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Food Texture Preferences in Infants Versus Toddlers

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Previous research has demonstrated that newborns are capable of preferentially responding to distinct tastes and food-related odors. However, whether infants are also capable of responding to distinct food textures has not been previously investigated. The present research determined whether food texture preferences differ during two developmental periods, infancy and toddlerhood, and whether experience with textures influenced infants' food preferences. In the present research, infants displayed more negative expressions, negative head movements and negative body movements when presented with more complex textures. In contrast, toddlers showed more positive head and body movements and more eagerness for complex textures. The data also suggest that experience with difficult-to-chew textures can facilitate a preference for a more complex texture. The present research adds to our understanding of early perceptual and discriminatory abilities and their development between infancy and early toddlerhood. In addition, the data highlight the need for food texture variation (within the range of the infants' feeding skills) to satisfy the infants' and toddlers' novelty preferences.

Key words: Food texture, infants, toddlers, food preferences, feeding, eating behaviors

Previous research has demonstrated that facial expression behaviors in response to taste and food odors are present at birth (Fox & Davidson, 1986; Steiner, 1979). Steiner (1979) presented neonates with three tastants representing sweet, sour and bitter concentrations which, when tested with adults, elicited definite facial expres-

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sion reactions. Neonates also displayed differential facial expressions in response to the different stimuli. The newborn's most typical response to the sweet solution included an expression resembling a smile followed by a licking of the upper lip. According to Steiner (1979), this gustatory stimulus typically induced a burst of eager sucking movements. In contrast with the sweet solution, responses to the sour stimulus included lip pursing, nose wrinkling and blinking. Furthermore, responses to the bitter stimulus included lowering the mouth corners, elevating the upper lip, flattening the tongue and spitting behaviors.

Food-related odors also elicit facial expressions in infants (Steiner, 1979). In Steiner's (1979) research, infants were presented with artificial food flavors selected by adults to represent "fresh" and "rotten" flavors. Infants' responses to the presentation of the food odors were categorized into two types: "acceptance, like, enjoyment, satisfaction" or "aversion, dislike, disgust" (p. 274). The first type, typically observed during the presentation of the pleasant odor, was similar to the infants' response to the sweet stimulus in the gustatory study. The aversion responses elicited by offensive odors were similar to the behaviors elicited by the bitter tasting stimulus.

Although different facial expressions in response to taste and food-related odors have been demonstrated in infants, their ability to discriminate and respond preferentially to different food *textures* has not yet been investigated. Texture has been found to contribute to acceptability and preference of foods in adults (Aukes, Felling & Kayser, 1989). In addition, textural attributes affect food processing characteristics such as frequency of chewing cycles and, in turn, are likely to affect food preferences. Additionally, the number and duration of chewing cycles increase as texture becomes harder (Gisel, 1988; Schwartz, Niman & Gisel, 1984). Children of a particular age group who have difficulty manipulating certain textures in the mouth may reject those foods (Szczesniak, 1972). If infants and toddlers are capable of discriminating different food textures, they may show preferences for or reject foods because of their textural properties, not only because of flavor or aroma (Steiner, 1979).

Infants do perceive the textural properties of orally explored objects (Kaye & Bower, 1994; Meltzoff & Borton, 1979; Pecheuz, Lepecq & Salzarulo, 1988). Infants who were orally familiarized with texture information (nubby or smooth pacifier) looked significantly longer at a large replica of the stimulus that corresponded to the one that was orally explored (Kaye & Bower, 1994; Meltzoff & Borton, 1979; Pecheux *et al.*, 1988).

In Meltzoff and Borton's study (1979), infants were familiarized for a brief period (90 seconds) in which the infant orally-tactually explored one of two objects. Following familiarization, infants were shown a pair of visual shapes, only one of which matched the tactual stimulus. Visual fixation to the matching versus non-matching shape was recorded. Infants looked significantly longer at the visual replica that matched the stimulus they had orally explored. Thus, infants are capable of perceiving the textural properties of orally explored objects. However, whether infants' ability to detect textural information generalizes to food texture has not yet been investigated. Furthermore, whether infants' preferences for dif-

ferent foods are based on textural properties as well as taste and odor information has not yet been determined.

A preference paradigm, similar to that used with visual stimuli (Fantz, 1963), was utilized in the present study to determine whether infants and toddlers differ in their food texture preferences. In Fantz's paradigm, infants were presented with two different visual stimuli simultaneously. A preference was demonstrated when looking time to one stimulus was significantly greater than to the other stimulus. In the present study, a modification of the typical preference paradigm was used in which positive and negative behavioral responses were recorded as subjects were presented successively with different food textures. A preference for one texture over another was indicated by a greater number of positive responses during the presentation of that texture. Familiarizing infants to a visual stimulus for a period of time results in a preference for novelty (Fagan, 1974). The more familiar a stimulus becomes, the less interesting it is to explore. A familiarization procedure was also employed in the present research to determine whether a novelty preference would be exhibited after infants were familiarized to another texture.

