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A longitudinal examination of the role of sensory exploratory behaviors in young children's acceptance of new foods

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Abstract

Objective: Prompted engagement with a new food's sensory properties (smell, texture) has been associated with young children's acceptance of new foods. However, little is known about the prevalence and stability of children's sensory exploratory behaviors exhibited spontaneously when trying new foods. The aim of this analysis was to examine developmental trajectories of sensory exploratory behaviors (i.e., smelling, licking, spitting) in response to new foods.

Method: This 3-year longitudinal study included observational data collected from 244 preschoolers. At age 4 years, children were asked to taste four novel foods. An experimenter recorded the child's displays of smelling, licking, spitting, refusals, and acceptance. Assessments were repeated at 4.5, 5.5, and 6.5 years of age. Summary scores were created for each child by totaling the number of foods smelled, licked, spit out, refused, and accepted at each time point. A series of growth models were fit to the summary scores to examine individual sensory behavior trajectories and associations between trajectories of sensory behaviors and acceptance.

Results: Linear growth model parameters indicated that licking, spitting, and refusals decreased over time (all p-values < 0.05), whereas acceptances increased ($p < 0.05$). Furthermore, decreases in licking, spitting, and refusals were associated with increases in acceptance across the study period (p-values < 0.05).

Discussion: The decline in young children's sensory exploratory behaviors in response to new foods was associated with increases in food acceptance. Our findings suggest that sensory exploratory behaviors promote familiarity and may help children learn that new foods are acceptable and safe to consume.

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Keywords

preschooler; eating behavior; longitudinal; exploratory behavior

Early childhood is characterized by the emergence of challenging eating behaviors, such as picky eating and food neophobia.[1] During this time, children often begin rejecting foods based on their sensory characteristics, such as texture or aroma [2] or their unfamiliarity, as is the case in food neophobia, or unwillingness to taste new foods.[3] Food neophobia is viewed as a typical aspect of child development [4] and is quite common, with an estimated 40 to 44% of young children displaying neophobic tendencies.[5, 6] Although it is speculated that wariness in response to new foods reaches a peak during early childhood [3], no longitudinal studies have presented findings following the trajectory of food neophobia in early childhood.[1] Furthermore, there is limited research on specific behaviors that may accompany children's neophobic tendencies, such as sensory exploratory behaviors like smelling, licking, and spitting out foods after tasting them.

Parents anecdotally report irritation with behaviors such as licking and spitting out foods, and even very young children know that these types of behaviors are unacceptable at the family table.[7] However, it is possible that these behaviors may facilitate acceptance of new foods over time. Rozin and colleagues[8] describe the concept of "learned safety," a process through which omnivores (e.g., rats) learn that a novel food is safe to consume after repeated tastes and consumption without deleterious physiologic consequences. Observations have demonstrated that young children may also use other behaviors, such as smelling, licking, and tasting then spitting out foods, to gather additional information about a new food before they consume it.[9] Prior research has demonstrated that these behaviors are exhibited by a small percentage of children (~12% depending on the behavior)[9, 10] when presented with a novel food, but the prevalence of these behaviors is thought to decline after repeated exposures to the new food over time.[9] However, there appear to be developmental differences in the prevalence of these behaviors, with preschoolers exhibiting these behaviors more commonly than toddlers.[11]

Results of intervention studies have provided some support for the role of sensory exploratory behaviors in food acceptance; children may be more likely to consume a novel food after they have been exposed to the new food's sensory properties, such as its appearance, texture, and/or aroma. For example, toddlers between the ages of 12 and 36 months were more likely to touch and taste unfamiliar foods after they had participated in a series of activities involving exposure to the sights, sounds, textures, and smells of the foods.[12] Similarly, preschool children who engaged in a sensory play task with fruits and vegetables (i.e., making a picture with the foods) tasted more of the foods used in the activity compared to children who participated in a non-food sensory play task or a visual exposure task.[13] Interventions focused on just one aspect of sensory exposure to a novel food, such as appearance[14, 15] or texture,[16] have also reported some success in increasing young children's willingness to consume new foods.

