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Providing Information about a Flavor to Preschoolers: Effects on Liking and Memory for Having Tasted It

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Abstract

This study sought to determine if providing affectively positive information about a flavor to preschool-aged children during tasting will increase recognition of and liking for the flavor and if the recognition and liking are associated. Forty-six 3- to 6-year-old children tasted 10 flavors: 5 presented with affectively positive information and 5 without. The 10 flavors were then presented again interspersed with 10 distracter flavors. Children reported whether they had tasted the flavor previously and provided hedonic ratings for each flavor. Children's ability to remember having tasted a flavor was greater when the flavor was presented with affectively positive information than without in children throughout the age range of 3–6 years. In children younger than 4.5 years, the provision of information had no effect on hedonic rating, whereas in older children, the provision of information was associated with greater hedonic ratings. We conclude that providing affectively positive information to children about a flavor can increase their ability to recognize the flavor as previously tasted and increases hedonic rating of the flavor in children older than 4.5 years.

Key words: child development, food preferences, memory

Introduction

Greater dietary variety, particularly with regard to whole grains, fruits, and vegetables, is a main focus of federal dietary guidelines (Johnson and Kennedy 2000). "Picky eating" is a common parental concern (Reau et al. 1996; Galloway et al. 2003; Carruth et al. 2004) and perhaps with good reason: Dietary variety in early childhood seems to predict dietary variety into later childhood and adulthood (Skinner et al. 2002; Nicklaus et al. 2005). Increasing the variety of foods that preschool-aged children will eat has therefore been the focus of a number of broadly based nutrition education programs (Knai et al. 2006).

Food preference formation begins very early; exposure to flavors in the mother's diet both prenatally and via breast milk impacts future flavor preferences (Mennella et al. 2001) and exposure to different formula flavors in infancy impacts sour and bitter preference in later childhood (Mennella and Beauchamp 2002). There may also be innate differences in bitter taste perception that impact children's vegetable consumption (Keller et al. 2002; Bell and Tepper 2006). Beyond these biological predispositions and generally inadvertent environmental exposures, there are few methods by which caregivers report consciously attempting to increase a child's preference for target foods (Casey and Rozin 1989; Hendy and Raudenbush 2000). These essentially include variations on repeated exposure (Birch and Marlin 1982; Birch et al. 1987; Wardle et al. 2003; Liem and deGraaf 2004), modeling (Duncker 1938; Harper and Sanders 1975; Birch 1980; Hendy and Raudenbush 2000; Addessi et al. 2005), reward (Birch et al. 1980; Hendy et al. 2005), pairing liked with disliked flavors (Pilner and Stallberg-White 2000; Havermans and Jansen 2007), and structured teaching. Implementing most of these methods is relatively straightforward. Serving food to children repeatedly and requiring that they sample a bite each time accomplishes repeated exposure. Having adults, peers, or admired figures eat a target food in front of the child accomplishes modeling. Providing a child a food with positive social attention serves to increase liking, and adding a sweet sauce (e.g., ketchup) pairs flavors effectively. It is less clear, however, how to most effectively implement structured teaching about food to shape children's food preferences.

Structured teaching about food occurs through schools, by parents and caregivers, and via television. Television commercials effectively shape children's food preferences (typically by increasing liking for unhealthy foods) (Borzekowski and Robinson 2001). Exactly how caregiver teaching about food operates on a child's preference for a food or flavor has not, to our knowledge, been investigated.

There are 2 potential mechanisms by which the pairing of affectively positive information with a flavor may lead to increased liking for it. The first is simple classical conditioning, a potential contributor to the development of food likes and dislikes, which has been reviewed in detail elsewhere (Rozin and Zellner 1985). The second is that providing children information about a flavor allows it to be more ''easily processed,'' making it seem more familiar and thereby increasing liking for it. Repeated exposure leads to increased liking for food (Birch and Marlin 1982; Birch et al. 1987; Liem and deGraaf 2004), though it is less well understood if the increased liking that results from repeated exposure is facilitated by enhancing memory for having tasted the food. As was first posited by Craik and Lockhart (Craik and Lockhart 1972), processing information at a deeper level seems to allow enhanced memory for the information compared with when it is processed at a ''superficial'' or ''sensory'' level alone. As reviewed in their seminal paper (Craik and Lockhart 1972), stimuli are thought to be processed rapidly at a number of different levels. The preliminary stages involve the analysis of angles, brightness, pitch, and, we propose in the present case, taste. Later stages of stimulus processing seek to ''match the stimulus against stored abstractions from past learning'' and are referred to as occurring at a greater ''depth of processing'' (Craik and Lockhart 1972). Deeper processing, which equates to easier processing, is theorized to lead to a greater sense of familiarity and, as a result, greater liking.