The purpose of the present research was twofold; first, to determine whether food texture preferences differ during two developmental periods, infancy and toddlerhood (Study 1). Toddlers were expected to prefer a more complex, difficult-to-chew texture. We also wanted to determine whether (a) infants demonstrate, after a lengthy familiarization phase, a novelty preference for textures different from what they had experienced, (b) whether experience with difficult-to-chew textures beginning early in life can facilitate a preference for a more complex texture at a developmental period earlier than infants are typically presented more complex texture foods; and (c) whether a developmental progression, in which the complexity of the texture is gradually increased, plays a role in infants' food preferences (Study 2).

STUDY 1

Method

Subjects

Twelve infants (between 6 and 12 months, $M = 9.7$, $SD = 2.7$) and 12 toddlers (between 13 and 22 months, $M = 17.2$, $SD = 2.6$) were recruited from the university's preschool. Their parents were from nuclear dual career families of middle to upper middle socioeconomic status ($M = 2.0$ on the Hollingshead two-factor index) and varying ethnicity (67% Caucasian, 21% Black, 12% Hispanic). All infants/toddlers involved in this study were full-term, physically healthy and did not have an eating disorder or other developmental problem. The infant and toddler groups were each comprised of five boys and seven girls. Parents were requested not to feed their infants applesauce during the course of the study. For the study, the infants/toddlers were fed only apple products specifically prepared by Gerber with the textures being: (a) Pureed; (b) Lumpy; and (c) Diced.

Assessments

Prior to the first feeding session, parents completed a *Demographic and Background Information Questionnaire* which consists of seven items regarding living arrangements, education and occupation.

Breast and Formula Feeding Practices. Prior to the first feeding session, breast-feeding mothers were questioned regarding the number of times a day (and night), and the length of time, they spent breast-feeding their babies. Formula-feeding mothers reported the brand of formula they used, how it was prepared and how long one can of formula lasted. All mothers were asked whether their babies took bottles to bed and whether any food or beverages were ever added to the bottles.

Anthropometry. Height, weight and head circumference were obtained for each child immediately prior to the initial feeding session.

Teacher/Parent Questionnaires. A Baby Food Usage Questionnaire, A Food Preference Questionnaire, and an Eating Behavior Checklist were developed specifically for this study and were completed by the teachers on the first and last days of the study period. The teacher completed these questionnaires since the children were provided with many of their meals at the preschool. However, the teacher confirmed with the parent all information on the questionnaires. A Developmental Screener (Coletta, Ott & Stark, 1992) was given to the parents to determine whether the children's feeding skills and development were consistent with their age.

1. *Baby Food Usage.* The purpose of this questionnaire was to determine the brand of baby food (e.g., Gerber, Beechnut, Heinz or other brands) and types of food (i.e., cereal, fruits, vegetables, meats, and juice) the child was typically fed.
2. *Food Preference Questionaire.* The child's teacher was asked to indicate on a four point scale how much the child likes/dislikes each of several food items listed including different kinds of vegetables, meats, juices and cereals.
3. *Eating Behavior Questionaire.* Teachers completed this food list based on texture categories that were included in the 1989 Gerber Infant Nutrition Survey (Gerber, 1989) on children ages 2 to 18 months. This list included the following foods: (1) breads/rice, (2) eggs, (3) cereals, (4) fruit, (5) vegetables, (6) meats and (7) cheese. Scores were based on the children's level of exposure ("0" = none, "1" = some and "2" = much exposure).
4. *Developmental Screener.* This measure, consisting of 14 items assessing the child's feeding skills, was completed by the parent prior to the initial feeding session (Coletta, Ott & Stark, 1992).

Feeding Sessions. The infants were tested in a quiet room free from distraction. To control for satiety, the interval between testing and the last meal was approximately one hour. Infants/toddlers were seated in a high chair. The director of the infant nursery program was seated directly across from the child.

Applesauce was presented in three textures (pureed, lumpy and diced) in counterbalanced order of texture across three days (1, 2, 3; 2, 3, 1; 3, 1, 2) alternating morning and afternoon sessions, as is exemplified in the Latin Square in Figure 1. Each texture presentation consisted of three level spoonfuls (i.e., three trials of each texture).

Subject 1				
Day 1:	Morning	Pureed	Lumpy	Diced
Day 2:	Afternoon	Lumpy	Diced	Pureed
Day 3:	Morning	Diced	Pureed	Lumpy
Subject 2				
Day 1:	Afternoon	Pureed	Diced	Lumpy
Day 2:	Morning	Lumpy	Pureed	Diced
Day 3:	Afternoon	Diced	Lumpy	Pureed

Figure 1 Latin Square Schematic for Food Trials.

