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The Association between Flavor Labeling and Flavor Recall Ability in Children

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Abstract

This study sought to determine if the ability to label a flavor is associated with an improved ability to recall having tasted the flavor in preschool-aged children. A total of 120 3- to 6-year-old English-speaking children tasted and labeled 20 different flavors, blinded to color. Children's labels for the flavors were scored for consistency and accuracy. Recall for having tasted the flavor was tested. Both labeling ability and recall ability improved rapidly between the ages of 3 and 6 years in this cohort. Regression analysis indicated that independent of the child's age, consistent accurate labeling was positively associated with recall ability. Higher maternal education was an independent and marginal contributor to greater recall ability. The combination of consistent and accurate labeling, age, and maternal education accounted for 28% of the variance in flavor recall ability. Consistent but inaccurate labeling alone contributed little to the variance in flavor recall ability. We conclude from these findings that children's ability to recall having tasted a flavor develops rapidly during the preschool age range and that improved recall ability is associated with the ability to consistently and accurately label the flavor. We conclude that language mediates memory for flavors in young children.

Key words: child development, food preferences, language development, memory

Introduction

Early childhood has been proposed as a sensitive period for food preference formation (Cashdan, 1994) and the development of long-lasting eating habits (Birch and Fisher, 1998). New food preferences are induced more easily in younger children than in older children and adults (Peryam, 1963; Birch, 1979; Birch and Marlin, 1982), and dietary variety in the preschool years is the greatest predictor of dietary variety later in childhood (Pelchat and Pliner, 1986; Skinner *et al*., 2002a,b). Children prefer foods that are familiar to them due to repeated exposure by tasting (Birch and Marlin, 1982; Birch *et al*., 1987; Wardle *et al*., 2003). The mechanism that causes increased liking by repeated exposure, however, has not been identified (Zajonc, 1968).

Repeated exposure to a stimulus presumably leads to a memory for it. Memory is made up of both "familiarity" and "recall" (Tulvig, 1985; Gardiner and Parkin, 1990; Gloor, 1990). Familiarity occurs in the absence of recall when you recognize a passerby on the street but cannot place him. Until you recall his name or another identifier (you met him at a dinner last week), he remains just vaguely familiar. The inverse is also true. Recall occurs in the absence of familiarity when you are able to remember Latin terminology for an anatomy examination because it was studied and memorized, even though neither the name nor the anatomical part is familiar from prior experiences. Familiarity (even in the absence of active recall) (Zajonc, 1980) and recall (even in the absence of familiarity) each promote increased preference (Reber *et al*., 1998), at least for nonfood stimuli.

A growing body of research has attempted to determine the type of memory responsible for the increased preference that results from the mere exposure effect (Seamon *et al*., 1995). Implicit memory is defined as nonintentional, nonconscious retrieval of previously acquired information and is demonstrated by enhanced performance on tests that do not require conscious recollection of the past. The memory for the face of a stranger that cannot be identified by name, which we are terming "familiarity," is an example of implicit memory. Explicit memory, on the other hand, requires intentional, conscious recollection of the past (Cooper and Schacter, 1992). Thus, remembering the name of a stimulus or where it was encountered before requires explicit memory. To our knowledge, prior research on the type of memory underlying the mere exposure effect has never investigated food as a stimulus. For nonfood stimuli, a growing body of evidence suggests that the increased preference resulting from mere exposure is the result of implicit memory (familiarity) as opposed to explicit memory (recognition). The encoding to implicit memory is also thought to occur more efficiently via global encoding as opposed to via localized or episodic encoding (Schacter *et al*., 1990). For example, it is hypothesized that certain stimuli already have ''representations'' in the memory system and therefore can ''fast-map'' onto an already existing memory system for the stimulus. In contrast, other stimuli require attention to and memorization of their individual features, which is thought to be more of a function of localized encoding and explicit memory. Each type of memory benefits differently from repeated exposure. Implicit memory, which is thought to underlie the increasing preference resulting from mere exposure, does not increase after repeated exposures, presumably because the repeated exposures are unnecessary since the original stimulus fast-mapped onto an already existing memory system for the stimulus type. In contrast, explicit memory, such as that exhibited by improved recognition of a stimulus, does improve with repeated exposures (Schacter *et al*., 1991).