Although intervention studies have demonstrated the principle that prompted engagement with a food's sensory properties may increase young children's willingness to try new foods,

little is known about the prevalence and stability of young children's sensory exploratory behaviors exhibited spontaneously when trying new foods.[10, 11] The present study had three primary aims. First, we examined the prevalence of young children's sensory exploratory behaviors (i.e., smelling, licking, and spitting), in addition to refusals and acceptances of new foods, across early childhood (4 to 7 years of age). Second, we investigated the individual trajectories of each sensory exploratory behavior, refusals, and acceptances. Third, we explored whether the trajectories of smelling, licking, spitting, and refusals were associated with the trajectory of acceptances (i.e., tasting and swallowing the food). Since food neophobia is posited to decline across early childhood,[3] we hypothesized that refusals, smelling, licking, and spitting would decline across the study period, but we expected the total number of acceptances to increase. Furthermore, we hypothesized that the decline in sensory exploratory behaviors and refusals would be associated with an increase in children's acceptance behaviors.

MATERIALS AND METHODS

Study Design

The Colorado Longitudinal Eating And Physical activity (LEAP) project was a 3-year longitudinal study utilizing a controlled, quasi-experimental design in four rural communities. Children in the intervention group received *The Food Friends – Fun with New Foods*® nutrition and *Mighty Moves* physical activity programs in Head Start/preschool sites and "booster" programming in kindergarten and first grade. The intervention was built on social cognitive theory constructs and social marketing tenets, and utilized fun, child-centered activities to promote children's willingness to try new foods and enhance children's development of gross motor skills (see [17] for more detailed information regarding intervention programming). Children in the control group received a preschool standard curriculum. Children in both study groups participated in observational assessments of their willingness to taste new foods at 4 time points: baseline, post-intervention, one-year follow up (Y1), and two-year follow-up (Y2). Written parental consent was obtained at baseline and child assent was obtained at each time point. Although the intervention did not specifically address or encourage the use of sensory exploratory behaviors when trying new foods, it is possible that the intervention influenced children's willingness to taste new foods at each time point. Therefore, intervention group was analyzed as a covariate in all statistical models.

Participants

Observational data were collected on a total of 244 preschoolers (n = 133 female; n = 141 in the intervention group). At baseline, children averaged 4.7 years of age and the majority of children were of normal weight status (~30% overweight or obese). Children were mostly White (40.8% Hispanic) and many were from families that qualified for federal nutrition assistance programs (69.2%). Children were included in the present analysis if they participated in the observational tasting task (described below) at any of the four time points: baseline (n = 233), post-intervention (n = 213), Y1 (n = 183), or Y2 (n = 174).

Procedures

Children's willingness to taste novel foods and their sensory exploratory behaviors while tasting them were observed during the Tasting Game task, a modification of the Sullivan and Birch taste preference assessment.[18] At all four time points, children participated in the task individually with a trained experimenter who invited the child to taste 9 different foods: beets, couscous, garbanzo beans, grapefruit, Gouda cheese, jicama, pineapple, salmon, and spinach. These foods were selected to include both familiar and novel foods, as well as a variety of food groups (e.g., vegetable, fruit, protein, etc.,) and tastes (e.g., sweet, savory). Children selected the order in which they would taste the foods, if at all. The experimenter recorded whether the child engaged in the following sensory exploratory behaviors: smelling, licking, and spitting. Experimenters also recorded whether the child refused to taste or swallowed a portion of the food. Children's consumption of and liking ratings in response to jicama from the Tasting Game task have been published previously [19], but neither liking ratings nor behavioral responses to jicama were considered in the present study.