The director of the infant nursery program, who regularly fed the children three to four times a week during the previous three months, served as the feeder. The director, naive with regard to the specific hypotheses, was instructed to present the food using a standard infant spoon and to move the spoon through a horizontal plane. A research assistant placed the three textures in separate paper cups numbered "1", "2", and "3", prior to each session. The numbers corresponded to the order of stimulus presentation for each child. The interval between the presentation of different textures was 20 seconds. If the subject refused a spoonful of food, the director waited for a period of twenty seconds prior to beginning the next presentation. If the subject cried or became upset, the director was instructed either to end the session and resume the next day, or wait until the subject gave a cue that he/she was ready to resume feeding. The decision to end the session and resume the next day was based on whether the child continued to cry for more than twenty seconds. In this case, the session resumed from the beginning on the next day. If the child cried or became upset for only a brief period (less than twenty seconds) followed by a calm and alert state the feeding resumed with the next presentation.

Videotaping. A videocamera was placed approximately 6 feet from the right side of the child's chair and level with the child's face to obtain a profile view of the face and neck. A second videocamera faced the infant for a frontal view.

Measures

Videotapes were coded for the following: (1) *Texture preferences.* To determine food texture preferences the videotapes were coded using the Harris and Booth (1990) coding system on the following categories: (a) positive or negative facial expression (i.e., smiling or grimacing); (b) positive or negative vocalization (i.e., babbling or fussing/crying); (c) positive body movements (i.e., movement of body or head toward the offered food); and (d) negative body movements (i.e., head or body movements down or away from the spoon. (2) *Food Acceptance.* Food acceptance was coded as: (a) eager (i.e., the infant opens its mouth before the spoon was offered, although the spoon does not touch the mouth); (b) neutral (i.e., the infant accepted the food when the spoon touched the mouth, or was pushed into the mouth); (c) refusal (i.e., the infant closed the mouth when the spoon was offered, touched the mouth, or was pushed into the mouth); (d) retracted offers (i.e., the

spoon was withdrawn because the infant was distracted or unready to accept); and (e) holding food in the mouth. (3) *Number of chewing cycles.* A chewing cycle was defined as an upward and downward movement of the chin.

Videotapes were coded by an observer blind to the presentation order of the stimuli. The videotapes were played and then paused following each segment beginning with the initial presentation and ending with the child's final swallow of each spoonful. During the pause, the observer coded all behaviors viewed in that segment of tape. The remaining food presentations were coded in a similar manner and for each subject. Because the children received three spoonfuls of each texture, the frequency of each observed behavior was averaged across the three presentations (i.e., spoonfuls). These average scores were entered into the analyses. A subsample of 10 tapes were scored by two independent investigators to determine interrater reliability. Cohen's Kappa based on the number of agreements and disagreements between the two observers was 0.82.

RESULTS

T tests and Chi Square analyses yielded a group effect on the *Anthropometry* scale, in which recumbent length ($t(14) = -4.31$, $p < .001$), weight ($t(8) = -2.40$, $p < .05$) and head circumference ($t(12) = -2.00$, $p < .05$) were greater for the toddlers compared to the infants. The groups differed, of course, on mean age ($t(22) = -7.56$, $p < .001$). No other group differences on the demographic/background variables were found, on the parent/teacher measures between day 1 and day 3. Therefore, only day 1 scores are noted in the table (See Table 1). The *Feeding Preference Questionnaire* findings suggested that toddlers showed a greater preference for meat compared to infants ($t(11) = -2.36$, $p < .05$).

Separate MANOVAs followed by ANOVAs and posthoc *t*-tests were performed on the *texture preference* and *food acceptance* behaviors using age group (infants and toddlers) as the between groups effect and food texture (pureed, lumpy, diced) as the within group repeated measures effect. An ANOVA was also performed on the *number of chewing cycles.*

Within the *texture preference* category, significant interaction effects suggested that infants: (1) showed more frequent *negative expressions* to the diced texture ($F(1, 22) = 7.20$, $p < .01$), (2) displayed more *negative head movements* for the lumpy ($F(1, 20) = 4.29$, $p < .05$) and diced textures ($F(1, 20) = 4.29$, $p < .05$), and (3) more *negative body movements* for the lumpy texture ($F(1, 22) = 5.86$, $p < .05$). Toddlers, in contrast, showed a (1) greater number of *positive head movements* for all three textures; lumpy ($F(1, 20) = 8.04$, $p < .01$), diced ($F(1, 20) = 7.44$, $p < .01$) and pureed ($F(1, 20) = 8.27$, $p < .01$), and (2) more *positive body movements* for both the lumpy ($F(1, 22) = 7.93$, $p < .01$) and diced textures ($F(1, 20) = 8.07$, $p < .01$) (See Table 2).

