recorded during a novel food (hummus, cottage cheese) feeding task. Infants' reactions (acceptance and rejection behaviors) and maternal responsiveness and affect during the interaction were coded from the recordings by teams of coders. Mothers reported on their infants' temperamental approach via the Infant Behavior Questionnaire-Revised (IBQ-R) and their infants' feeding history (previous exposure to solid foods and exclusive breastfeeding). Regression analyses revealed that infants rated lower on approach showed less acceptance of the first offer of novel food than infants rated higher on approach. Additionally, low approach infants who were previously exposed to a greater number of solid foods showed fewer rejection behaviors in response to the later offers of food. Exclusive breastfeeding for 4 months did not appear to have an effect on acceptance or rejection. Finally, greater maternal responsiveness was related to the infants' acceptance of the new food whereas lower maternal responsiveness was associated with rejection of the novel food. These results suggest that the acceptance and rejection of new foods by infants is dependent upon their temperament and previous exposure to solid foods, as well as the manner in which mothers present the novel food.

Keywords

Infant temperament; Feeding history; Novel food responses; Maternal responsiveness

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Introduction

Human infants, like other omnivores, are faced with a dilemma when trying novel foods: they must accept the new foods to ensure dietary variety, but they also risk the possibility of ingesting toxic substances. In order to protect themselves from harm, young infants respond to bitter and sour tastes with negative facial expressions indicating initial rejection of these flavors (Rosenstien & Oster, 1988; Steiner, 1977). More recent research by Forestell and Mennella (2007) revealed that the majority of infants display facial expressions of distaste, such as squints, brow movements, and upper-lip raises, when eating a novel vegetable (i.e. green beans). However, this study also showed that infants exhibit clear individual differences in their facial expressions that predicted variability in acceptance of the new food (Forestell & Mennella, 2007). These findings are important because they highlight that infants display individual differences in their responses to novel foods. The present study investigates two factors that may contribute to these individual differences: infant temperament and feeding history.

Infant temperament is defined as individual differences in emotional and behavioral reactivity and regulation (Rothbart & Bates, 2006; Rothbart & Derryberry, 1981). Temperamental differences appear early in life and can account for why individuals respond differently to the same stimuli (Goldsmith et al., 1987). In particular, the temperamental dimension of approach, which characterizes individual differences in infants' responses to novelty, might be related to the ease or difficulty infants have in accepting new foods. Infants who are high on the dimension of approach tend to show positive affect and physically approach novel stimuli, but infants who are low on the dimension of approach tend to show negative affect and withdraw from novel stimuli (Rothbart & Bates, 2006).

Empirical works by Schaffer, Greenwood, and Parry (1972), Rothbart (1988), and Putnam and Stifter (2002) indicate that infants tend to approach novel stimuli to a varying degree until the second half of the first year of life. After this time, infants develop the ability to inhibit their approach tendencies and may show hesitation in response to novelty. However, there are individual differences in infants' inhibition of approach; some infants do not become wary in novel scenarios and continue to exhibit approach behaviors, even exhibiting positive affect to novelty (Putnam & Stifter, 2002; Rothbart, 1988). If infants respond in the same way to new foods as they do to other novel stimuli, it is likely that there will also be individual differences in their responses to novel foods. On the extreme ends, some infants may show positive affect and accept novel foods readily, while other infants may show negative affect and reject novel foods.

To date, only one study has examined the relationship between infant approach and food acceptance. Forestell and Mennella (2012) had mothers of infants ranging from 4–9 months feed their infants a green vegetable (i.e. green beans) and rate their infants' temperamental approach. The results of the study showed that when controlling for past exposure to vegetables, higher scores on the approach dimension of temperament were related to greater consumption of green beans, a longer duration of feeding, fewer lip raises and nose wrinkles while eating the food, and higher ratings by the mother on how much she thought her infant liked the food (Forestell & Mennella, 2012). The present study aims to expand upon

Forestell & Mennella's results in four ways: (1) by examining whether approach is also related to infants' responses to a novel food; (2) by determining whether approach also predicts infants' behavioral responses to a new food (i.e. acceptance and rejection); (3) by testing whether temperamental approach predicts infants' responses to a new food after infants have developed inhibition of approach (i.e. at 12 months); (4) by examining the interaction between the infants' levels of approach and their feeding history, another predictor examined in the present study.

Repeated exposure to novel foods has consistently emerged as one strategy that can increase acceptance of new foods. Research has shown that infants increase their consumption of a novel food after repeated exposures to that food (e.g. Forestell & Mennella, 2007; Gerrish & Mennella, 2001; Sullivan & Birch, 1994). These increases in consumption have been shown to be particularly strong for breastfed infants (Sullivan & Birch, 1994). Additional work has also shown that very few exposures are required to increase consumption: infants in one study doubled their intake of a new food after only one exposure to that food (Birch, Gunder, Grimm-Thomas, & Laing, 1998). However, as Forestell and Mennella (2007) suggest, consumption of a food does not necessarily indicate liking for that food. In their study, infants showed increased consumption of a food after repeated exposure, but the infants' facial expressions, which indicate like or dislike of the food, did not change. This result suggests that few exposures may be required to increase consumption of a novel food but that significantly more exposures are required to increase liking for that food (Forestell & Mennella, 2007).