When pairing a flavor with affectively positive information, increased liking could therefore be a result of either 1) classical conditioning or 2) facilitation of development of memory (and thereby sense of familiarity and liking) through increased ease of processing. If the pairing of the flavor with affectively positive information is linked to increased liking, but not increased memory, we would propose that this suggests that the mechanism is primarily classical conditioning. If the pairing of the flavor with affectively positive information is linked with both increased liking and increased memory and the increased liking is accounted for by the increased memory, we would propose that this suggests that the mechanism of effect is primarily ease of processing.

The primary aims of this study were therefore to determine 1) if teaching children affectively positive information about a food will lead to increased liking for the food, 2) if teaching children affectively positive information about a food will lead to increased memory for having tasted the food, and 3) if the hypothesized effects of teaching on liking and memory operate independently or are interrelated. Our primary hypotheses were that preschool-aged children would express 1) greater liking for and 2) greater recognition of foods presented in association with affectively positive information. We further hypothesized that increased memory for a stimulus would lead to increased liking for it and that memory and liking would be associated with one another. Support for this hypothesis would suggest that part of the effect of pairing a flavor with affectively positive information on increased liking for the flavor is accounted for by greater memory for the flavor, as opposed to classical conditioning alone.

To address these questions, we presented forty-six 3- to 6-year-old children with 20 flavors and tested their memory and liking for flavors presented with teaching of information versus without teaching of information.

Methods

Participants

Forty-six 3- to 6-year-old children were recruited at Head Start (a federally funded preschool program serving primarily low-income children) in Jackson, MI. Exclusion criteria included a language other than English spoken at home, a history of allergy or adverse reaction to a food, a medical problem affecting appetite or eating, and/or a language delay reported by the parent. Mean age was 4.5 ± standard deviation (SD) 0.7 years, range 3.13–5.64 years. The sample was 59% male, 54% white and 35% black. This study was approved by the University of Michigan Medical School Institutional Review Board, and parental written informed consent was obtained.

Stimuli

Jelly beans (Jelly Belly) were chosen as the vehicle for flavor delivery, as has been done in prior studies in this age range (Lumeng et al. 2005), to overcome some of the natural resistance to sampling new foods that occurs in preschool-aged children (Cooke et al. 2003). Jelly beans also provide a large number of standardized and reproducible flavors without variation in texture or other sensory characteristics that cannot be masked. All children in this sample were familiar with jelly beans and had eaten them at least once before. Twenty different flavors were used as stimuli: apricot, banana, berry blue, caramel corn, chocolate, coffee, cream soda, Dr Pepper, grape, honey graham cracker, kiwi, lemon, melon, piña colada, pink grapefruit, plum, raspberry, root beer, strawberry cheesecake, and watermelon. Children tasted one-quarter of each jelly bean. The 20 jelly bean flavors were randomly assigned at the beginning of the protocol individually for each child to be either ''test flavors'' or ''distracter flavors,'' as will be described below. Thus, no flavor was consistently presented under a particular condition for the group. All flavors were presented to children while their eyes were closed, thus preventing any visual recognition, as will be detailed below.

We asked 26 parents recruited from the same population, but not participating in the present study, to rate their child's familiarity with the 20 flavors on a scale from 1 to 5, with 1 indicating ''not familiar'' and 5 indicating ''very familiar.'' Familiarity ratings reflected familiarity with the flavor itself, in any form, and not specific to jelly beans. Overall mean familiarity rating was 3.04 ± SD 1.50, range 1–5. There were significant differences in parental familiarity rating by flavor (F (19, 508) = 32.3, $P < 0.0001$). Flavors were ranked by familiarity rating into quartiles. Mean familiarity ratings were 1.88 ± SD 1.17 in Quartile 1 (least familiar), 2.48 ± 1.24 in Quartile 2, 3.17 ± 1.31 in Quartile 3, and 4.40 ± .89 in Quartile 4 (most familiar). The familiarity quartiles are provided for each flavor in Table 1.