Of interest in the present study were the children's behaviors in response to four of the foods intended to be novel: beets, couscous, garbanzo beans, and grapefruit. These foods were selected for this analysis based on prior research demonstrating that the majority of these foods were novel to children in the target population.[20] Although jicama was also considered novel, behaviors in response to jicama were not included in this analysis since jicama served as the target novel food for the intervention group and children were exposed to this target food repeatedly across the intervention period [17]. Gouda cheese, salmon, and spinach were also intended to be novel but did not function as such since children often voluntarily labeled them as "cheese," "chicken," and "lettuce," respectively. Prior research indicates that foods recognized as familiar based on their appearance and sensory features are more likely to be tasted, regardless of whether the children accurately label the food as familiar or not.[3] For this reason, Gouda cheese, salmon, and spinach were excluded from the present analysis. Pineapple was intended to be a familiar food for the children and, as such, it was excluded from this analysis. Therefore, the present analysis was limited to behaviors displayed in response to beets, couscous, garbanzo beans, and grapefruit. Summary scores were created for each behavior by summing the total number of foods smelled, licked, spit out, refused, and swallowed (hereafter referred to as "acceptance") at each time point (range 0–4 for each behavior).

Statistical Analysis

To examine the prevalence of children's sensory exploratory behaviors in response to new foods across early childhood, the percentage of children displaying smells, licks, and spits at least once, as well as the percentage of children displaying any of these behaviors, was calculated for each time point. Frequencies of smelling, licking, spitting, refusing, and accepting were also calculated.

To examine the longitudinal trajectories of each behavior, a series of growth models [21, 22] were fit to the smelling, licking, spitting, refusal, and acceptance scores measured at the four time points in M*plus* Version 8.1 (Muthén & Muthén, 1998–2018). A no growth model, a

linear growth model, and a latent basis model was fit for each behavior using maximum likelihood estimation. A logit link function was used to account for the ordinal nature of the outcomes (cumulative logit). Since the growth models for each behavior are hierarchically nested, likelihood ratio tests (LRT) were used to assess comparative model fit. Once the final model was selected for each behavior, model parameters were examined. To examine whether the trajectories of the sensory exploratory behaviors and refusals were associated with the trajectory of acceptances, multivariate growth models were fit with smelling, licking, spitting, and refusals separately with acceptance. Bonferroni corrections were used to account for multiple testing and the alpha level was set a $p < .01$ for both the univariate ($p = .05/5$ tests = .01) and multivariate models ($p = .05/4$ tests = .01 tests). Finally, since it is possible that participating in the intervention may have influenced children's total number of acceptances at each time point, study group (control = 0; intervention = 1) was entered into all models as a covariate and examined as predictor of both the slope and intercept of each behavior.

RESULTS

Preliminary Analysis

Just over half of children in the study displayed at least one of the sensory exploratory behaviors (smell, lick, spit) at baseline (53%) and this percentage declined across the study period (See Figure 1). Twenty-seven percent of children spit, 26% licked, and 19% smelled at least one of the novel foods at baseline (See Figure 1). However, when children displayed one of the sensory exploratory behaviors, they typically did so in response to only one of the foods (See Supplemental Table 1). The percentage of children displaying any smells, licks, and spits decreased over time (See Figure 1).

At baseline, the majority of children (79.8%) accepted at least one of the novel foods and many children accepted all four foods (39.5%) (See Figure 2). Acceptances increased over the period with almost all children (96.5%) accepting at least one of the foods at Y2 and a substantial number (84.9%) accepting all four foods. Conversely, refusals declined throughout the study with many children refusing at least one food at baseline (39.5%) and very few (7.6%) refusing at least one food at Y2.

Behavior Trajectories

The growth models for all variables (smelling, licking, spitting, refusing, and accepting) converged to proper solutions. For each behavior, the linear growth models fit significantly better than the no growth models (all p-values < 0.01), but the latent basis models did not fit significantly better than the linear growth models (p-values > 0.01). Thus, linear growth models were retained for the all five behaviors.

Sensory Exploratory Behaviors.—The parameters of the linear growth models indicated that spitting ($\beta_1 = -0.80$, $p < 0.01$) decreased over time, on average, whereas licking ($\beta_1 = -0.90$, $p = 0.06$) and smelling ($\beta_1 = -0.85$, $p = 0.10$) showed non-significant change. There were no significant individual differences in the likelihood of spitting ($\sigma_0^2 = 1.40$, $p = 0.07$), licking ($\sigma_0^2 = 3.85$, $p = 0.02$), or smelling ($\sigma_0^2 = 4.79$, $p = 0.02$) at baseline.