Within the *food acceptance* category, significant interaction effects suggested the following: (1) toddlers showed more *eagerness* for the lumpy texture compared to the infants ($F(1, 18) = 5.66$, $p < .05$) and (2) the infants, in contrast, displayed more *neutral behaviors* to the lumpy ($F(1, 18) = 4.45$, $p < .05$). Within the *number of chewing*

Table 1 Demographic and Background Data for Study 1

	INFANT (n=12)	*TODDLERS (n=12)*	
	M	*M*	*p*
Child's Age	9.7 (2.3)	17.3 (2.6)	.001
Gender			
Female (#)	7	7	
Male (#)	5	5	1.00
Hollingshead	1.9 (1.1)	2.6 (0.8)	.15
Breast and Formula Feeding Practices			
Breast fed (%)	17	00	
Formula fed (%)	33	83	
Both (%)	50	17	
Breast feeding (# months):	2.5 (1.5)	2.2 (1.8)	.74
Anthropometry			
Length (cm)	71.3 (5.4)	83.2 (5.6)	.001
Weight (lbs)	21.0 (6.8)	27.7 (2.8)	.04
Head Circumference (cm)	45.0 (2.9)	48.4 (1.7)	.05
Baby Food Usage			
(product usage %)			
Gerber	46	42	.59
Heinz	0	0	
Beechnut	4	4	
Homemade	0	4	
Food Preference Questionnaire Range: 0 = does not like – 3 = likes a lot			
Veggies	1.7 (1.1)	1.4 (0.7)	.54
Meats	1.3 (0.8)	2.1 (0.5)	.04
Fruits	2.3 (1.0)	2.0 (0.6)	.54
Milk	2.4 (1.3)	2.8 (0.7)	.55
Water	1.7 (1.4)	1.8 (1.4)	.91
Juice	1.3 (0.9)	1.8 (0.5)	.27
Cereals	2.2 (0.9)	1.2 (1.3)	.17
Salty	1.0 (1.4)	0.4 (1.1)	.38
Sweet	1.2 (1.6)	0.8 (1.4)	.61
Sour	0.8 (1.1)	0.1 (0.4)	.13
Bitter	0.5 (1.0)	0.0 (0.0)	.20
Eating Behavior Questionnaire Scale: 0 = never, 1 = rarely, 2 = often eats			
Texture Item			
Bread	0.6 (0.7)	0.8 (0.5)	.62
Eggs	0.7 (1.2)	0.7 (0.6)	1.00
Cereals	1.2 (1.2)	1.2 (0.3)	.98
Fruit	0.8 (0.8)	0.9 (0.4)	.80
Vegetables	0.8 (0.4)	0.8 (0.4)	1.00
Developmental Screener			
Classification (%)			
Infant	83	0	
Transition	17	33	
Toddler	0	67	

Note. *SD*s are in parentheses.

Table 2 Infants vs. Toddlers: Mean Proportions for Preference Behaviors in Study 1

	INFANTS (n = 2) *M*	*TODDLERS (n = 12)* *M*	*p-value*
Facial Expressions			
Positive			
Pureed	.22 (.40)	.59 (1.06)	.26
Lumpy	.32 (.39)	.60 (1.06)	.40
Diced	.27 (.46)	.58 (1.08)	.39
Negative			
Pureed	.54 (.78)	.10 (.20)	.08
Lumpy	.20 (.29)	.08 (.14)	.18
Diced	.57 (.70)	.02 (.08)	.01
Vocalizations			
Positive			
Pureed	.03 (.10)	.50 (1.04)	.17
Lumpy	.08 (.20)	.33 (.78)	.30
Diced	.11 (.29)	.44 (.94)	.27
Negative			
Pureed	.42 (.91)	.03 (.09)	.18
Lumpy	.04 (.09)	.08 (.29)	.61
Diced	.27 (.42)	.03 (.09)	.08
Head Movements			
Positive			
Pureed	1.00 (.75)	2.03 (.90)	.01
Lumpy	1.09 (.91)	2.24 (.98)	.01
Diced	.86 (.74)	1.94 (1.06)	.01
Negative			
Pureed	1.17 (.85)	.52 (.80)	.08
Lumpy	1.06 (.60)	.38 (.90)	.05
Diced	1.18 (.69)	.49 (.84)	.05
Body Movements			
Positive			
Pureed	1.64 (.97)	2.26 (.83)	.11
Lumpy	1.38 (1.06)	2.45 (.79)	.03
Diced	1.33 (.82)	2.30 (.84)	.01
Negative			
Pureed	.92 (.74)	.54 (.74)	.22
Lumpy	.96 (.83)	.22 (.66)	.02
Diced	1.03 (.65)	.63 (.84)	.21

Note. *SD*s are in parentheses.

cycles category, an ANOVA revealed no significant differences between the two age groups. (See Table 3).