In addition to the consistent body of work highlighting the importance of repeated exposures for novel food acceptance, other work examines variables that are associated with infants' responses to the first exposure of a new food. For example, Gerrish and Mennella (2001) and Lange et al. (2013) showed that previous exposure to a variety of foods led to increased acceptance of a novel food on the first exposure. Similarly, Mennella, Nicklaus, Jagolino, and Yourshaw (2008) found that repeated exposure to a variety of fruits increased acceptance of a novel fruit, but not a novel vegetable. Finally, Maier, Chabanet, Schaal, Leathwood, and Issanchou (2008) found that offering three vegetables for three consecutive days each did not increase consumption of a new vegetable (i.e. peas), whereas alternating the three vegetables daily did increase consumption of the new vegetable. Together, these results suggest that exposure to a variety of flavors may lead to increased acceptance of new foods. However, this effect may be dependent on the similarity between the variety of foods and the novel food (Mennella et al., 2008; see Birch et al., 1998 for a similar finding) and how often the various foods are rotated.

Another aspect of an infant's feeding history that may be related to novel food acceptance or rejection is exposure to breast milk. However, there are mixed results on this topic. One study found no differences between breastfed and formula-fed infants on their initial intake of a novel food (Sullivan & Birch, 1994), whereas another study showed that breastfed infants ate more calories of a novel fruit (i.e. peaches) than did formula-fed infants (Forestell & Mennella, 2007). Differences in results between the studies may be attributed to differences in mothers' consumption of the novel food while lactating. Forestell and Mennella (2007) found evidence to show that breastfeeding may only offer an advantage to

infants if the tastes of the target food are transmitted to the infant through breast milk. Additional research on the relationship between breastfeeding and infants' acceptance of novel foods is needed.

The purpose of the present study was to investigate whether infant temperament and feeding history were associated with acceptance and rejection of a novel food, hummus or cottage cheese, at 12 months of age. We had three primary goals for the study. First, we examined whether infant temperament predicted infants' responses to the novel food. High approach infants tend to show more positive responses to novel stimuli (e.g. Rothbart & Bates, 2006), so we predicted that high levels of approach would be associated with more acceptance behaviors and less rejection of the new food. Conversely, we expected infants rated lower in approach to show less acceptance and more rejection behaviors in response to the novel food.

The second goal of this study was to examine the relationship between infants' previous feeding history and responses to the novel food. Since exposure to a variety of foods has been shown to increase infants' acceptance of a novel food (Gerrish & Mennella, 2001; Lange et al., 2013), we hypothesized that exposure to a greater number of solid foods would be associated with more acceptance and less rejection of the novel food in the present study. Also, although research on the relationship between breastfeeding and acceptance of novel foods has yielded mixed results (e.g. Forestell & Mennella, 2007; Sullivan & Birch, 1994), we predicted that infants who were exclusively breastfed for at least 4 months would be more accepting and less rejecting of the novel food than infants who were exclusively breastfed for less than 4 months. Finally, since the duration of exclusive breastfeeding may affect the rate at which the mothers introduce their infants to solid foods, both feeding history variables were included in the same analyses to examine the effects of each variable above and beyond the effects of the other variable.

The third goal was to examine the combined effects of temperament and feeding history on infants' responses to the novel food. Low approach infants are unlikely to accept novel foods because they tend not to show positive responses to novelty (Rothbart & Bates, 2006). However, it is possible that exposure to a greater number of solid foods and/or exclusive breastfeeding for at least 4 months may help low approach infants accept a new food due to their familiarization with a variety of flavors. Conversely, since high approach infants tend to accept novel stimuli, it is likely that they will show more acceptance behaviors and less rejection regardless of the number of solid foods they previously tasted or the duration they were exclusively breastfed.

Finally, when testing each of the above hypotheses, we examined the infants' responses to both the first and subsequent offers of a novel food during the infants' first exposure to the food. The first spoonful of a new food is the only offer that is completely novel to the infant, so it is possible that infants' reactions to this first spoonful will differ from their responses to subsequent spoonfuls of the food. However, previous research has focused on differences in infants' responses *across* feedings instead of *within* the infants' first experience with the food. For this reason, no hypotheses could be made regarding differences in infants' responses to the first versus later spoonfuls of novel food in the present study.