There were also no individual differences in the rate of change in the likelihood of spitting ($\sigma_1^2 = 0.45$, $p = 0.29$), licking ($\sigma_1^2 = 0.86$, $p = 0.20$), or smelling ($\sigma_1^2 = 0.98$, $p = 0.12$) across the study period.

No significant differences emerged between the study groups for the likelihoods of spitting ($\sigma_0^2 = 0.15$, $p = 0.65$), licking ($\sigma_0^2 = 0.16$, $p = 0.70$), or smelling ($\sigma_0^2 = -0.23$, $p = 0.63$) the novel foods at baseline. However, the two study groups differed in their rate of change in spitting: children in the intervention group demonstrated steeper declines in the rate of change in spitting compared to children in the control group ($\beta_1 = -1.11$, $p < 0.01$). There were no significant differences between study groups for the rate of change in licking ($\beta_1 = -0.60$, $p = 0.14$) or smelling ($\beta_1 = 0.27$, $p = 0.49$).

Refusals.—The number of refusals decreased over time, on average ($\beta_1 = -4.09$, $p < 0.001$). However, there were no significant differences in the likelihood of refusing at baseline ($\sigma_0^2 = 3.47$, $p = 0.02$) or in the rate of change in refusals over time ($\sigma_1^2 = 5.51$, $p = 0.06$). Also, no significant differences emerged between study groups for the likelihood of refusing at baseline ($\sigma_0^2 = -0.89$, $p = 0.02$) or in the rate of change in refusals over time ($\beta_1 = 0.05$, $p = 0.95$).

Acceptances.—Unlike the other behaviors, acceptances increased over time, on average ($\beta_1 = 1.75$, $p < 0.001$). Children varied significantly in their likelihood of accepting (i.e., swallowing portions of the foods) at baseline ($\sigma_0^2 = 5.15$, $p < 0.001$). However, there were no significant individual differences in the rate of change in accepting the novel foods over time ($\beta_1 = 1.44$, $p = 0.04$). There was also no significant difference between study groups for the likelihood of accepting the novel foods at baseline ($\sigma_0^2 = 0.75$, $p = 0.06$) or in the rate of change in acceptances over time ($\beta_1 = 0.69$, $p = 0.07$).

Relative Timing.—The probability curves for demonstrating each behavior at least once are displayed in Figure 3. The probabilities of accepting one or more foods increased across the study period, whereas the probabilities of refusing, spitting, licking, and smelling one or more of the foods decreased. Furthermore, the probability of refusing one or more foods appears to decline more rapidly than the probabilities of spitting, licking, or smelling one or more foods (see Figure 3).

Associations among Behavioral Trajectories

The likelihoods of spitting ($r_{spit,accept} = -0.97$, $p < 0.001$), licking ($r_{lick,accept} = -0.89$, $p < 0.001$), and smelling ($r_{smell,accept} = -0.67$, $p < 0.001$) the foods at baseline were inversely associated with the likelihood of accepting the novel foods concurrently. Furthermore, decreases in spitting ($r_{\Delta spilt,\ \Delta\text{accept}} = -0.92$, $p < 0.01$), licking ($r_{\Delta lick,\Delta accept} = -0.97$, $p < 0.01$) , and refusals ($r_{\Delta refuse,\ \Delta accept} = -0.97$, $p < 0.01$), were significantly associated with increases in acceptance across the study period. However, decreases in smelling were not significantly associated with increases in acceptance over time ($r_{\Delta smell,\Delta accept} = -0.17$, $p = 0.62$).

DISCUSSION

Our results demonstrate that children's spitting and refusals in response to new foods declined significantly across early childhood (see Figure 4). Licking and smelling showed nonsignificant change across the same period, but children exhibited both behaviors infrequently at the start of the study and very rarely at the end of the study. In fact, by approximately age 7, very few children displayed any sensory exploratory behaviors and the majority of children accepted all four previously novel foods. Furthermore, the trajectories of some sensory exploratory behaviors and refusals appear to be linked with acceptance; decreases in licking, spitting, and refusing were associated with increases in total novel food acceptances across the study period. This study, therefore, provides preliminary evidence that some typically developing children's sensory exploratory behaviors, exhibited spontaneously when trying new foods, may play a role in acceptance of new foods over time.