Study 2

This study determined whether (a) infants demonstrate a novelty preference for textures different from those they have previously experienced, (b) whether expe-

Table 3 Infants vs. Toddlers: Mean Proportions for Food Acceptance and Chewing Behaviors in Study 1

	INFANTS (n = 12) *M*	*TODDLERS (n = 12)* *M*	*p-value*
FOOD ACCEPTANCE			
Eager			
Pureed	.82 (1.10)	1.30 (1.30)	.10
Lumpy	.91 (1.10)	2.30 (1.10)	.03
Diced	.64 (1.00)	2.00 (.95)	.07
Neutral			
Pureed	1.98 (1.04)	1.67 (.82)	.43
Lumpy	2.10 (1.10)	.67 (.99)	.05
Diced	2.40 (1.10)	.92 (.99)	.50
Refusal			
Pureed	.27 (.91)	.08 (.29)	.98
Lumpy	.09 (.30)	.08 (.29)	.48
Diced	.27 (.65)	.42 (.90)	.46
Retract			
Pureed	.63 (1.00)	.33 (.89)	.33
Lumpy	.45 (.69)	.50 (1.00)	.62
Diced	.81 (.98)	.58 (1.20)	.65
Holding			
Pureed	.00 (.00)	1.00 (1.50)	.18
Lumpy	.20 (.63)	.75 (1.40)	.07
Diced	.70 (1.30)	.67 (1.20)	.23
NUMBER OF CHEWS			
Pureed	3.90 (1.30)	4.20 (1.90)	.83
Lumpy	5.50 (2.10)	5.10 (2.20)	.62
Diced	6.30 (2.60)	6.10 (2.30)	.29

Note: *SD*s are in parentheses.

rience with difficult-to-chew textures beginning early in life can facilitate a preference for a more complex texture at an earlier developmental period and (c) whether a developmental progression in which the complexity of the texture is gradually increased plays a role in infants' food preferences. These were assessed using a between groups design with three treatment groups and two choice tests. (See Figure 2). For each choice test, three different categories of behaviors were used as dependent measures: *Texture Preference*, *Food Acceptance*, and *Number of Chewing Cycles*.

Subjects

Participants were twelve full-term infants between four and eight months ($M = 6.3$ months, $SD = 2.5$) who were just starting on solid food. The sample was selected from the same population of infants described for Study 1. Subjects were from nuclear dual career families of middle to upper-middle socioeconomic status ($M = 1.6$ on the Hollingshead two-factor index) and varying ethnicity (45% Caucasian, 27% Hispanic, 18% Asian/Indian, 10% Black). Procedures were similar to those de-

7 Mos.	*7–1/2*	*8*	*8–1/2*	*9*
GROUP 1 (n = 4):				
PUREED	LUMPY	CHOICE TEST	DICED	CHOICE TEST
GROUP 2 (n = 4):				
LUMPY	LUMPY	CHOICE TEST	DICED	CHOICE TEST
GROUP 3 (n = 4):				
PUREED	PUREED	CHOICE TEST	DICED	CHOICE TEST

Figure 2. Design for Study Group 2.

scribed in Study 1. Parents were requested not to feed their infants applesauce during the course of the study. For the study, the infants were fed only apple products specifically prepared by Gerber with textures: (a) Pureed; (b) Lumpy; and Diced.

Procedure

Infants were assigned to one of three controlled feeding groups. The infants started participating in the study as soon as they were ready to begin eating solid foods. One group of infants ($n = 4$) was exposed to ten spoonfuls of the pureed texture for ten days followed by ten days of exposure to lumpy (See Figure 2). A second group ($n = 4$) was exposed only to the lumpy texture across the twenty days. A third group was exposed to only the pureed texture across the twenty days ($n = 4$). To determine whether infants demonstrated a novelty preference and/or showed a preference for a more complex texture, all three groups of infants received a choice test, in which three spoonfuls of both the pureed and lumpy textures were presented on day 21 (presentation order, A = pureed, B = lumpy: AAA, BBB, AAA, BBB) and day 22 (BBB, AAA, BBB, AAA). Infants in group one, who were exposed to both textures, were expected to prefer the lumpy texture because they had experienced a developmental progression from a less complex to a more complex texture. This experience was expected to make these infants more accepting of complex textures compared to the other two groups. However, since they were most recently familiarized to the lumpy texture, as opposed to the pureed, they might show instead a novelty preference for the pureed texture. Infants in group two who were exposed only to the lumpy texture were expected to show a novelty preference for the pureed texture. Infants in group three who were exposed to only the pureed texture were expected to prefer the novel lumpy texture.

Following the completion of the first choice test, all three groups of infants were exposed for ten days to the diced texture. A second choice test was then presented, in which three spoonfuls of each of the three textures were presented on day 33 (presentation order, A = pureed, B = lumpy and C = diced: AAA, BBB, CCC) and 34 (BBB, CCC, AAA). Because all three groups of infants had been familiarized to the diced texture, a strong novelty preference for the diced texture was not

expected for any of the three groups. However, if gradually increasing the level of complexity is important then group 1, which received a developmental progression in level of complexity, would be expected to show a stronger preference for diced.

Videotaping

The videotaping procedure was identical to that described in study 1.

Assessments

The assessments were the same as those described in Study 1 and were administered prior to the first session and included: Demographic and Background Questionnaire, Breast and Formula Feeding Practices, Anthropometry and four teacher-parent measures: (1) Baby Food Usage Questionnaire, (2) Food Preference Questionnaire, (3) Eating Behavior Checklist, and (4) Developmental Screener.

Measures

The dependent variables were the same as those described in Study 1.