Method

Participants

Infant–mother dyads ($N = 115$; 52 female infants) were recruited as part of a longitudinal study with data collection when the infants were within 2 weeks of being 4, 6, 12, and 18 months of age. The dyads were recruited through birth announcements and a local community hospital in Central Pennsylvania. Criteria for inclusion in the study were mothers' full-term pregnancy and ability to read and speak English. Also, mothers had to be 18 years or older to participate in the study. The families were primarily Caucasian ($n = 108$) with 2 American Indian, 2 Asian, 2 African American, and 1 Pacific Islander family. Mothers averaged 29.93 years of age (range = 19–41) at the birth of their infant and 14.67 years of education (range = 11–20) when the infants were 4 months old. The highest percentage of families reported an average annual income of either \$40,000 to \$60,000 (26%) or \$20,000 to \$40,000 (25%). The majority of mothers were married ($n = 93$).

The present study includes data from laboratory visits when the infants were 12 months old ($n = 89$). Of the original sample ($N = 115$), 20 families did not participate in the 12-month visit. Primary reasons for study attrition include family relocation and inability to contact families to schedule laboratory visits. In addition, 6 families who completed the 12-month visit were excluded from the present study: three had missing questionnaire data, one infant was not eating solid foods at 12 months of age, one infant did not take a bite of the novel food, and a final infant was excluded because she was an extreme outlier on previous exposure to solid foods (3.61 *SD* below the mean). There were no systematic differences between the participants who completed the 12-month visit ($n = 89$) and those who dropped out of the study on the following variables: maternal education, family income, maternal age, maternal body mass index (BMI), and feeding method.

Procedures

When the infants were 4 and 6 months of age, mothers reported on their infants' feeding history including whether the infant was being exclusively breastfed and the age the infant was introduced to solid foods. Prior to the 12 month laboratory visit, mothers were sent questionnaires that assessed infant temperament and additional questions on feeding history (i.e. previous exposure to solid foods). In addition, mothers were asked to select one of two foods that their infants had not previously tasted: hummus or cottage cheese. Mothers were also asked to bring a food with them to the visit that was familiar to their infants. At the visit, the mother–infant dyads participated in both a familiar and novel food task. Procedures for the tasks are described below.

Familiar food task—Prior to the novel food task, the experimenter asked the mothers to feed their infants three spoonfuls or bites of the familiar food they brought with them to the laboratory visit. During the familiar food task, the infant was seated in a high chair across from the mother and the experimenter watched the interaction from an observation booth. The purpose of this task was to transition the infants into feeding before exposing the infant to a novel food. The familiar food task was digitally recorded, but the interaction was not coded for the present study.

Novel food task—After the infant took three spoonfuls or bites of the familiar food, the experimenter entered the room, removed the familiar food, and gave the mother a plastic spoon and a small cup containing the previously selected novel food: hummus ($n = 54$) or cottage cheese ($n = 35$). The experimenter asked the mother to feed her infant the new food until the infant rejected it three times or until three minutes had elapsed. The three minute duration for the task was used to ensure that only infants' initial responses to the food that were not influenced by satiation were captured. The interaction was digitally recorded; one camera focused on the infant, while another camera focused on the mother. From the observation booth, the experimenter watched for rejection of the novel food. Rejections of the food included turning away, swatting the spoon, or refusing to eat a bite of the food. The task ended when the experimenter observed the infant rejected the food three times or when three minutes had elapsed. In the present study, 61 infants (69%) rejected the novel food three times before three minutes had elapsed. In a few cases, the task ended when the infant had finished the entire cup of food. The mother stopped feeding her infant after the experimenter re-entered the room unless she requested to continue feeding her infant. At the end of the novel food task, the mothers had the option to return to feeding the infant the familiar food if they thought their infants were still hungry.

Measures

Infant temperament—Mothers completed the Infant Behavior Questionnaire-Revised (IBQ-R) to assess infant temperament when their infants were 12 months of age (Gartstein & Rothbart, 2003). The 173-item questionnaire asks mothers to rate the relative frequency of specific behaviors in the past 1–2 weeks (e.g. “When hair was washed, how often did the baby smile or laugh?”). Mothers indicated their responses on a 7-point Likert scale ranging from 1 (*never*) to 7 (*always*); higher scores indicated more frequent occurrences of the behavior. Previous research has shown that the individual items can be combined to form 14 internally consistent dimensions of infant temperament. Only the approach dimension was considered in the present study. This dimension combines twelve items that assess the infants' responses to novelty and positive anticipation of pleasurable activities (e.g. “How often during the last week did the baby move quickly toward new objects?” “When given a new toy, how often did your baby immediately go after it?”) (Gartstein & Rothbart, 2003). Cronbach's alphas showed internal consistency for the approach dimension ($\alpha = .81$) in the present study.