In this study sample, the decline in spitting and refusals across early childhood appears to be a developmental shift since children did not differ in how quickly or slowly they decreased these behaviors over time. In contrast, differences in the rate of acceptance were partially explained by how quickly children decreased certain sensory exploratory behaviors (i.e., licking, spitting) and refusals in response to the new foods. However, it is important to note that the potential utility of the sensory behaviors for food acceptance may not be immediately realized. At baseline, engagement in smelling, licking, and/or spitting was inversely associated with acceptance of the novel foods concurrently. Engaging in these behaviors without consuming the food during a meal may be perceived by parents as "playing with the food," which may contribute to parents' irritation with these behaviors.

It is important to note that the associations between rates of decline in sensory behaviors and increased acceptances were only observed for licking and spitting, but not smelling. This pattern of results supports the concept of "learned safety"[8] where *ingestion* of new foods without deleterious consequences may be required for humans to learn that a novel food is safe to consume. Since smelling does not involve ingestion of the food, this behavior may not be sufficient to facilitate learning. However, it is important to note that smelling occurred very infrequently at baseline and did not change significantly across the study period. These two factors may have contributed to the lack of an association between rates of smelling and acceptance over time.

Prior research has demonstrated the importance of smelling in children's willingness to try new foods. Monnery-Patris and colleagues[23] reported that toddlers who displayed greater smell reactivity, or more variability in their responses to different smells, were rated as more neophobic by their parents. Similarly, Coulthard and colleagues [24] reported that negative smell evaluations of a novel vegetable (i.e., the food "smells strange") were associated with both food neophobia and refusals to taste the food among older children (ages 7 to 11 years of age). In the present study, smelling the foods at baseline was associated with fewer acceptances of the foods concurrently. Although we did not ask children to evaluate how the foods smelled, it is possible that they chose not to taste the food based on their olfactory evaluations. Also, the low base rates of smelling in the present study could have been due to

the young age of children examined. Coulthard and colleagues[24] demonstrated that older children were more likely to rate a novel food as “smelling strange,” whereas younger children were more likely to rate the food as “looking strange.” Based on these results, the authors suggested a developmental shift in middle childhood where children begin to make decisions to try new foods based on their olfactory evaluations, rather than other judgements, such as visual evaluations.[24, 25] Thus, the low base rates of spontaneous smelling in the present study could be due to the young children not yet experiencing the developmental shift towards making decisions to taste a food based on its smell.

The frequencies of children’s spontaneous sensory exploratory behaviors in this study at baseline were somewhat similar to those observed by Johnson and colleagues [9] in preschoolers of similar ages (~3 to 5 years). However, Momin and colleagues[11] reported fewer observations of these behaviors in toddlers (ages 1 to 3 years) as did Blissett and colleagues[10] in preschoolers (ages 2 to 4 years). Taken together, these results suggest that young children’s sensory exploratory behaviors begin at low frequencies during very early childhood (ages 1 to 3 years), increase until approximately age 4, then decline thereafter. This pattern is quite similar to the proposed trajectory of food neophobia across early childhood.[3] However, longitudinal studies following children from toddlerhood through middle childhood are needed to confirm the possible overlap between the trajectories of sensory exploratory behaviors and food neophobia, as well as individual trajectories of each.

The emerging literature on children’s sensory processing suggests that sensory exploration and evaluation is linked to children’s willingness to taste and consume novel foods.[24, 25] This hypothesis is strengthened by the results of intervention studies demonstrating that engagement with a new food’s sensory properties increases children’s willingness to try new foods.[12, 13, 16] These controlled studies help us understand the cause and effect relationship between sensory processing and food acceptance, but it is also important to understand the longitudinal trajectories of these behaviors exhibited spontaneously by children. Here, the declines in some sensory exploratory behaviors between 4 and 7 years of age were associated with increases in acceptance of the novel foods, providing further support that sensory processing may be linked to food acceptance. Unfortunately, parents often discourage the use of sensory behaviors, likely because they are unaware of their potential utility and often view these behaviors as exhibiting poor table manners. It is unclear how doing so may influence children’s long-term acceptance of new foods.