Procedure

Children participated in the protocol during regular class time at their preschool between the hours of 0800 and 1500. Each child was taken to a quiet area outside the classroom. Children in the preschool were provided food either as a meal or snack by the preschool about every 1.5 h, per regulations. Testing took place during these intervals. Each session lasted under 10 min. On the first day, children were told that they would be participating in a game, which was explained, and assent was obtained.

To accommodate the young children's limited attention spans, testing was divided into 4 sessions over 4 days. Given that there were 10 ''test'' flavors to which the children would be exposed (as will be detailed below), flavor presentations could not be evenly divided between the 4 days. As a result, flavors were presented as follows (conditions of exposure will be described in detail below): Day 1 (2 flavors in Condition 1), Day 2 (2 flavors in Condition 2), Day 3 (3 flavors in Condition 1), and Day 4 (3 flavors in Condition 2). The rationale for this division was 2-fold. First, there were fewer flavor presentations on Days 1 and 2 because these days also included other tasks, as will be detailed below. Secondly, each condition had its 5 flavors presented once among 2 flavors and once among 3 flavors. Therefore, any effect of the number of flavors presented simultaneously was equal across groups and therefore not a confounder of condition of exposure.

Table 1 Characteristics of flavors overall and in younger and older children for select variables

Flavor	Familiarity quartile	Hit rate	False alarm rate	*Pr*			Hedonic rating		
				Total	Younger children	Older children	Total (mean (SD))	Younger children (mean (SE))	Older children (mean (SE))
Apricot	1	0.63	0.41	0.22	0.24	0.23	4.23 (1.31)	3.86 (0.28)	4.57 (0.27)
Banana	4	0.56	0.32	0.24	0.21	0.26	4.15 (1.22)	3.87 (0.25)	4.43 (0.25)
Berry blue	2	0.50	0.37	0.13	0.15	−0.01	4.39 (0.93)	4.17 (0.19)	4.61 (0.19)
Caramel corn	2	0.76	0.33	0.43	0.46	0.42	3.67 (1.60)	3.18 (0.33)	4.13 (0.32)
Chocolate	4	0.82	0.17	0.65	0.55	0.74	4.02 (1.18)	3.96 (0.25)	4.09 (0.25)
Coffee	2	0.63	0.37	0.26	0.21	0.35	3.17 (1.58)	2.74 (0.32)	3.61 (0.32)
Cream soda	1	0.50	0.52	−0.02	−0.08	0.06	3.76 (1.43)	3.52 (0.30)	4.00 (0.30)
Dr Pepper	2	0.63	0.44	0.19	0.62	−0.23	4.22 (1.15)	3.87 (0.23)	4.56 (0.23)
Grape	4	0.40	0.29	0.11	0.07	0.14	4.22 (1.18)	4.18 (0.25)	4.26 (0.25)
Graham cracker	4	0.74	0.59	0.15	−0.25	0.48	3.49 (1.47)	3.18 (0.31)	3.78 (0.30)
Kiwi	3	0.42	0.55	−0.13	−0.36	0.12	4.23 (1.20)	3.96 (0.25)	4.48 (0.25)
Lemon	3	0.55	0.38	0.17	0.17	0.13	4.21 (1.20)	4.13 (0.23)	4.43 (0.23)
Melon	3	0.58	0.18	0.40	0.52	0.30	4.15 (1.13)	3.65 (0.21)	4.65 (0.21)
Piña colada	1	0.57	0.27	0.30	0.27	0.30	4.02 (1.36)	3.82 (0.29)	4.22 (0.29)
Pink grapefruit	1	0.39	0.36	0.03	0.02	0.04	4.00 (1.35)	3.95 (0.29)	4.04 (0.28)
Plum	2	0.43	0.50	−0.07	−0.31	0.13	4.47 (0.78)	4.17 (0.15)	4.79 (0.15)
Raspberry	3	0.75	0.39	0.38	0.39	0.37	3.94 (1.39)	3.74 (0.29)	4.09 (0.29)
Root Beer	3	0.56	0.33	0.23	0.32	0.13	3.85 (1.46)	3.91 (0.31)	3.74 (0.31)
Strawberry cheesecake	1	0.55	0.42	0.13	−0.15	0.27	3.80 (1.44)	3.70 (0.30)	3.91 (0.30)
Watermelon	4	0.60	0.48	0.12	0.36	−.13	4.13 (1.27)	3.78 (0.23)	4.47 (0.23)

An introductory visual sequential memory exercise served as a familiarization with the game format and a screener for difficulty responding to simple verbal directions. All children successfully completed this task. We next familiarized each child with the experimental format by having children taste 2 sample flavors, cherry and orange, while a visual cue (e.g., picture of cherries) was simultaneously displayed. Children were immediately asked to sample the 2 flavors again, along with 2 new distracter flavors. Because the goal of the study was to test children's ability to differentiate previously tasted flavors from distracter flavors, children were coached through the question, ''Have you already tried that one today?'' All participants were successfully instructed on the accurate completion of this task.