Infant feeding history—When the infants were 4, 6, and 12 months of age, mothers completed the *Baby's Basic Needs Questionnaire* (BBNQ) which assessed the infants' feeding history (Stifter, Anzman-Frasca, Birch, & Voegtline, 2011). Mothers reported the infants' current feeding method and the age the infants had been introduced to solid foods (in weeks) ($M = 17.70$, $SD = 4.53$) and formula, if applicable. Based on the responses to these items, infants were classified into two groups: infants exclusively breastfed for at least 4 months ($n = 33$) and infants who were exclusively breastfed for less than 4 months ($n = 56$). Prior to the 12 month laboratory visit, mothers indicated whether their infants had been exposed to eighteen common infant foods (e.g. apples, peas, squash, etc.). Mothers listed any additional foods their infants had tasted. An “exposure to solid foods” variable was created by summing the total number of solid foods the infant was exposed to prior to the

12-month laboratory visit ($M = 17.45$, $SD = 2.41$). The breastfeeding variable (exclusive breastfeeding for 4 months vs. not) and the previous exposure to solid foods variable were analyzed as predictors of infants' acceptance and rejection of the novel food.

Infant novel food response—In order to assess the infants' responses to the novel food, recordings of the 12-month novel food task were coded using an interval-based computer program (Better Coding Approach, Danville, PA). Five behaviors were coded in response to each offer of food: positive behavior, neutral response, negative behavior, force out, and refusal. Brief descriptions of each behavior are presented in Table 1. Trained pairs of coders rated the presence or absence of each behavior in response to each offer of novel food. An offer began when the mother approached the infant with a spoonful of novel food and ended when she began to approach the infant with another spoonful. In order to better capture infant behaviors within each offer, the offers were coded in 5-second intervals. Multiple codes could be selected for each interval. Inter-rater drift reliabilities were calculated for 20% of the total recordings. Final inter-rater reliability Cohen's kappas for infant novel food responses can be found in Table 1.

Composite variables for analyses: Composite variables were created for infants' responses to the first and later offers of novel food. Since the novel food task followed the familiar food task where the infant was exposed to a food that he/she had previously tasted, it is possible that the infants' reactions to the first spoonful of novel food were in response to the unexpected switch from the familiar food to the novel food. Moreover, some infants may have had some familiar food left in their mouth when they first tasted the novel food. For these reasons, the initial offer of novel food was considered separately from the later offers in all analyses. The scoring for the later offers of novel food were limited to the first seven offers of food to ensure that the infants' responses were not influenced by satiation.

Composite variables were created for infant *acceptance* and *rejection* to the initial and later offers of novel food. The *acceptance* proportion score was created by summing the frequencies of positive behaviors and neutral responses and dividing this sum by the total number of behaviors exhibited in response to the first offer of food. Positive behaviors and neutral responses were included together in this proportion score because both behaviors indicate the infants' liking or willingness to eat the food. The *rejection* proportion score combined the scores for force out, negative behaviors, and refusal since each of these behaviors indicate a physical display of rejection. The frequencies for the three behaviors were summed and divided by the total number of behaviors exhibited in response to the first offer of food. Force out and negative behaviors were strongly correlated ($r = .57$, $p < .001$), but refusal was not correlated with either of the other behaviors. This was due to the fact that only one infant displayed a refusal to the first offer of food. Corresponding proportion scores were also created for *acceptance* and *rejection* to the later offers of food. The denominator for these proportion scores was the total number of behaviors exhibited in response to offers two through seven. Refusal and negative behaviors were correlated for the later offers ($r = .23$, $p = .03$).

Potential covariates—The following variables were examined as potential covariates in the present study because they may be related to the infants' responses to the novel food:

age the child was introduced to solid foods (in weeks), type of novel food introduced (hummus or cottage cheese), number of offers received, and amount of time since last feeding (in minutes). In order to calculate the amount of time since the infants' last feeding, mothers were asked to report the time of the most recent feeding upon arrival to the 12 month lab visit. The current time was recorded and the amount of time since the last feeding was calculated for each infant in minutes ($M = 98.79$, $SD = 55.34$). Demographic variables may also be related to infants' responses to novel food, so mothers were asked to report their years of education, age, and family income in a demographic survey. Maternal body mass index (BMI) was calculated from maternal height and weight measurements collected from laboratory visits. All four demographic variables were examined as potential covariates in the present study.

Additionally, because it is likely that mothers' behaviors while feeding the infant would influence the infant's responses to the novel food, maternal responsiveness and affect were coded during the novel food task and examined as potential covariates. Codes for maternal responsiveness characterized the appropriateness of the mothers' responses to the infants' actions and were selected from a 4-point scale including none, low, moderate, and high responsiveness. Brief descriptions of each behavior are presented in Table 1. One code was selected for each 10-second interval. The codes for each level of responsiveness were averaged to create a maternal responsiveness score for each mother (range 1.25–2.45). Maternal positive and negative affect were coded separately by indicating the peak level of each type of affect that occurred during each 10-second interval. The scale for positive affect ranged from 0 (no positive affect) to 3 (high positive affect) and the negative affect scale ranged from 0 (no negative affect) to –3 (high negative affect). Descriptions of each code are presented in Table 1. Since positive and negative affect were coded separately, mothers could be coded as exhibiting both positive and negative affect during the same interval. The codes for positive and negative affect were averaged separately to create an average positive (range 0–2.00) and an average negative affect score (range 0–0.31) for each mother.