Strengths of this study include the longitudinal study design and repeated observational assessments of a diverse sample of young children and their sensory exploratory behaviors exhibited spontaneously when trying a variety of new foods. One notable limitation of this study is that the same novel foods (beets, couscous, garbanzo beans, and grapefruit) were offered at each of the four study assessments. It is possible that children’s sensory exploratory behaviors and refusals declined due to increased familiarity with these foods over time rather than due to a developmental shift in the prevalence of these behaviors. However, the time between exposures to the new foods in this study (once every 6 months or 1 year) occurred less often than the literature suggests may be needed to increase preference for new foods.[18] Additionally, the observed associations between the decline in sensory

exploratory behaviors and the increase in food acceptance cannot be viewed as causal due to the lack of an experimental design.

In summary, the results of this study suggest that children's tendencies to spit and refuse new foods wane across early childhood. The disappearance of licking, spitting, and refusals also appears to be accompanied by increases in food acceptance, suggesting that sensory exploratory behaviors may help children learn that novel foods are safe to consume. Although continued investigation of the function of these behaviors is needed, the disappearance of behaviors such as spitting new foods may be pleasing to caregivers, who commonly view this behavior as inappropriate.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Longitudinal analysis revealed increased new food acceptance across early childhood
- Sensory exploratory behaviors (spitting, licking) decreased across early childhood
- Declines in sensory behaviors were associated with increased food acceptance