After children were made comfortable with the format through the warm-up exercises, the tasks began. These consisted of flavor sampling, flavor recognition, and hedonic rating. The jelly beans were placed in each child's mouth when his or her eyes were closed during all phases of the study, to prevent any visual information from impacting performance.

Flavor-sampling task

Each child sampled flavors in 2 conditions: a ''teaching condition'' in which children were provided with affectively positive information about the flavor and a ''nonteaching condition'' in which children were simply presented with a jelly bean to taste with no discussion between the researcher and child about the flavor.

The teaching condition was designed to elicit the best possible performance from the children in terms of committing to memory the new information about each flavor. We therefore taught the children the affectively positive information about the flavor using several methods to enhance their learning. Specifically, we presented the new information via multiple sensory modalities: visual, taste, and auditory as information from one modality strengthens memory for information in another modality (Greene et al. 2001), and the presentation of information about a flavor via multiple modalities mirrors how information about flavors is learned in natural settings. Secondly, we presented the name of the flavor repeatedly because repeated presentation of information should strengthen learned associations (Rock 1957). Finally, pilot testing indicated that simply showing children a picture of the food represented by the flavor and teaching the child the word for the flavor did not engage the children's attention, and the children had a great deal of difficulty recalling the name of the flavor or the picture. In order to enable a deeper level of processing, we sought to link the flavors to a rich schema of information that the children already possessed. We therefore used cartoon characters that were easily recognized by the children, as anchors around which to base the teaching of new information about the flavor, thereby theoretically providing a deeper level of processing (Craik and Lockhart 1972; Bransford et al. 2000).

These teaching methods were specifically implemented in the following manner. The researcher placed the jelly bean in the child's mouth while the child's eyes were closed to prevent any visual information from impacting performance. Once the jelly bean was in the child's mouth and while the child was tasting it the child was asked to open his or her eyes. The researcher then displayed a picture of one of five familiar cartoon characters, which was randomly assigned for each flavor. As the child tasted the flavor, the researcher verbally presented the following scripted dialogue about the flavor and the character's preference for that flavor: ''That is a [grape] jelly bean. Does it taste like [grape]? [Grape] is [Winnie the Pooh]'s favorite flavor of jelly bean ⋯'' The script remained constant for all flavors in the teaching condition, with variation only in the name of the flavor and character. The name of each flavor was repeated 8 times within the script, and children were asked to repeat the name of each flavor once.

Each child sampled 10 ''test'' flavors, 5 randomly assigned to the teaching condition and 5 to the nonteaching condition. Jelly beans were placed in the child's mouth while the child's eyes were closed, thus preventing the child from obtaining any visual information, in all presentations in both conditions. In both the teaching and the nonteaching conditions, children were instructed to try to remember what each flavor tasted like because they would be asked later if they had tried it. The length of time children were given to taste each jelly bean was held constant between the teaching and nonteaching conditions (1 min per jelly bean) to control for the possible effect of different lengths of exposure on liking. The 10 flavors were presented over 4 days, with the teaching condition on 2 days and the nonteaching condition on the other 2 days, as detailed above. Both order of presentation of conditions (teaching or nonteaching) and order of presentation of individual jelly beans within a condition were randomized, with the restriction that the conditions alternate days.

Flavor recognition task

The flavor recognition task began after a retention interval of 4 min. The 10 ''test'' flavors from the flavor-sampling task were presented again but randomly dispersed among an additional 10 new ''distracter'' flavors. An equal number of test flavors and distracter flavors were presented on each day, with the 20 total flavor presentations divided over 4 days. Specifically, on Days 1 and 2 (outlined above), the 2 test flavors on each day were then presented along with 2 distracter flavors for a total of 4 flavors. On Days 3 and 4, the 3 test flavors on each day were then presented along with 3 distracter flavors for a total of 6 flavors.