Data analysis plan

In order to test the potential covariates, correlations and independent samples t-tests were conducted between the infant novel food response composites (acceptance and rejection behaviors) and the following variables: age the child was introduced to solid foods (in weeks), maternal education, maternal age, family income, maternal BMI, infant gender, type of novel food the infant received during the visit (hummus or cottage cheese), amount of time since last feeding (in minutes), number of offers received, maternal responsiveness, maternal positive affect, and maternal negative affect. Separate analyses were conducted for the first offer and later offers. The number of offers the infants received and maternal responsiveness were related to the infants' acceptance and rejection behaviors, so they were included as covariates in subsequent analyses. All other variables were unrelated to the infants' responses to the food so they were not considered further. Table 2 includes descriptive statistics and Table 3 includes the correlations for the covariates, infant temperament, feeding history, and novel food responses.

Multiple regression analyses were conducted to test all study hypotheses. Infant temperament (i.e., approach), previous exposure to solid foods, and exclusive breastfeeding (for 4 months vs. not) were used to predict acceptance and rejection behaviors to the novel food during the first and later offers. Interactions between temperament and feeding history (i.e. previous exposure to solid foods and exclusive breastfeeding) were also included in the regression analyses to examine the moderating effect of feeding history on the relationship between temperament and infants' responses to the novel food. All analyses were conducted using SAS version 9.3 (SAS Institute, Cary, North Carolina) and a significance level of $p < .05$ was retained.

Results

Responses to the first offer of food

As shown in Table 4, the model predicting acceptance in response to the first offer was significant ($p = .02$) and the model predicting rejection behaviors was marginally significant ($p = .07$). Approach significantly predicted acceptance of the first offer of food. Infants who were rated lower on approach showed fewer acceptance behaviors in response to the first offer of food than infants rated higher on approach. As expected, maternal responsiveness predicted acceptance and rejection behaviors. Mothers who were highly responsive had infants who showed more acceptance and less rejection in response to the first offer of food. Neither of the feeding history variables predicted infants' responses to the novel food and none of the interactions between approach and the feeding history variables were significant.

Responses to the later offers of food

The models predicting acceptance and rejection behaviors in response to the later offers of food were both significant (p 's $< .05$). As expected, maternal responsiveness and the number of offers the infants received significantly predicted the infants' responses to the later offers of food. Highly responsive mothers had infants who were more accepting and less rejecting in response to the later offers. Also, infants who received more offers of novel food tended to be more accepting and less rejecting than infants who received fewer offers of food. Breastfeeding did not significantly predict infants' responses to the novel food, alone or in interaction with approach.

The interaction between approach and previous exposure to solid foods significantly predicted rejection behaviors in response to the later offers of food. Following Aiken and West's (1991) guidelines, the relationship between previous exposure to solid foods and rejection behaviors was examined separately for infants rated one standard deviation above and one standard deviation below the mean on approach. Figure 1 illustrates this relationship. Follow-up tests examining whether the slopes for low and high approach were significantly different from zero revealed only the slope for low approach to be significant, $b = -0.04$, $p = .047$ (indicated by an asterisk in Fig. 1). As hypothesized, low approach infants who were exposed to more solid foods prior to the novel food task showed fewer rejection behaviors than low approach infants who were exposed to fewer solid foods.

Discussion

The purpose of the present study was to examine the individual and combined effects of infant temperament and feeding history on infants' responses to a novel food at 12 months of age. Consistent with our hypotheses, infants who were rated lower on approach showed fewer acceptance behaviors in response to the first offer of novel food than infants rated higher on approach. However, approach alone did not predict infants' responses to the later offers. Instead, it was the combination of approach and previous exposure to solid foods that predicted infants' later rejection behaviors. Additionally, maternal responsiveness was associated with greater acceptance and less rejection of the novel food by infants during the first and later offers.