Research on children's food preferences has focused on familiarity (i.e., implicit memory) (Birch and Marlin, 1982; Birch *et al*., 1987) but not recall (i.e., explicit memory). Factors associated with increased recall for a food or flavor have not been evaluated. Increased recall should lead to more rapid development of a child's preference for a target food (and its flavor) and expansion of the preference to similar foods (Birch, 1981; Birch *et al*., 1998). Simply put, although requiring that a child try one bite of broccoli each night at dinner over a period of weeks may slowly increase preference via the familiarity induced by repeated exposure, promoting the child's ability to ''recall'' having tasted the food in a slightly different form in other settings may accelerate preference formation (and therefore achieve the goal of getting the child to eat the broccoli sooner). Identification of a method of promoting recall would provide a potential point for intervention to accelerate and expand preference formation for target foods in preschool-aged children. Given the present obesity epidemic, there is a critical need for effective methods to shape children's food preferences (Hedley *et al*., 2004).

Language is a powerful mediator of recall. Labeling a stimulus with a word is associated with increased recall for visual (Zelinsky and Murphy, 2000), olfactory (Lehrner *et al*., 1999), and auditory (Rogers, 2001) stimuli. Labeling presumably allows verbal encoding of a stimulus to memory. Children's earliest memories are believed to be limited by the child having the vocabulary word to encode the event to memory at its original occurrence (Bauer and Wewerka, 1995). Prior research on memory for odors has indicated that these stimuli are encoded both semantically (i.e., use of the word is necessary to commit the stimulus to memory) and perceptually (i.e., the sensory attributes of the stimulus alone also form a representation in memory) (Cain and Potts, 1996). In the present study, we focus on the role of semantic encoding of flavors to memory in children.

The primary aim of this study was therefore to determine if there is a positive association between the ability to label a flavor and the ability to recall having tasted it in a memory-testing paradigm in preschool-aged children. We targeted this age range because of the rapid development of both language and eating behavior during this time period. We hypothesized that the ability to label a flavor reflects verbal encoding of the flavor and would therefore be associated with an increased ability to recall having tasted it. The secondary aim of this study was to determine if socioeconomic status is associated with flavor labeling and recall ability. Because socioeconomic disadvantage is associated with reduced expressive and receptive language (Dollaghan *et al*., 1999), we hypothesized that children of lower socioeconomic status would have a lower ability to accurately label flavors and a lower recall ability when compared to children of higher socioeconomic status. To address these aims, we presented 120, 3- to 6-year-old children with 20 flavors and tested their ability to accurately label and thereafter accurately recall having tasted the flavors in the laboratory.

Materials and methods

One hundred and twenty 3- to 6-year-old children were recruited via flyers in communities of diverse socioeconomic status (Ann Arbor, Jackson, and Ypsilanti, MI). Exclusion criteria included a language in addition to, or other than, English spoken at home, a history of food allergy or adverse reaction, a medical problem affecting appetite or eating or a language delay reported by the parent. Written informed consent was obtained at the study center. This study was approved by the University of Michigan Medical School Institutional Review Board.

Mothers provided the child's birth date, gender, race/ethnicity (categorized as white or not white), and highest level of maternal education attained. Maternal education was selected as the index of socioeconomic status because it has the most potent effect on child development and behavior of any of the traditional components of social status measures (education, occupation, and income) (Bornstein *et al*., 2003; Gottfried *et al*., 2003). For this analysis, maternal education was dichotomized as ''less than a 4-year college degree'' versus ''4-year college degree or more.''

Flavor tasting protocol

Testing consisted of a flavor-labeling task and a flavor recall task. A total of 20 flavors were used, all of which were pilot tested with 14 adults to ensure that the adults could accurately identify all 20 flavors and differentiate them from one another. Jelly beans (Jelly Belly™) were chosen as the vehicle for flavor delivery to overcome some of the natural resistance to sampling new foods that occurs in this age range (Cooke *et al.*, 2003). Jelly beans also provide a large number of standardized and reproducible flavors easily recognizable to children, without variation in texture or other sensory characteristics that cannot be masked. Pilot testing was conducted with three children representative of the larger sample to ensure that children would sample all the jelly beans, could attend to the procedure, and could correctly name at least some of the presented flavors. Most children in this sample were familiar with jelly beans and had eaten them at least once before. The flavors were apple, blueberry, bubble gum, cherry, chocolate, cinnamon, coconut, coffee, grape, lemon, licorice, marshmallow, pear, peach, pineapple, popcorn, root beer, strawberry, vanilla and watermelon. Children tasted one-quarter of each jelly bean, which was adequate to elicit a flavor response in pilot testing. The test took ~35 min.