The presentation of flavors during this phase did not occur in conjunction with any teaching (i.e., no script or pictures involving cartoon characters were presented). The flavors were again placed in children's mouths while their eyes were closed to prevent them from obtaining any visual information about the flavor. After tasting each jelly bean, children were asked to report if the flavor was one they had already tried that day, to which they responded "yes" or "no." Responses were recorded on paper and coded in the following manner. A "hit" occurred when a flavor was correctly identified as previously presented. The hit rate was therefore the number of hits obtained divided by the potential number of hits (10), producing a proportion between 0 and 1. A "false alarm" occurred when a flavor was incorrectly identified as previously presented. The potential number of false alarms in this study was 10 (represented by the 10 distracter flavors). The false alarm rate therefore also had a range of 0–1. Accuracy of flavor recognition was reflected in *Pr*, which is the difference between the hit rate and the false alarm rate and is based on signal detection theory (Snodgrass and Corwin 1988). Perfect recognition is reflected in a *Pr* of 1.0 (a hit rate of 1.0 and a false alarm rate of 0.0), performance at random results in a *Pr* of 0.0 (a hit rate equal to the false alarm rate), and the worst possible performance would result in a *Pr* of −1.0 (a hit rate of 0.0 and a false alarm rate of 1.0).

Pr may be calculated for either individual children who have been presented with both test stimuli and distracter stimuli (therefore providing both hits and false alarms with which to calculate *Pr*) or for individual flavors that have been presented to multiple children as both test stimuli and distracter stimuli. Both methods of calculation are used in this study. Recognition of an individual flavor by an individual child can be indexed only by examining the hit rate or false alarm rate (depending on whether the flavor was a test stimulus [previously presented] or distracter stimulus [not previously presented]).

Hedonic rating task

Immediately after children reported recognition for a flavor, they were asked to rate their preference for the flavor using a 5-face scale (faces ranging from sad/disgust to happy/pleasure). This rating occurred without the children having ever seen the jelly bean, and therefore, no visual information would have contributed to hedonic rating. This rating also occurred without any repeat presentation of the cartoon character stimuli. As reviewed elsewhere, the use of a 5-face rating scale to provide ratings of food preferences has been well validated in children as young as 4 years (Guinard 2000). The faces were first verbally described to the children as "really yucky," "kind of yucky," "ok," "kind of yummy," and "really yummy." Prior to assessing flavor preferences, children were asked, "Which face would you point to if I gave you something that tasted really yummy?" The question was repeated for the term "really yucky." All 46 children answered these screening questions correctly, and all therefore participated in hedonic ratings of the flavors. One child refused to provide a hedonic rating for 6 of the 20 flavors, and one other child refused to provide a hedonic rating for 1 of the 20 flavors. Thus, of the potential 920 hedonic ratings (20 ratings for each of 46 subjects), 7 were missing for a final sample of 913. Responses were recorded with paper and pencil.

The validity of using of a 5-face hedonic rating scale in children younger than 48 months has been called into question by a single prior study, which demonstrated that children younger than 48 months were more reliably able to use a 3-face scale (Chen and Resurreccion 1996). Of our 46 subjects, 11 were younger than 4 years. To determine whether the younger children may have been more likely to use the extreme ends of the scale as opposed to the "yucky (2)" and "yummy (4)" ratings, we therefore tested the distribution of the older and younger children's use of the scale in analyses to be described below.

Statistical analysis

All statistical analyses were performed using SAS 9.1 (SAS Institute Inc., Cary, NC). Univariate statistics were employed to describe the sample. Given the rapid development of the cognitive skills and taste preferences tested in these experiments during this age range, we tested the interaction of age with each predictor in each of the models to be described a priori. Consistent with our hypothesis, the relationships between our predictors and outcomes frequently differed significantly based on age. We therefore dichotomized age at the median (4.55 years) and stratified all analyses by age group (younger age group, 3.00–4.55 years, vs. older age group, 4.55–6.00 years).

Mixed models accounting for repeated measures within subjects were used to test if hit rate, false alarm rate, *Pr*, or hedonic ratings differed by familiarity quartile, as well as to determine if *Pr* differed in the teaching versus nonteaching conditions. Hedonic ratings were available for both the test stimuli and the distracter stimuli (to which by definition there had been no prior exposure). Therefore, for hedonic ratings, 3 exposure conditions were considered: 1) no prior exposure, 2) tasted with teaching, and 3) tasted without teaching. Mixed models were used to test if hedonic rating differed by exposure condition. Mixed models accounting for repeated measures within subjects were also used to test whether the relationship between *Pr* and hedonic rating differed based on condition or the child's age, as well as whether hedonic rating differed based on whether the child achieved a "hit" or a "false alarm." Two-tailed *P* values are reported.