Since low approach infants do not tend to show positive responses toward novel stimuli (Rothbart, 1988; Rothbart & Bates, 2006), we predicted that low approach infants would also show low levels of acceptance in response to the novel food in the present study. Our findings showed that this was the case: low approach infants showed fewer acceptance behaviors in response to the first offer of food than infants rated higher on approach. This result indicates that initial responses to a novel food reflect an infant's temperamental predisposition to approach or withdraw from novelty. Thus, parents of low approach infants should not expect their infants to accept novel foods on the first exposure. However, initially low levels of acceptance do not indicate that these infants cannot learn to accept new foods. Previous research has shown that repeated exposures to a novel food can lead to increased consumption of the food, even if the food was initially rejected (e.g. Forestell & Mennella, 2007; Gerrish & Mennella, 2001; Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007; Sullivan & Birch, 1994). For this reason, parents of low approach infants should be encouraged to persist beyond the initial presentations of a novel food with their infant.

Our findings are consistent with the results of Forestell and Mennella (2012) who showed that infants rated lower in approach consumed less of a green vegetable, ate the food for a shorter period of time, exhibited more lip raises and nose wrinkles while eating the food, and received lower liking scores than infants rated higher in approach. Our study extends these results by revealing that low approach is also related to infants' behavioral responses to a new food, specifically low levels of acceptance behaviors (e.g. reaching toward the spoon, exhibiting positive or neutral affect, etc.). Further, this is the first study to show that infant approach is related to infants' responses to a food that is completely novel.

One strategy that may reduce low approach infants' negative responses to novel foods, particularly during later offers, is exposure to a variety of solid foods. Consistent with our study hypotheses, low approach infants exhibited fewer rejection behaviors (e.g. turning away, swatting the spoon) in response to the later offers of food when they had been exposed to a greater number of solid foods prior to tasting the novel food. Thus, if parents of low approach infants can persist with introducing their infants to a variety of new foods despite their infants' initially low acceptance of these foods, low approach infants may exhibit fewer rejection behaviors to later foods introduced. On the other hand, exposure to a greater number of solid foods was not associated with fewer rejection behaviors in high approach infants; they showed fewer rejection behaviors regardless of the number of foods

they had previously tried. This is the first study to show that the joint effects of infant temperament and previous feeding history predict infants' responses to novel foods.

Previous research has shown mixed results for the effect of breastfeeding on infants' acceptance of novel foods on the first exposure (e.g. Forestell & Mennella, 2007; Sullivan & Birch, 1994). Our findings support the previous work showing no relationship between breastfeeding and infant novel food acceptance (Sullivan & Birch, 1994). However, this lack of relationship in the current study could be due to two possible factors. First, only a small proportion of the infants in this study were exclusively formula-fed; over 90% of the infants had received breast milk for at least a short period of time, so they had some exposure to flavors from their mothers' diet through the breast milk. Thus, the lack of relationship between breastfeeding and novel food response may be due to the lack of variability in infants' milk feeding method in the present study. Second, it is possible that the mothers' diet while lactating may have affected the results of this study. Forestell and Mennella (2007) found that breastfeeding may only offer an advantage to infants when mothers regularly ingest the target food during lactation. Since maternal diet during lactation was not measured in the present study, it is impossible to tell whether the null results for breastfeeding are due to a true lack of relationship between breastfeeding and novel food acceptance or whether they are due to the mothers not consuming the novel food (hummus or cottage cheese) regularly while breastfeeding. Future work should continue to examine the effects of breastfeeding to determine when and how breastfeeding plays a role in novel food acceptance.

An additional factor that was related to infants' acceptance and rejection of the novel food was the mothers' level of responsiveness while presenting the new food to their infants. Mothers who were more responsive to their infants' cues, whether the cues were positive or negative, had infants who showed greater acceptance and fewer rejection behaviors in response to the novel food. Interestingly, the mothers' levels of positive and negative affect were unrelated to the infants' responses. Taken together, these results suggest that it is not the mothers' facial affect per se that was associated with the infants' responses to the food, but rather how appropriate and sensitive the mothers' behaviors were in response to the infants' actions (i.e. smiling when the infants are smiling, giving the infants another bite when they reach for the spoon). These results are important as they highlight that maternal responsiveness may be another strategy that increases the likelihood of infants accepting a new food.

To our knowledge, this is the first study to show how parenting behaviors relate to infants' responses to a novel food. Previous research has shown that parent feeding strategies, such as prompting the child to eat and offering rewards for eating, are associated with responses to a novel food in preschoolers (Blissett, Bennett, Donohoe, Rogers, & Higgs, 2012), but there is a lack of studies investigating the effectiveness of parent feeding strategies for infants' acceptance of new foods. Future work needs to replicate our results for maternal behavior in other samples. Despite the strong relationship between maternal responsiveness and infants' responses to the novel food, there was a lack of variability in the mothers' levels of responsiveness. Most mothers in our sample were quite responsive during the feeding interaction. There was also a lack of variability in negative affect; most mothers in our study

showed very few, if any, negative facial expressions during the feeding interaction. Therefore, it is important to investigate the relationship between maternal feeding behaviors and infants' responses to a novel food in a sample where there is greater variability in parenting behavior.