Although clinical judgment allowed us to reasonably predict which of the 20 flavors were familiar or unfamiliar to US children in this age group, to confirm our impressions we collected rating scales from 32 parents (6 of whom were parents of children included in the present study and 26 of whom were parents of children included in subsequent similar studies and recruited from the same population pool). It should be noted that the 20 flavors were selected for the present study on the premise that they were reasonably familiar to the children. Parents were asked 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." Overall mean familiarity rating was 3.68 ± 1.24 SD, range 1–5. There were significant differences in parental familiarity rating by flavor ($F = 15.4$, $P < 0.0001$). Flavors were ranked by familiarity rating into quartiles. Mean familiarity ratings were 2.91 ± 1.27 SD in Quartile 1 (least familiar), 3.51 ± 1.16 in Quartile 2, 3.85 ± 1.16 in Quartile 3, and 4.43 ± 0.80 in Quartile 4 (most familiar). The familiarity quartiles are provided for each flavor in Table 1.

Children sat at a child-sized table with the examiner and a second adult acting as a model. A cup of water was available throughout the session. Children were told that they would be participating in a game, which was explained, and assent was obtained. An introductory exercise served as a familiarization with the game format and a screener for difficulty responding to simple verbal directions. Two pictures, each of a different familiar cartoon character, were given to the child. Two additional pictures were then presented, one

Table 1 Characteristics of flavors

Flavor	Familiarity quartile	Hit rate	False alarm rate	Pr	Accuracy	Consistency	Total words
Apple	4	0.68	0.46	0.22	0.73	0.76	39
Blueberry	1	0.45	0.56	−0.11	0.72	0.54	47
Bubble gum	3	0.72	0.39	0.33	0.61	0.40	52
Cherry	3	0.51	0.65	−0.15	0.70	0.79	45
Chocolate	4	0.50	0.59	−0.09	0.55	0.57	44
Cinnamon	2	0.74	0.44	0.30	0.14	0.53	44
Coconut	1	0.46	0.54	−0.07	0.58	0.39	65
Coffee	1	0.69	0.35	0.35	0.60	0.65	52
Grape	3	0.44	0.57	−0.14	0.52	0.58	47
Lemon	2	0.58	0.55	0.03	0.55	0.42	46
Licorice	1	0.67	0.47	0.20	0.16	0.30	49
Marshmallow	2	0.61	0.50	0.11	0.72	0.73	46
Peach	2	0.46	0.52	−0.06	0.63	0.51	45
Pear	3	0.49	0.57	−0.07	0.21	0.74	45
Pineapple	3	0.46	0.54	−0.08	0.13	0.41	45
Popcorn	4	0.56	0.47	0.09	0.20	0.63	48
Root beer	1	0.67	0.44	0.23	0.54	0.84	42
Strawberry	4	0.51	0.46	0.05	0.63	0.95	44
Vanilla	2	0.54	0.57	−0.03	0.37	0.50	46
Watermelon	4	0.46	0.51	−0.05	0.62	0.77	56

matching a character in the first set and one not. The child was then queried as to whether each picture was a match for the pictures they had been given. The child's performance on the task was recorded as pass/fail.

Flavor-labeling task

Children were asked to close their eyes to blind them to color. Ten randomly selected flavors from the 20 listed above were then presented in succession in random order and children were asked to label each after sampling. Children unable to provide a label were prompted with a standard series of questions, beginning with, ''Does it taste good or bad?'' If the response was vague (e.g., ''fruit''), children were queried once for more detail (e.g., ''What kind of fruit?''). Responses were recorded. Children were instructed to try to remember what each flavor tasted like, since they would be asked later if they had tried it. Children's responses were recorded with paper and pencil. This task took ~10 min.

Flavor recall task

After a retention interval of 15 min, the 20 flavors (10 from the flavor-labeling task along with 10 new distracter flavors) were presented in the same fashion, in randomized order with children blinded to color. Children were first asked to recall if the flavor was one they had already tried that day, to which they responded ''yes'' or ''no.'' Children were then asked to again label the flavor using the same protocol as in the flavor-labeling task. Responses were recorded with paper and pencil.

Coding responses

Prior experience with a flavor would enable labeling the flavor with a vocabulary word the child has heard applied before (an ''accurate'' label). Children who cannot apply an accurate label may still assign the flavor a label, and therefore, even an ''inaccurate'' label applied consistently could still facilitate encoding to memory. An example of this in our data set is one child who consistently labeled the flavor ''coffee'' as ''bacon'' and was able to accurately recall it, presumably due to consistent verbal encoding as ''bacon.''

Consistency

Since the consistent application of a label may facilitate verbal encoding to memory, consistency of labeling was scored via methods in prior work (Rabin and Cain, 1984; Lehrner, 1993; Lehrner *et al*., 1999). Consensus scoring by five researchers blind to individual subjects' identity and performance scored individual response pairs (label applied at flavor-labeling task and label applied at flavor recall task). No association between the two labels (e.g., lemon–coffee) or the inability to generate a label at either or both tasks received 0 points. A close association between the two labels (e.g., lemon–orange) received 1 point. The same association between the two labels (e.g., lemon–lemon) received 2 points. Points were summed for each subject to provide a consistency score. The maximum score was therefore 20, minimum 0.