RESULTS

Demographic and background data are presented in Table 4.

Separate MANOVAs followed by ANOVAs and posthoc *t*-tests were performed on the *texture preference* and *food acceptance* behaviors using group (pureed/lumpy, lumpy/lumpy and pureed/pureed) as the between groups effect for each choice test. An ANOVA was also performed on the *number of chewing cycles* followed by posthoc *t*-tests for each choice test.

For Choice Test 1 (pureed vs lumpy), significant interaction effects were found within the *texture preference* category for the following: (1) *positive head movements* for the pureed ($F(1, 10) = 9.30$, $p < .01$). Infants in Groups 1 (pureed/lumpy) and 2 (lumpy/lumpy) showed more positive head movements for the pureed texture than infants in Group 3 (pureed/pureed; $t(6) = 5.66$, $p < .001$ and $t(5) = 2.21$, $p < .05$, respectively), (2) *positive body movements* for pureed ($F(1, 10) = 7.79$, $p < .01$). Infants in Groups 1 (pureed/lumpy) and 2 (lumpy/lumpy) showed more positive body movements compared to infants in Group 3 (pureed/pureed; $t(6) = 3.25$, $p < .01$ and $t(5) = 2.66$, $p < .05$, respectively) and (3) *negative body movements* for pureed ($F(1, 10) = 4.86$, $p < .05$). Infants in Group 3 (pureed/pureed) showed more negative body movements than infants in Group 2 (lumpy/lumpy, $t(5) = -2.35$, $p < .05$) and Group 1 (lumpy/pureed, $t(6) = -2.22$, $p = < .05$) (See Table 5). No significant effects were found for the *food acceptance* or *number of chewing* cycles categories (See Table 5).

For Choice test 2, (pureed vs. lumpy vs. diced): within the *texture preference* category a significant interaction effect was found for *positive vocalizations* for the diced texture ($F(1, 9) = 2.70$, $p < .01$). Infants in Groups 1 (with the pureed/lumpy/diced experience) and 2 (lumpy/lumpy/diced) showed more positive vocalizations to the diced texture than infants in Group 3 (pureed/pureed/diced; $t(6) = 4.24$, $p < .005$

Table 4 Demographic and Background Data for Study 2 ($N = 12$)

	M
Child's Age (Months)	6.3 (1.7)
Hollingshead	1.6 (1.0)
Breast and Formula Feeding Practices	
Breast fed (%)	20
Formula fed (%)	40
Both (%)	40
Breast feeding (# months):	2.9 (2.1)
Anthropometry	
Length (cm)	62.8 (2.2)
Weight (lbs)	20.4 (1.7)
Head Circumference (cm)	43.3 (1.5)
Boby Food Usage	
Product usage (%)	
Gerber	80
Heinz	0
Beechnut	20
Homemade	0
Food Preference Questionnaire Range: 0 = does not like — 3 = likes a lot	
Veggies	0.3 (0.6)
Meats	0.0 (0.0)
Fruits	1.1 (0.7)
Milk	3.0 (0.0)
Water	2.0 (0.0)
Juice	0.2 (0.3)
Cereals	0.8 (0.8)
Salty	0.0 (0.0)
Sweet	2.7 (0.6)
Sour	0.0 (0.0)
Bitter	0.0 (0.0)
Eating Behavior Questionnaire Scale: 0 = never, 1 = rarely, 2 = often eats	
Texture Item	
Bread	0.0 (0.1)
Eggs	0.0 (0.0)
Cereals	0.2 (0.1)
Fruit	0.3 (0.2)
Vegetables	0.1 (0.1)
Developmental Screener	
Classification (%)	
Infant	100
Transition	0
Toddler	0

Note: *SDs* are in parentheses.

Table 5 Treatment Groups 1, 2 and 3: Mean Proportions for Food Texture Preference