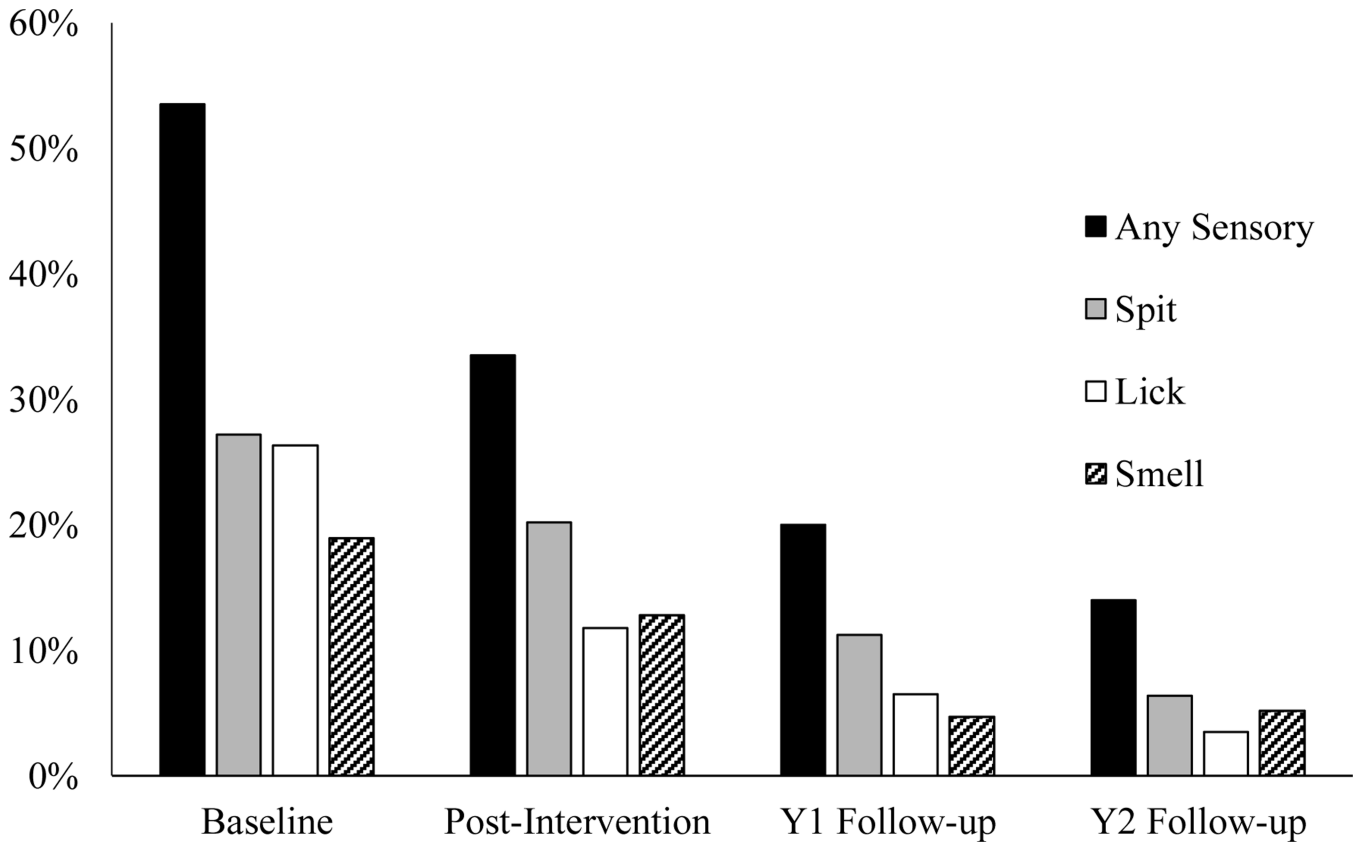
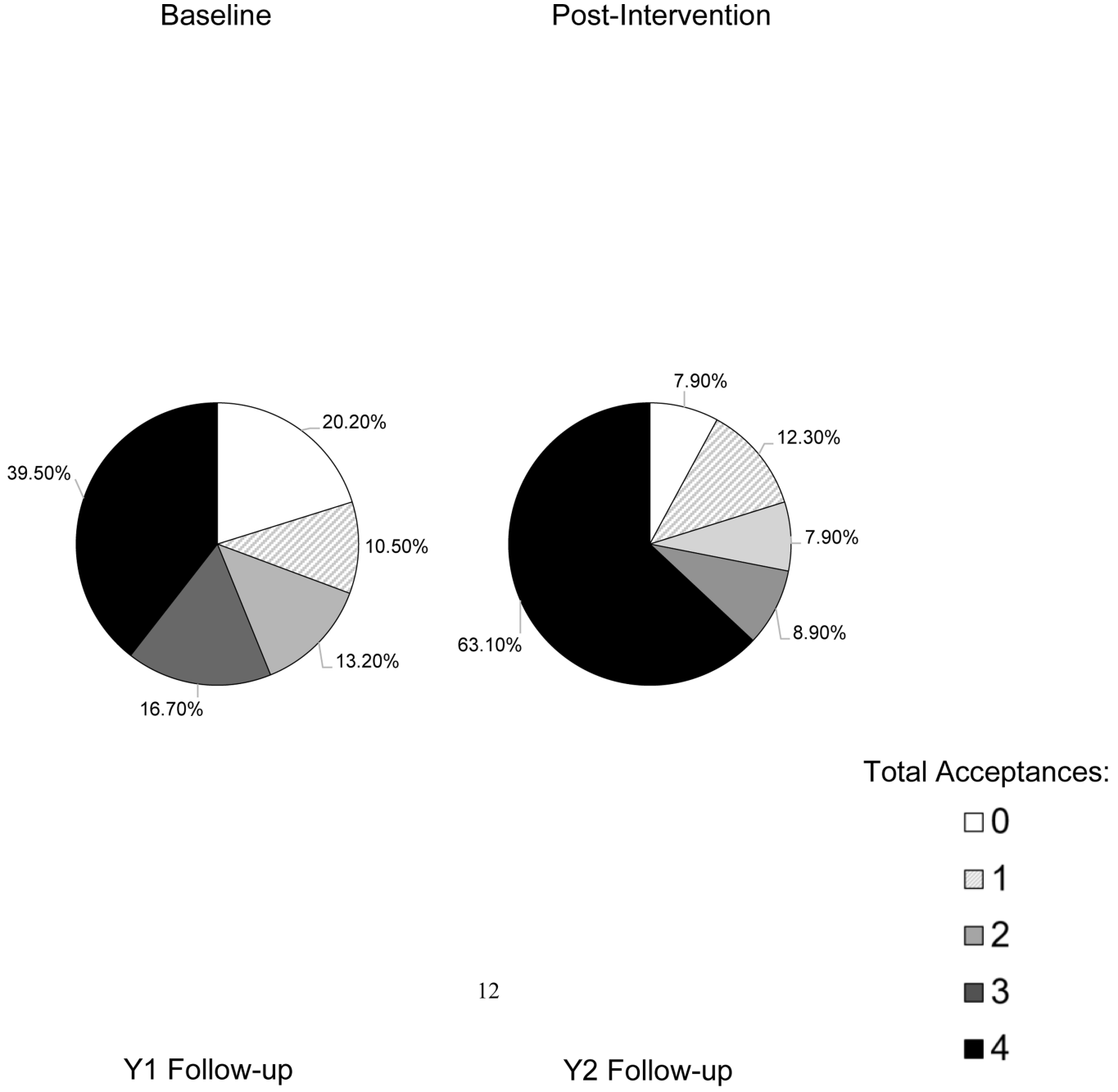