Accuracy

Accuracy of labeling was scored based on labels applied during the flavor recall task. Flavor-labeling accuracy was scored using the schema described by Cain for odors (Cain, 1979). Five researchers blind to individual subjects' identity and performance categorized generated flavor labels by consensus into three groups: a veridical label (the true name of the flavor, e.g., cherry for cherry); a near miss, i.e., names reasonably close to the veridical name (e.g., cherry for strawberry); and a far miss, i.e., names quite far from veridical labels (e.g., cherry for coffee). A veridical label received 2 points, a near miss received 1 point, and a far miss received 0 points. The maximum score for an individual subject was therefore 40, minimum 0.

Consistent and accurate labeling

Children also received a score for labels that were both consistent and accurate, as summary scores for either accuracy or consistency alone would not necessarily capture the consistent and accurate application of a label to an individual flavor. For example, without a score combining both accuracy and consistency, a child who labeled five flavors incorrectly but consistently and five flavors correctly but inconsistently would receive the same scores for consistency and accuracy as a child who labeled five flavors correctly and consistently and five flavors incorrectly and inconsistently. We felt that it was important to capture the difference between these types of performances. Therefore, a veridical label applied consistently in both tasks received 3 points. A near-miss label applied consistently (same association) in both tasks received 2 points. A veridical or near-miss label applied as only a close association received 1 point. All other answers received 0 points. Points were summed for each subject to provide an accurate and consistent labeling score. The maximum score was therefore 30, minimum 0.

Total number of words

The total number of ''different'' flavor labels applied during the recall task was summed. The maximum possible number of different labels was 20 if each flavor was labeled with a different word. Only labels that were clearly food or flavor related were counted towards the total.

Discrimination index (Pr)

Accuracy of flavor recall is reflected in the discrimination index (Pr), which is derived from hit rates and false alarm rates on the basis of signal detection theory (Snodgrass and Corwin, 1988). A hit occurs when a flavor is correctly identified as previously presented. The hit rate is therefore the number of hits obtained divided by the potential number of hits (10, in this study). The result is a proportion with a potential range therefore of 0–1. A hit rate of 0.5 indicates that the child correctly recognized half (5 out of 10) of the flavors as previously presented. A false alarm occurs when a flavor is incorrectly identified as previously presented. The potential number of false alarms in this study is 10 (represented by the 10 distracter flavors in the recall task), and the false alarm rate has a range of 0–1. Discrimination index (Pr) is the difference between the hit rate and the false alarm rate. By subtracting the false alarm rate from the hit rate, one is able to account for the child who reports that she recognizes all 20 flavors when she should recognize only 10. The child therefore has points subtracted for incorrectly reporting that she recognized the distracter flavors as being previously presented in the labeling task. The Pr thus provides an accurate reflection of the child's true recall ability. Perfect recall is therefore 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).

Statistical analysis

All statistical analyses were performed using SAS 8.2 (SAS Institute Inc., Cary, NC). Descriptive statistics included *t*-tests, analysis of variance, and chi-square test, as appropriate. Product–moment correlations between chronological age, consistency scores, flavor-labeling accuracy, total number of words, and Pr were calculated. Multiple linear regression models were used to evaluate the effect of each of three main effects: consistency scores, accuracy scores, and consistent and accurate labeling scores on Pr. Covariates tested for potential inclusion in the model included total number of words, chronological age, maternal education, race/ethnicity, and gender. Mallow's Cp criterion was used to identify the most parsimonious model with the best fit (Neter *et al*., 1996) for each of the three main effects of interest. Once each base model was identified, interactions and quadratic terms were tested. Two-tailed *P* values are reported.

Results

A total of 120 children participated in the study. Eight children did not complete the protocol because they were unable to either understand or attend to the procedure. They did not differ from the overall sample by gender, race/ethnicity, or maternal education, but they were significantly younger (3.9 ± 0.8 years vs. 5.0 ± 1.1 years, $P = 0.007$). The final sample was therefore composed of 112 children whose mean age was 5.0 ± 1.1 years, range 3.01–6.99 years. The sample was 55% male, 64% white, and 21% black. Seventeen percent of the mothers had a high school diploma or less, 28% had attended some college but had not graduated, 28% had a college degree, and 27% had attained education beyond a college degree.