	Choice Test I			*Choice Test II*		
	PUREED	*LUMPY*		*PUREED*	*LUMPY*	*DICED*
	M (SD) p	*M (SD) p*		*M (SD) p*	*M (SD) p*	*M (SD) p*
TEXTURE PREFERENCE						
Facial Expression						
Positive						
Group 1	.25 (.50) .40	.38 (.75) .57		.13 (.25) .45	.25 (.50) .80	.00 (.00) –
Group 2	.00 (.00)	.17 (.29)		.00 (.00)	.00 (.00)	.00 (.00)
Group 3	.63 (.63)	.75 (.87)		.50 (.71)	.25 (.50)	.00 (.00)
Negative						
Group 1	.38 (.25) .10	.50 (.41) .27		.63 (.95) .44	.50 (1.0) .75	.50 (.58) .75
Group 2	.17 (.29)	.17 (.29)		.50 (.71)	.25 (.35)	.50 (.71)
Group 3	.00 (.00)	.13 (.25)		.00 (.00)	.13 (.25)	.25 (.29)
Vocalizations						
Positive						
Group 1	.63 (.48) .25	.88 (.63) .99		.63 (.95) .98	1.00 (.82) .64	1.50 (.71) .01
Group 2	.50 (.87)	.83 (1.0)		.50 (.71)	1.25 (1.8)	1.50 (.71)
Group 3	1.25 (.50)	.88 (.75)		.63 (.95)	.50 (.71)	.00 (.00)
Negative						
Group 1	.13 (.25) .71	.13 (.25) .56		.38 (.75) .42	.50 (1.0) .53	.13 (.25) .53
Group 2	.00 (.00)	.17 (.29)		.75 (1.1)	.00 (.00)	.00 (.00)
Group 3	.13 (.25)	.00 (.00)		.00 (.00)	.00 (.00)	.00 (.00)
Head Movements						
Positive						
Group 1	1.88 (.25) .01	1.63 (.48) .34		1.75 (1.32) .90	2.00 (1.4) .90	2.00 (1.41) .97
Group 2	1.50 (.50)	1.00 (.50)		1.75 (1.77)	1.75 (1.8)	2.25 (1.06)
Group 3	.88 (.25)	1.00 (.82)		2.13 (.85)	2.25 (.96)	2.00 (1.08)
Negative						
Group 1	.13 (.25) .67	.25 (.29) .60		.75 (1.5) .65	.63 (1.25) .55	.50 (1.00) .94
Group 2	.17 (.29)	.50 (.87)		1.25 (1.8)	.75 (1.06)	.75 (1.06)
Group 3	.38 (.48)	.63 (.63)		.25 (.50)	.00 (.00)	.50 (.71)
Body Movements						
Positive						
Group 1	1.88 (.25) .01	1.75 (.29) .13		2.00 (1.1) .88	2.50 (.58) .81	2.25 (.96) .84
Group 2	1.83 (.29)	1.83 (.29)		1.75 (1.8)	2.00 (1.4)	2.50 (.71)
Group 3	.75 (.65)	1.00 (.82)		2.25 (.96)	2.25 (.96)	2.00 (1.1)
Negative						
Group 1	.13 (.25) .04	.25 (.29) .69		.75 (1.2) .74	.25 (.50) .25	.38 (.75) .97
Group 2	.00 (.00)	.50 (.87)		1.25 (1.8)	1.00 (1.4)	.50 (.71)
Group 3	.88 (.63)	.63 (.63)		.50 (.58)	.00 (.00)	.50 (.71)

Note. SDs are in parentheses.
Group 1: pureed/lumpy, choice test I, diced, choice test II.
Group 2: lumpy/lumpy, choice test I, diced, choice test II.
Group 3: pureed/pureed, choice test I, diced, choice test II.

Table 6 Treatment Groups 1, 2 and 3: Mean Proportions for Food Texture Preference

	Choice Test I			*Choice Test II*		
	PUREED	*LUMPY*		*PUREED*	*LUMPY*	*DICED*
	M (SD) p	*M (SD) p*		*M (SD) p*	*M (SD) p*	*M (SD) p*
FOOD ACCEPTANCE						
Eager						
Group 1	.75 (.87) .94	.75 (.96) .96		.63 (.75) .60	.50 (.71) .35	.38 (.75) .51
Group 2	.83 (1.04)	.67 (1.15)		1.25 (1.8)	1.50 (2.1)	1.50 (2.1)
Group 3	.63 (.48)	.88 (.85)		1.25 (.65)	1.63 (.85)	1.13 (1.1)
Neutral						
Group 1	1.25 (.87) .87	1.25 (.96) .98		2.00 (.71) .14	1.75 (1.3) .55	2.00 (1.2) .68
Group 2	1.00 (.87)	1.17 (1.0)		1.00 (.71)	1.00 (1.4)	1.50 (2.1)
Group 3	1.38 (.48)	1.13 (.85)		1.13 (.48)	.88 (.75)	1.25 (.50)
Refuse						
Group 1	.13 (.25) .89	.00 (.00) .59		.50 (.41) .19	.50 (.71) .31	.00 (.00) .53
Group 2	.17 (.29)	.17 (.29)		.50 (.71)	.00 (.00)	.00 (.00)
Group 3	.25 (.50)	.25 (.50)		.00 (.00)	.00 (.00)	.25 (.50)
Retract						
Group 1	.13 (.25) .71	.13 (.25) .71		.50 (1.0) .88	.38 (.75) .66	.38 (.75) .82
Group 2	.00 (.00)	.00 (.00)		.75 (1.1)	1.00 (1.4)	.50 (.71)
Group 3	.13 (.25)	.13 (.25)		.33 (.58)	.88 (.85)	.75 (.96)
Holding						
Group 1	.13 (.25) .89	.00 (.00) .36		.00 (.00) .53	.00 (.00) .53	.00 (.00) .53
Group 2	.17 (.29)	.67 (1.2)		.00 (.00)	.00 (.00)	.00 (.00)
Group 3	.25 (.50)	.13 (.25)		.13 (.25)	.13 (.25)	.13 (.25)
NUMBER OF CHEWS						
Group 1	6.50 (4.1) .82	7.88 (5.0) .43		7.01 (5.0) .52	6.44 (3.8) .45	6.75 (3.0) .14
Group 2	5.17 (2.2)	4.50 (1.2)		4.22 (1.2)	4.38 (.68)	5.57 (2.3)
Group 3	6.25 (1.5)	7.44 (2.3)		6.44 (.72)	6.86 (1.8)	9.93 (2.7)

Note: *SD*s are in parentheses.

and $t(4) = 4.90$, $p < .005$, respectively). No significant effects were found for the *food acceptance* or *number of chewing cycles* categories (See Table 6).