Results

Data regarding familiarity, memory, and liking for the individual flavors are provided in Table 1. Overall mean *Pr* was 0.18 ± SD 0.29 and overall mean hedonic rating was 4.00 ± 0.75. We found no difference in the likelihood of obtaining a hit ($F(3, 410) = 0.79$, $P = 0.50$) or a false alarm ($F(3, 402) = 0.05$, $P = 0.98$) by familiarity quartile. Neither hedonic rating ($F(3, 864) = 0.47$, $P = 0.71$) nor *Pr* ($F(3, 16) = 0.35$, $P = 0.79$) for a flavor differed by familiarity quartile.

The distribution of hedonic ratings for children overall, as well as in younger children versus older children, is presented in Table 2. Older children were more likely to give the flavors higher hedonic ratings overall than the younger children (χ^2 (4) = 51.5, $P < 0.001$). Children's use of hedonic ratings of "2" or "4" differed by age but not in the expected direction: 29.0% of the ratings of younger children were "2's" or "4's" compared with 21.3% of the ratings of older children (χ^2 (1) = 7.43, $P = 0.006$). Similarly, contrary to expectation, but affirming that the younger children used the full range of the 5-face scale. The older children were also more likely to select ratings at the extremes of "1" and "5" than the younger children: 52.5% of the ratings of the younger children were "1's" and "5's," whereas 71.3% of the ratings of the older children were (χ^2 (1) = 34.1, $P < 0.001$). In short, we did not find evidence to support the hypothesis that the younger children's use of the 5-point hedonic rating scale was restricted to use of the extremes.

There was a trend toward a positive association between the overall mean hedonic rating and *Pr* in individual subjects such that children who had a greater ability to recognize flavors as previously tasted also provided higher hedonic ratings to the flavors overall ($\beta = 0.10$, standard error [SE] = 0.05, $P = 0.07$). The relationship did not differ significantly in the younger ($\beta = 0.11$, SE = 0.09, $P = 0.19$) versus the older ($\beta = 0.08$, SE = 0.08, $P = 0.35$) children ($P = 0.75$) (Figure 1).

Children's ability to remember having tasted a flavor was significantly greater when the flavor was presented in the teaching condition as opposed to the nonteaching condition (Table 3) (F (1, 45) = 4.75, $P = 0.03$). The relationship between condition and *Pr* did not differ by age group, as evidenced by an interaction term of condition and age that did not reach statistical significance ($P = 0.31$).

There was no relationship between class of exposure (Table 3) and hedonic rating in the sample overall (F (2, 85) = 0.19, $P = 0.83$). The relationship between exposure condition and hedonic rating, however, differed significantly by age ($P = 0.0005$ for the interaction term). In the younger children, exposure condition was not associated with hedonic rating (F (2, 39) = 1.50, $P = 0.27$). In older children, hedonic rating varied significantly by exposure condition (F (2, 44) = 3.31, $P < 0.05$). Tukey's post hoc test demonstrated that the significant difference was between the teaching and nonteaching conditions ($P < 0.05$); children's ratings of flavors they had been exposed to in the teaching condition were significantly higher than their ratings of flavors they had been exposed to previously without teaching (4.4 ± 0.2 vs. 4.1 ± 0.2).

We next conducted a 3-way analysis of variance (age group × exposure condition [teaching vs. no teaching] × hedonic rating) to assess their effects on *Pr* for the 5 flavors in each condition which were presented in either the teaching or the nonteaching condition and then presented again to test recognition. We found older age, but not condition of exposure or hedonic rating, to be associated with *Pr* (Table 4). The interaction of condition of exposure and hedonic rating was not significant in these models ($P = 0.98$). Neither the interaction of age group and condition of exposure ($P = 0.52$) nor the interaction of age group and hedonic rating ($P = 0.78$) was significant.