Data regarding the individual flavors are provided in Table 1. We evaluated the effect of familiarity quartile on hit rate, false alarm rate, discrimination index, labeling accuracy, labeling consistency, and total number of different words applied. We found no difference in hit rate ($F = 1.61$, $P = 0.19$), false alarm rate ($F = 1.28$, $P = 0.28$), discrimination index ($F = 0.59$, $P = 0.63$), or total number of words applied ($F = 1.00$, $P = 0.42$) by familiarity quartile. The flavors most often accurately labeled (with a veridical label) were chocolate (42% of the children correctly labeled), coffee (31%), root beer (22%), and cinnamon (19%). We found that familiarity quartile was significantly associated with labeling accuracy ($F = 9.57$, $P < 0.0001$). Labeling accuracy scores averaged 0.42 ± 0.34 in Quartile 1 (least familiar), 0.43 ± 0.34 in Quartile 2, 0.57 ± 0.34 in Quartile 3, and 0.56 ± 0.34 in Quartile 4. The differences were significant between Quartile 1 and Quartiles 3 and 4, and between Quartile 2 and Quartiles 3 and 4. In summary, labeling accuracy was significantly greater among the flavors that were more "common" or familiar. There was also an overall effect of familiarity on labeling consistency ($F = 3.61$, $P = 0.01$), though it was not linear. Labeling consistency scores averaged 0.70 ± 0.05 in Quartile 1, 0.60 ± 0.05 in Quartile 2, 0.49 ± 0.05 in Quartile 3, and 0.66 ± 0.06 in Quartile 4. After Tukey's adjustment for multiple comparisons, the only significant difference was between Quartile 1 and Quartile 3 ($P = 0.01$), with a trend towards a difference between Quartile 3 and Quartile 4 ($P = 0.055$). In summary, there was the suggestion that the most unfamiliar flavors were most consistently labeled but that the most familiar flavors were more consistently labeled than slightly less familiar flavors.

The mean consistency score was 6.0 ± 3.8 out of a possible 20 total points, reflecting relatively inconsistent application of labels. The mean accurate labeling score was 9.8 ± 5.2 out of a possible 40 total points. The mean consistent accurate labeling score was low at 4.7 ± 3.7 and increased significantly with age such that the mean score more than doubled between age 3 (2.6 ± 3.1) and 6 years (7.4 ± 3.6) (Figure 1). About half (45.4%) of the children were unable to provide any label for at least 1 of the 30 flavor presentations (20 different flavors). Within this group, the number of flavors to which they were unable to apply a label was low (median = 3, mean 5.12 ± 4.95). This group of children did not differ based on race, age, gender, or maternal education from the children who applied a label to all 30 flavor presentations. The children applied an average of 8.0 ± 4.3 different labels (potential and actual range 0–20). Consistency scores, labeling accuracy scores, consistent accurate labeling scores, and total number of words were each significantly positively associated with age (Table 2).

The children's ability to recall having tasted the flavors (Pr) was also low at 0.13 ± 0.21, indicating that children performed better than chance by about one response. The child's age was significantly positively and linearly associated with Pr such that between ages 3 and 6 years the mean Pr

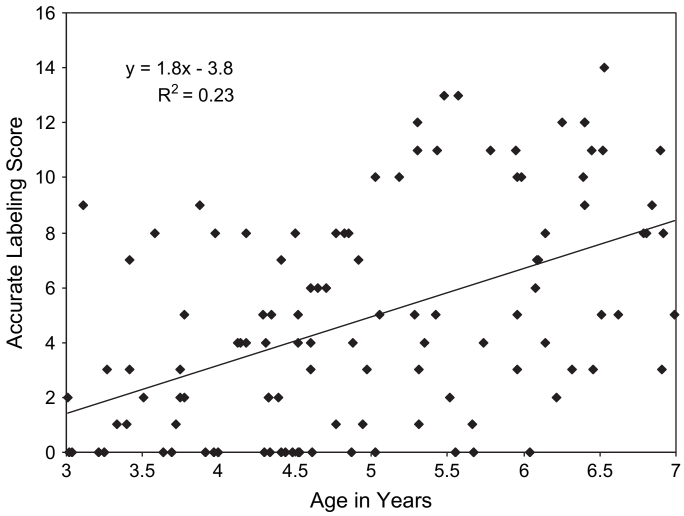

Figure 1 Age in years versus accurate labeling scores (n = 112).