Limitations and future directions

One limitation to the present study is the infants were introduced to the novel food after eating several spoonfuls of a familiar food. This order of tasks was used so that the infants could adjust to feeding without immediate exposure to the novel food. However, since the familiar food task immediately preceded the novel food task, the infants' reactions to the first offer of food could be due to the novelty of the food or to the violation of the infants' expectations that the next offer of food would be the same as the last. The present study cannot separate these types of responses. However, mothers are often encouraged to offer a new food after giving their infants a taste of a familiar food, so this study design may resemble actual feeding practices that take place in the home. Future studies should examine whether infants' responses to a novel food differ according to whether or not the infants received a familiar food prior to tasting the novel food.

Another limitation of the present study was that the novel foods were not randomly assigned to the infants. In cases where the infant had not tried either novel food (hummus or cottage cheese), the mothers were asked to select which food they would like to introduce to their infant. Random assignment would have helped guarantee more equal numbers of infants who received each type of food and would have balanced potential factors that may contribute to infants' acceptance and rejection of the novel food, such as feeding history, temperament, and maternal responsiveness. However, the analyses of novel food type (hummus or cottage cheese) revealed that there were no significant differences in infants' responses depending on the type of novel food they received. Furthermore, there were no differences between the infants who tried the hummus and infants who tried the cottage cheese on whether or not they were exclusively breastfed for 4 months, their previous exposure to solid foods, or their temperamental approach.

Although the findings of the present study indicate that temperament and exposure to a variety of foods were important to the acceptance of new foods, we did not examine how infants' responses to the novel food changed across offers. Yet, there are many factors that may contribute to an infant's responses over time that could be examined in future studies. First, infants' responses to a novel food may change across offers due to factors unrelated to the food itself. For example, infants who accepted the novel food during earlier offers (infants who are high in approach) may begin to reject the food if they become full or tired. Further, high approach infants may also become bored easily as the novelty of the food wears off after the first few offers. These factors may have clouded the relationship between approach and infants' responses to the later offers of novel food in the present study. Identifying and controlling for these types of factors, as well as looking at the course of reactions across time, will better help us understand the relationship between approach and infants' responses to novel food.

As infant feeding is a transaction between the infant and caregiver, future studies should examine how the behaviors of infants and their caregivers reciprocally affect one another during a feeding interaction with a new food. For example, mothers' specific behaviors such as smiling may lead to infants more readily accepting a new food whereas infant behaviors such as crying may influence caregivers to pause or terminate the feeding.

Conclusions

Acceptance of novel foods is critical during infancy to ensure that infants have a diet that is rich in various nutrients (Birch, 1999). For this reason, it is particularly important to understand factors that contribute to novel food acceptance and rejection. The results of this study confirm that the temperamental dimension of approach is one important factor that determines infants' responses to novel foods at 12 months of age. Infants who tend to withdraw from novel stimuli are less likely to accept novel foods than other infants who tend to approach novel stimuli. Furthermore, this study suggests that the combination of temperament and previous exposure to solid foods matters for infants' rejection of new foods. Previous exposure to many solid foods appears to reduce negative responses to novel foods in low approach infants. This study also shows mothers' behaviors while presenting a new food to their infants may play a role in the infants' acceptance or rejection of that food. Future work should continue to examine the joint effects of temperament and feeding history, as well as the impact of maternal behaviors, on infants' acceptance of novel foods.

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Fig. 1.

Interaction between infant approach and previous exposure to solid foods predicting infants' rejection behaviors to the later offers of novel food.

Table 1

Definitions of codes for infants' responses and maternal behavior during the novel food task.

Infants' behavior	Definition	Kappa
Rejection	Sum of negative behaviors, force outs, and refusals divided by the total number of behaviors exhibited by the infant	
Negative behavior	Crying, fussing, whining, or negative affect	0.88
Force out	Physically removing food from mouth	0.85
Refusal	Swatting spoon, back arching, mouth pursed shut, turning away	0.87
Acceptance	Sum of positive behaviors and neutral responses divided by the total number of behaviors exhibited by the infant	
Positive behavior	Smiling, reaching toward the spoon, leaning forward, or opening mouth in anticipation of the next bite	0.89
Neutral response	A neutral bite in response to the food	0.82
Maternal behaviors	Definition	Kappa
Responsiveness		
None	Ignoring the infant for the majority of the interval	N/A
Low	One or more instances of intrusive (e.g. forcing the infant to take a bite of the food) or insensitive behavior (e.g. not responding to infant's cues for another bite)	0.92
Moderate	Passively watched infant eat for the majority of the interval	0.85
High	Actively responded to or vocalized about the infant's actions for the majority of the interval	0.85
Positive affect		
None	Mother does not show positive affect during the interval	0.78
Low	Mother shows slight positive affect (e.g. slight or half smile, quiet laugh)	0.77
Moderate	Mother shows a medium level of positive affect (e.g. clear smile or laugh)	0.89
High	Mother shows a high level of positive affect (e.g. intensely laughs out loud or smiles with mouth open wide)	0.94
Negative affect		
None	Mother does not show negative affect during the interval	0.84
Low	Mother shows slight negative affect (e.g. slight nose wrinkles or furrowed eyebrows)	0.89
Moderate	Mother shows a medium level of negative affect (e.g. clear frown or disgust facial expression)	N/A
High	Mother shows a high level of negative affect (e.g. intense frown, scowl, or disgust facial expression)	N/A