The likelihood of obtaining a hit (correctly recognizing that the flavor had been previously presented) for a particular

Table 2 Distribution of hedonic ratings given by sample overall and by age (%) (*N* = 913 hedonic ratings)

	Total	Younger children (<4.55 years)	Older children (≥4.55 years)
1 (least preferred)	10.0	11.7	8.3
2	4.3	5.3	3.3
3	12.8	18.3	7.4
4	20.9	23.8	18.0
5 (most preferred)	52.0	40.8	63.0

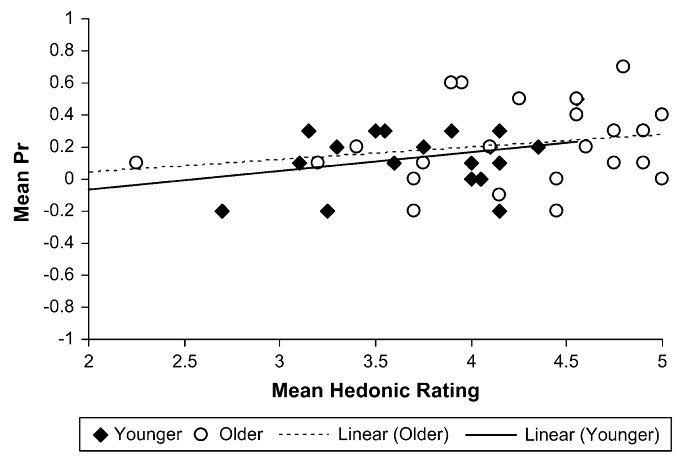

Figure 1 Mean hedonic rating and *Pr* (*N* = 46 subjects).

Table 3 *Pr* and hedonic rating by condition of exposure, in total sample and in younger and older children

	Total (N = 46)	Younger children (<4.55 years)	Older children (≥4.55 years)
Pr (mean (SE))			
Teaching condition	0.24 (0.04)	0.20 (0.06)	0.27 (0.06)
Nonteaching condition	0.13 (0.04)	0.10 (0.06)	0.15 (0.06)
Hedonic rating (mean (SE))*			
Teaching condition	4.04 (0.11)	3.60 (0.14)[a]	4.42 (0.16)[a]
Nonteaching condition	3.98 (0.11)	3.85 (0.14)[a]	4.10 (0.16)[b,c]
No prior exposure	3.99 (0.11)	3.80 (0.14)[a]	4.17 (0.16)[a,c]

Different letters indicate that the values are statistically significantly different at the $P < 0.05$ level.

Table 4 Predictors of *Pr* for 5 flavors exposed in teaching condition versus 5 flavors in nonteaching condition for overall sample and by age group

	Total sample (N = 46)		Younger children (N = 23)		Older children (N =23)	
	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*
Age group (older vs. younger)	0.02 (0.06)	0.72	—	—	—	—
Hedonic rating	0.08 (0.04)	0.09	0.09 (0.06)	0.16	0.08 (0.06)	0.32
Exposure condition (teaching vs. none)	0.13 (0.06)	0.01	0.17 (0.08)	0.04	0.10 (0.09)	0.12
	F (3, 87)	0.02	*F* (2, 41)	0.08	*F* (2, 45)	0.13

flavor did not differ based on the child's hedonic rating for the flavor (F (1, 408) = 0.01, P = 0.90). Likewise, the likelihood of correctly rejecting a particular flavor (correctly indicating that a flavor had not been previously presented) did not vary based on the hedonic rating given for the flavor (F (1, 404) = 0.00, P = 0.99). The interaction terms for age group and hedonic rating were not significant in either model.

Discussion

The data supported our 2 primary hypotheses. First, we found that in preschool-aged children, the provision of affectively positive, semantically rich information during tasting was associated with a greater ability, a few minutes later, to accurately discriminate the flavor as having been tasted previously, in comparison to flavors that were tasted without the provision of information. The children were provided the information on a single occasion and were later able to recognize these flavors by taste alone (not in conjunction with a repeat verbal presentation of the information) more than flavors presented previously without information. We propose that this suggests that "taste memory" can be promoted by information presented through other sensory channels, akin to findings by others that memory for stimuli can traverse sensory modalities (Greene et al. 2001). Secondly, the provision of affectively positive information while tasting resulted in greater hedonic ratings of the flavors compared with flavors for which no information had been provided, when children were queried a few minutes after tasting. This positive effect of the provision of affectively positive information on liking was present only in children who were older than 4.5 years and not in the younger children.