Table 2 Correlations of language contributors to discrimination index (Pr) (n = 112)

		1	2	3	4	5	6
1	Age	—	0.41**	0.38**	0.47**	0.31*	0.41**
2	Flavor-labeling consistency		—	0.59**	0.78**[a]	0.20*	0.32**
3	Flavor-labeling accuracy			—	0.77**[a]	0.60**	0.32**
4	Consistent and accurate labeling				—	0.38**	0.46**
5	Total number of words					—	0.25*
6	Flavor recall						—

[a]High correlation not unexpected given that consistent and accurate labeling scores include both consistency and accuracy as components.
*P < 0.05; **P < 0.01.

increased from 0.02 ± 0.19 to 0.26 ± 0.26 (Figure 2). Thus, by age 6 years, children were performing better than random by nearly three responses.

There were no differences in labeling accuracy, labeling consistency, consistent accurate labeling, total number of words used, or discrimination index based on gender, race (white vs. nonwhite), or maternal education (college degree or more vs. less than a 4-year college degree). Regression analyses assessing the main effect of consistency of labeling on flavor recall indicated that age (partial R^2 = 0.16, P < 0.0001), maternal education (partial R^2 = 0.04, P = 0.03), and consistency (partial R^2 = 0.03, P = 0.04) each were significant contributors to flavor recall scores. The combination of age, maternal education, and consistent labeling thus accounted for 23% of the variance in recall scores, with only 3% of the variance accounted for by the child's ability to consistently label the flavors. Regression analyses assessing the main effect of accurate labeling on flavor recall (not taking into account the consistent use of accurate labels) indicated again that age (partial R^2 = 0.16, P < 0.0001) and maternal education (partial R^2 = 0.03, P = 0.05) were significant contributors to flavor recall scores, with accurate labeling also contributing significantly (partial R^2 = 0.03, P = 0.04). The combination of age, maternal education, and accurate labeling thus accounted for 22% of the variance of recall scores, with only 3% of the variance being accounted for by the child's ability to accurately label the flavors.

When both labeling consistency and labeling accuracy were included simultaneously in the model with maternal education and age predicting flavor recall scores, both labeling consistency and labeling accuracy became insignificant in the model (P = 0.19, P = 0.30, respectively), reflecting their colinearity. In unadjusted models, labeling consistency contributed 10.5% of the variance of flavor recall scores and labeling accuracy contributed 10.1% of the variance. All these findings reflect that children who consistently labeled were also accurately labeling (although not necessarily consistently applying accurate labels).

Regression analyses assessing the main effect of consistent accurate labeling on flavor recall (incorporating the consistency of accurate label use into the score) indicated that consistent accurate labeling (partial R^2 = 0.21, P < 0.0001) and age (partial R^2 = 0.05, P = 0.01) were each significant contributors to flavor recall scores. Maternal education (partial R^2 = 0.03, P = 0.054) contributed a small amount of additional variance. Thus, the combination of consistent accurate labeling, age, and maternal education accounted for 28% of the variance in flavor recall scores, most of which was from consistent accurate labeling. For each of these main effect models, interaction and quadratic terms for all included covariates were tested and none were significant.

Nine of the 112 children failed the introductory cartoon character exercise. This group performed significantly worse in consistently accurately labeling the flavors (1.6 ± 2.2 vs. 5.0 ± 3.9, P = 0.01) and had marginally worse Pr values (−0.005 ± 0.166 vs. 0.15 ± 0.221, P = 0.0498). Their ability to consistently apply a label, their ability to accurately apply a label (without necessarily consistency), and the total number of vocabulary words used did not differ. Children in this group were more likely to have mothers with lower education levels (P = 0.02), but did not differ significantly by age or gender. We repeated the analysis excluding these nine children, and results did not differ.

Discussion

We found in a diverse community sample of preschool-aged children that accurate and consistent labeling of a flavor is associated with an improved recall for having tasted the flavor in a memory-testing paradigm. The findings are

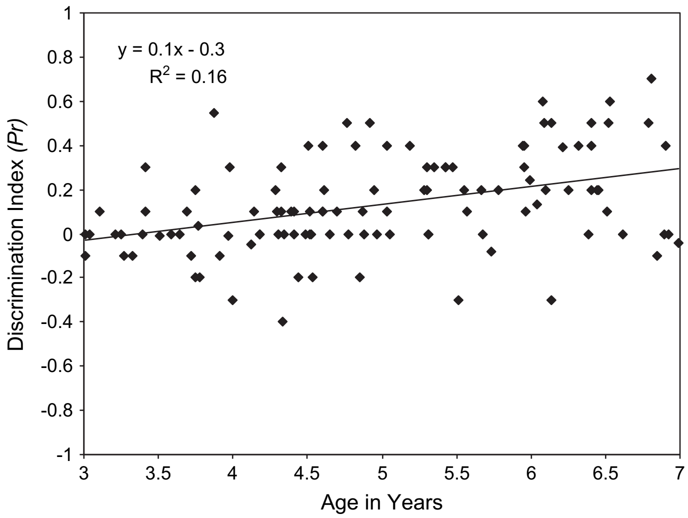

Figure 2 Age versus discrimination index (Pr) (n = 112).

congruent with prior research by others demonstrating the power of language in improving recall for a variety of stimuli (Bauer and Wewerka, 1995; Lehrner *et al.*, 1999; Zelinsky and Murphy, 2000; Rogers, 2001). To our knowledge, our study is the first to demonstrate an association between language and flavor recall in preschool-aged children.