Note: Kappa is a measure of inter-rater drift reliability that takes into account the agreement that may occur by chance between raters. N/A is listed for codes that did not occur during drift reliability files.

Table 2

Descriptive statistics for maternal behavior, infant temperament, feeding history, and infant novel food responses.

	% or <i>M</i>	<i>SD</i>	Min	Max
Maternal behavior				
Number of offers	6.54	.95	3.00	7.00
Maternal responsiveness	1.96	.19	1.25	2.45
Maternal positive affect	0.74	.48	0.00	2.00
Maternal negative affect	0.04	.07	0.00	0.31
Temperament				
Approach	5.75	.63	3.75	7.00
Infant feeding history				
Exposure to solid foods	17.45	2.41	11.00	23.00
Exclusive breastfeeding				
4+ months:	37%	–	–	–
Less than 4 months	63%	–	–	–
Novel food response				
First offer				
Acceptance	.65	.44	.00	1.00
Rejection behaviors	.13	.30	.00	1.00
Later offers (2–7)				
Acceptance	.52	.39	.00	1.00
Rejection behaviors	.40	.37	.00	1.00

Note: n = 89.

Table 3

Correlations between covariates, infant temperament, feeding history, and infant novel food response.

Variable	1	2	3	4	5	6	7	8	9
1. Number of offers	–								
2. Maternal responsiveness	.25*	–							
3. Approach	.06	.03	–						
4. Exposure to solid foods	–.03	.15	–.16	–					
5. Breastfeeding	.08	–.04	–.08	–.06	–				
6. Acceptance (offer 1)	.45**	.32**	.21*	.12	.07	–			
7. Rejection behaviors (offer 1)	–.59**	–.34**	.06	.00	–.04	–.59**	–		
8. Acceptance (offers 2–7)	.56**	.41**	.16	.06	.07	.58**	–.45**	–	
9. Rejection behaviors (offers 2–7)	–.62**	–.43**	–.11	–.05	–.05	–.47**	.54**	–.94**	–

Note: $n = 89$.+ $p < .10$.* $p < .05$.** $p < .01$.*** $p < .001$.

Table 4

Multiple regression results for infants' responses during the first and later offers of novel food.

	<i>B</i>	<i>SE(B)</i>	β	<i>F</i>	<i>R</i> ²
I. Acceptance – first offer				3.00*	.18
Maternal responsiveness	.71	.24	.31**		
Approach	.18	.07	.25*		
Previous exposure to solid foods	.02	.02	.12		
Exclusive breastfeeding	.09	.09	.10		
Approach $\times$ previous exposure to solid foods	-.02	.03	-.06		
Approach $\times$ exclusive breastfeeding	-.12	.15	-.09		
II. Rejection behaviors – first offer				2.04+	.13
Maternal responsiveness	-.52	.17	-.34**		
Approach	.04	.05	.08		
Previous exposure to solid foods	.01	.01	.05		
Exclusive breastfeeding	-.03	.06	-.04		
Approach $\times$ previous exposure to solid foods	.01	.02	.05		
Approach $\times$ exclusive breastfeeding	-.04	.10	-.05		
III. Acceptance – later offers				8.52***	.43
Number of offers	.20	.04	.49***		
Maternal responsiveness	.49	.19	.24*		
Approach	.09	.06	.15		
Previous exposure to solid foods	.01	.01	.08		
Exclusive breastfeeding	.05	.07	.06		
Approach $\times$ previous exposure to solid foods	-.03	.03	-.09		
Approach $\times$ exclusive breastfeeding	.09	.11	.07		
IV. Rejection behaviors – later offers				11.53***	.50
Number of offers	-.21	.03	-.54***		
Maternal responsiveness	-.48	.17	-.25**		
Approach	-.06	.05	-.11		

	<i>B</i>	<i>SE(B)</i>	β	<i>F</i>	<i>R</i> ²
Previous exposure to solid foods	-.01	.01	-.07		
Exclusive breastfeeding	-.02	.06	-.03		
Approach $\times$ previous exposure to solid foods	.05	.02	.18*		
Approach $\times$ exclusive breastfeeding	-.05	.10	-.04		

Note: *n* = 89.

+ *p* < .10.

* *p* < .05.

** *p* < .01.

*** *p* < .001.