DISCUSSION

Previous researchers have demonstrated that newborns perceive and respond preferentially to different tastes and food odors. The present findings provide information regarding infants' and toddlers' ability to use textural properties to discriminate between and show preferences for different foods. Furthermore, their preferences appear to shift with age and experience or familiarity with the complexity of the texture.

The results of Study 1 demonstrate that the infants responded more negatively than the toddlers to more complex textures. Within the *texture preference* category, the infants showed more negative expressions and more negative head and body movements for the more complex textures, lumpy and diced. In contrast, the toddlers showed more positive head and body movements. Within the *food acceptance* category, the toddlers also displayed more eagerness (i.e., opening of the mouth before the spoon was offered) for lumpy. These findings suggest that there is a shift between infancy and toddlerhood toward a preference for greater texture complexity. Surprisingly, no differences were found between the infants and toddlers in the *number of chewing cycles*. Even though comparisons between these two groups on the Developmental Screener revealed differences in their motor skills, number of teeth, and feeding behaviors, the group's chewing cycles did not differ even on the more complex lumpy texture. The lumpy texture was apparently well within the feeding skill range for both the infants and toddlers. The infants' preference could be determined only by their facial expressions, body movements, and acceptance behaviors (eagerness at opening their mouths to an approaching spoon).

The second study was designed to determine whether experience with a particular texture was related to infants' texture preferences on a choice test. It is important to note that, because of the very small sample size for each subgroup, results of study 2 need to be interpreted with caution. However, following a lengthy familiarization phase, infants showed a novelty preference for a texture different from what they had experienced. Infants who had been exposed to only the lumpy texture (Group 2) for the twenty days preferred the novel pureed texture on choice test 1. Infants who had been exposed to only the pureed texture (Group 3), showed a preference for the novel lumpy texture on the first choice test. Finally, infants who had been first exposed to pureed followed by lumpy (Group 1), showed a preference for the earlier presented, but relatively more novel (at time of testing) pureed texture.

The results also suggest that experience with difficult-to-chew textures beginning early in life can facilitate a preference for a more complex texture at an earlier developmental period. Although all three groups were familiarized to diced during the final familiarization phase, infants in Groups 1 (pureed/lumpy/diced) and 2 (lumpy/lumpy/diced) who received more exposure to the complex textures compared to Group 3 (pureed/pureed/diced) showed more positive vocalizations for the diced texture on the second choice test.

Finally, the results also suggest that having experienced a progression in texture complexity plays a role in infants' food preferences. Infants in the groups who experienced more complex textures, Groups 1 (pureed/lumpy/diced) and 2 (lumpy/lumpy/diced), responded to the diced texture with more positive vocalizations compared to the infants who had experienced only the simplest texture, Group 3 (pureed/pureed/diced). This finding could reflect the fact that the infants in Group 3 were not exposed the lumpy texture (which was of intermediate complexity, between pureed and diced) prior to their exposure to the more complex diced texture. Infants in Group 3, then, experienced a more abrupt change in texture complexity compared to those infants in the other two groups. The more gradual

progression experienced by groups 1 and 2 may have enabled infants to accommodate more easily to the more complex diced texture. This finding is consistent with the Piagetian (1952) concept of assimilation and accommodation, a process by which children adapt to their environment by gradually modifying and reorganizing existing schemas to better fit new experiences.

In summary, infants and toddlers are capable of preferentially responding to food textures. Preferences appear to be related to both the children's developmental stage and to their prior experience with the textures.

The data from the two studies combined highlight the importance of texture variations within the child's feeding skill range. Given the infants'/toddlers' ability to manage the feeding texture (i.e., ability to chew the texture food) novelty appears to be a factor in the infants'/toddlers' texture preference. Variations in flavor would certainly interact with variations in texture to sustain the child's interest. Although further research is needed to assess these complex texture preferences and texture/flavor interactions in a larger sample, the results of the present study are highly suggestive because of the power of the design and its built in controls and the consistency of the results from the cross-sectional and longitudinal studies.

Research in this area can add to our knowledge base on early perceptual and discriminatory abilities. Furthermore, in the more applied area, it will be useful in developing dietary guidelines, which should include a variety of food textures, during infancy and toddlerhood. Finally, the results offer the suggestion that caregivers need to offer variety and novelty in their food choices to infants and toddlers to enhance the child's enjoyment and the caregiver-child relationship in the feeding context.

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