Our results provide an interesting mirror image of the findings of others who have investigated the role of cognitive factors in the decline in odor-identification ability with age (Larsson *et al.*, 2004). Larrson *et al.* (2004) found that the well-documented age-related decline in odor-identification ability is only partially accounted for by declines in cognitive indices. Our study, in contrast, found that the age-related increase in flavor recall ability in early childhood is largely accounted for by semantic labeling ability. Cognitive factors appear to mediate memory for sensory stimuli at both ends of the life span, but to varying degrees.

Neither consistent (but inaccurate) labeling alone nor accurate (but inconsistent) labeling was sufficient in our sample to improve flavor recall significantly. An adult may attempt to label an unrecognizable flavor with several descriptors (e.g., ''sweet, slightly sour, and not citrus'') and thereby still verbally encode it to memory. The children in our sample either did not possess this vocabulary or could not easily apply it, with the result being consistent but vague and inaccurate labeling (or the inverse, accurate but inconsistent application of labels) and very limited flavor recall. These findings indicate that either prior experience with particular flavors or a flavor descriptor vocabulary accurately applied is necessary to promote verbal encoding and therefore flavor recall. Neither experience with food in general nor possession of a broad but nonspecific food-related vocabulary appears sufficient to promote recall because the total number of food vocabulary words voiced was not a significant contributor or a confounder of the relationship between labeling and recall.

Although the most common or familiar flavors (e.g., apple or chocolate) were among the most often accurately labeled, a number of flavors in the most uncommon or unfamiliar flavor quartile were among those most frequently given veridical labels (e.g., coffee and root beer). This finding is consistent with prior research indicating that the ability to accurately recall a stimulus is actually greater when it is less familiar (Estes and Maddox, 2002). For example, one is likely more able to recall what was eaten for dinner last night if it was something unusual as opposed to something eaten frequently. Similarly, it is not entirely surprising that children sometimes had high recall for flavors that were likely less familiar to them. This does not explain, however, the fact that recall was significantly associated with the ability to name the flavor. If a lack of familiarity or the unusual nature of the flavor alone was enabling recall, then accurately labeling the flavor would not have been a significant contributor to recalling whether or not the flavor had been tasted from the first task to the second. Rather, we propose that in order to recall having tasted a flavor (including the unusual or unfamiliar ones), children needed to be able to label the flavor with a vocabulary word, which they theoretically used to verbally encode the tasting in the first task to memory.

Familiarity and recall were separate processes in our sample of children. Familiarity was not associated with improved recall with the flavors used in our study. Because the processes were so independent, confirmation that increased recall leads to increased preference (independent of familiarity) in preschool-aged children with food becomes necessary. Although familiarity has been associated with increased preference for foods in preschoolers (Birch and Marlin, 1982; Birch *et al.*, 1987), the relationship between recall and preference has only been demonstrated with nonfood stimuli in different age groups (Reber *et al.*, 1998). Extension of this research to confirm that recall promotes preference for food in preschool-aged children is the necessary next step following these findings and awaits further study.

Our results also raise interesting questions about how young children may process food stimuli unrelated to semantic processing. For example, others (Jehl *et al.*, 1995) have found that with stimuli that are similar but unfamiliar (and therefore presumably not semantically encoded), familiarization in the form of repeated exposure does not change discrimination indices. Rather, repeated exposure to these novel and similar stimuli results not only in a reduced false alarm rate but also in an increased hit rate. In other words, the more familiar a subject became with a stimulus, the less likely he was to simply assume sameness; with two very similar stimuli, repeated exposure results in a greater ability to discriminate subtle differences, as opposed to assuming sameness. This may be important to understanding how repeated exposure increases preference in young children. Repeated exposure may allow children to expand the repertoire of foods in their diet by enabling them to better differentiate between various food stimuli and therefore develop more sophisticated methods of assessing preference. For example, if initially a child views all green foods as aversive (and undifferentiated), repeated exposure should serve to enable the child to appreciate subtle differences (i.e., between the flavors of green beans and peas), potentially allowing the child to develop a preference for some green vegetables but not others, as opposed to simply extending a dislike for one green vegetable to all foods in this group. How the ability to differentiate stimuli may play a role in the mere exposure effect, in addition to the potential role of language as a mediator of encoding, requires additional study.