The data did not, however, support our hypothesis that recognition and hedonic rating would be associated. Thus, children rated flavors that had been presented to them in a positive script several minutes earlier as more palatable than flavors presented previously without a positive script, even if the children could not accurately remember if they had tasted the flavor in the prior round. Of the 2 potential mechanisms that may account for the increased liking resulting from pairing a flavor with affectively positive information, the data would suggest that classical conditioning is the primary mechanism, as opposed to facilitating ease of processing (and thereby familiarity). There is, however, an alternative explanation. Recognition is based on both explicit and implicit memory processes. Recognition may occur when a stimulus evokes some specific experience (explicit memory) or when a stimulus gives rise only to feelings of familiarity (implicit memory). In most cases, both processes are invoked when an item is recognized (Rajaram 1996). Presumably, the more easily new information is processed, the more familiar it feels and the more a stimulus is liked (Seger 1994). Indeed, conceptual fluency has been demonstrated to be one mechanism through which advertising enhances liking for a product (Shapiro 1999; Lee and Labroo 2004). We propose that when children were provided information linked to an already existing conceptual framework while tasting, the information created conceptual fluency (Murphy et al. 2003), which led to a sensation of greater familiarity and therefore greater liking. Explicit and implicit memory are thought to be 2 separate processes, and one form of memory is frequently impacted without impacting the other. When our teaching impacted liking (presumably via implicit memory), it did not necessarily impact recognition performance (presumably through both implicit and explicit memory processes). In other words, although the stimulus may have seemed more familiar (implicit memory) and therefore was more liked, the implicit memory processes may not have been enough to elicit recognition.

In this explanatory model, a critical remaining question is why teaching appeared to impact liking only in older and not younger children whereas teaching improved recognition performance throughout the age range in this study. It is possible that, given the greater reluctance to sample new foods in younger children (Cashdan 1994), the amount of teaching about a flavor that is needed to overcome this neophobia and increase hedonic rating is greater in the younger compared with the older child. It is also possible that the younger children were not as familiar with the cartoon characters and therefore may have been less likely to easily develop conceptual fluency for the new flavor stimulus. Less conceptual fluency may equate with a lesser sense of familiarity and therefore a lower rating of liking.

The study has several limitations. Although the use of jelly beans as the flavor vehicle facilitated young children's participation, the sweet base of the jelly bean flavors also led to them all being relatively palatable. Ideally, future studies would elicit cooperation from young children using flavors without the sweet base of the stimuli in the present study and with a wider range of palatability. Secondly, the familiarity ratings of the flavors were obtained post hoc from parents of children from the same population but not from the parents of the children in the present study. We also did not have data regarding the volume of children's prior meal, and testing occurred at variable intervals following the most recent meal or snack.

Finally, it is important to note that although in the older children, teaching information in conjunction with tasting the flavor resulted in a higher hedonic rating compared with no prior exposure to the flavor at all, this effect did not reach statistical significance (P = 0.14). This observation may be a result of limited power in the present study. Alternatively, it is possible that the observation is real and implies that when a flavor is tasted a second time, teaching information about the flavor does not significantly impact liking compared with when the flavor is unfamiliar or new. However, when flavors are tasted repeatedly (as are most in typical life experience), the flavor tasted repeatedly in conjunction with teaching information about it will be liked more than that tasted without teaching. In short, the effect of teaching information about a flavor on liking may increase with repeated exposures. Additional work in this area with both a larger sample size as well as a larger number of repeat exposures than just the 2 tested here would help to sort out these possibilities.

Little is known regarding the most effective method of teaching preschool-aged children about food to change their consumption patterns. The present study suggests that simply associating a flavor with a familiar, affectively positive, and rich schema for the children results in greater recognition that the flavor has been tasted before and greater liking for the flavor in children older than about 4.5 years. As the teaching effect on memory and liking of foods becomes better understood, it could be more effectively employed as an intervention to increase children's acceptance of target foods. Future work is needed to address whether the increased liking for a flavor that occurs when it is paired with an affectively positive schema extends to the flavor presented in other foods. For example, it is unknown if a child's liking for ''fresh'' strawberries increases after a strawberry-flavored ''candy'' is presented in conjunction with an affectively positive schema. It is also unknown whether the strength of association decays over time or how long the effect on increased liking persists. In short, additional studies should address the stability and generalizability of the effect. It would also be of interest to determine if the simple provision of information to children, but without a positive affective valence, would have the same effect on liking as well as to determine the effect on liking and memory of attaching information with a negative affective valence to flavors.

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