Our findings also provide further evidence for the rapid development of children's cognitions around food during the preschool age range. Parents and adults often become frustrated when children reject a food because they view it as unfamiliar due to a minor change in its presentation (e.g., broccoli in a casserole as opposed to raw broccoli). Our findings indicate, however, that children's ability to recall and label flavors accurately in this age range is limited. The ability of children to recognize foods as familiar seems to evolve through childhood due to a number of cognitive factors, and this aspect of children's developmental status needs to be taken into consideration when trying to understand their eating behavior. Maternal education was, if anything, only a marginal contributor to children's ability to recall having tasted a flavor. Larger sample sizes are typically necessary to uncover differences in child development or eating behavior measures based on socioeconomic status. Our finding with this sample size therefore takes on added significance and requires investigation in future research.

Jehl *et al.* (1995) found that the more familiar two odors were, the better able a subject was to discriminate between two dissimilar odors. In contrast, familiarity had no effect on a subject's ability to recognize that two odors are the same (Jehl *et al.*, 1995). The findings of Jehl *et al.* are relevant to the current study to the extent that one would hypothesize that flavors parents rated as familiar would have a lower false alarm rate but no difference in hit rate in comparison to flavors parents rated as unfamiliar. However, there were no differences in hit rates or false alarm rates by parental familiarity ratings. Thus, unlike Jehl *et al.*, we did not find that familiarity with a flavor (at least, parental perception of children's familiarity with a flavor) altered the child's ability to recognize a flavor. In summary, although flavors that are more familiar to this population of children in the United States are more accurately labeled, labeling consistency is not related to familiarity in a linear fashion. Neither hit rate nor false alarm rate is affected by flavor familiarity. Our evaluation of the effect of familiarity on these parameters, however, is significantly limited by our measure of familiarity. Although the parental ratings of flavor familiarity among 3- to 6-year-old US children are consistent with our clinical experience, these familiarity data are not drawn specifically from the 112 children in the present study, and perhaps more importantly, they are not reported by the children themselves but by their parents. It is unknown if parental ratings of the children's familiarity would accurately reflect a child's own familiarity (a task which in our experience children of this age would be unable to accurately complete).

We did not have data regarding children's perceptions of the hedonic qualities of the flavors. All the flavors were selected on the premise that they would be palatable to preschool-aged children, and therefore, variability in palatability was not anticipated. Few children in the course of the study expressed extreme distaste for any of the flavors. Thus, the present study cannot comment on the potential role of affective response to a flavor in preschool-aged children's ability to recall having tasted the flavor, though clearly further work is needed in this area.

The study has several limitations. We did not evaluate flavor recall for vegetables, the primary target food for dietary change. We did not test vegetables in this study due to pilot work indicating extreme reluctance of children to assent to a protocol in which vegetable tasting was necessary. We theorize that the findings here would extrapolate to a variety of food groups, though this hypothesis requires testing. We also do not have information about the children's perceptions of variation in flavor intensity or flavor quality (i.e., how similar in quality or intensity are strawberry and cherry as opposed to strawberry and blueberry), which may have contributed to flavor recall scores (Jehl *et al.*, 1995). Although the use of jelly beans as the flavor vehicle enabled young children's participation, the sweet base of the jelly bean flavors also restricted the variability in the sensory experience of the individual flavors, which may have contributed to the children's limited recall abilities. Ideally, future studies would elicit cooperation from young children using flavors without the sweet base of the stimuli used in the present study. The present study also does not test whether "teaching" a child a correct label will improve recall. These questions require investigation in future research. This study also did not attempt to differentiate taste and olfaction; thus, our ability to link cognitive and demographic factors with purely either sensory modality was impeded. However, the two sensory modalities are not typically discrete entities in daily experience, and we therefore propose that the real-world applicability of this study is a strength.

Children develop rapidly in the preschool years in a variety of domains, but it has been increasingly recognized that this age range may be a critical period for the development of children's cognitions around food (Rozin, 1990; Macario, 1991; Nguyen and Murphy, 2003). Although language has classically been viewed as a window into children's understanding of the world around them, it is increasingly recognized that language may actually shape our understanding of that which we encounter (Rakison and Oakes, 2003). To this extent, the rapid development of children's language, understanding of food, and ability to apply language to food during the preschool age range may actually shape how they understand food and therefore behave with it.

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