Figure 1.
Percentages of children displaying any sensory exploratory behavior and any smells, licks, and spits at each study time point.



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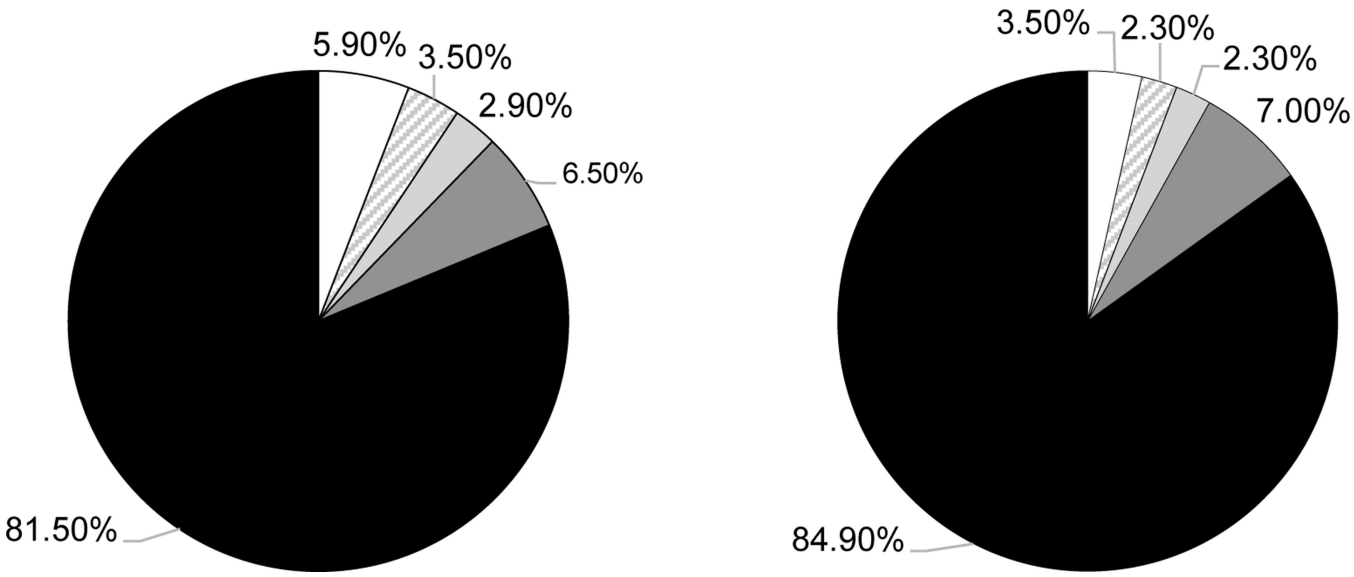

Figure 2.
Percentages of children displaying 0, 1, 2, 3, and 4 total acceptances of new foods at each study time point.

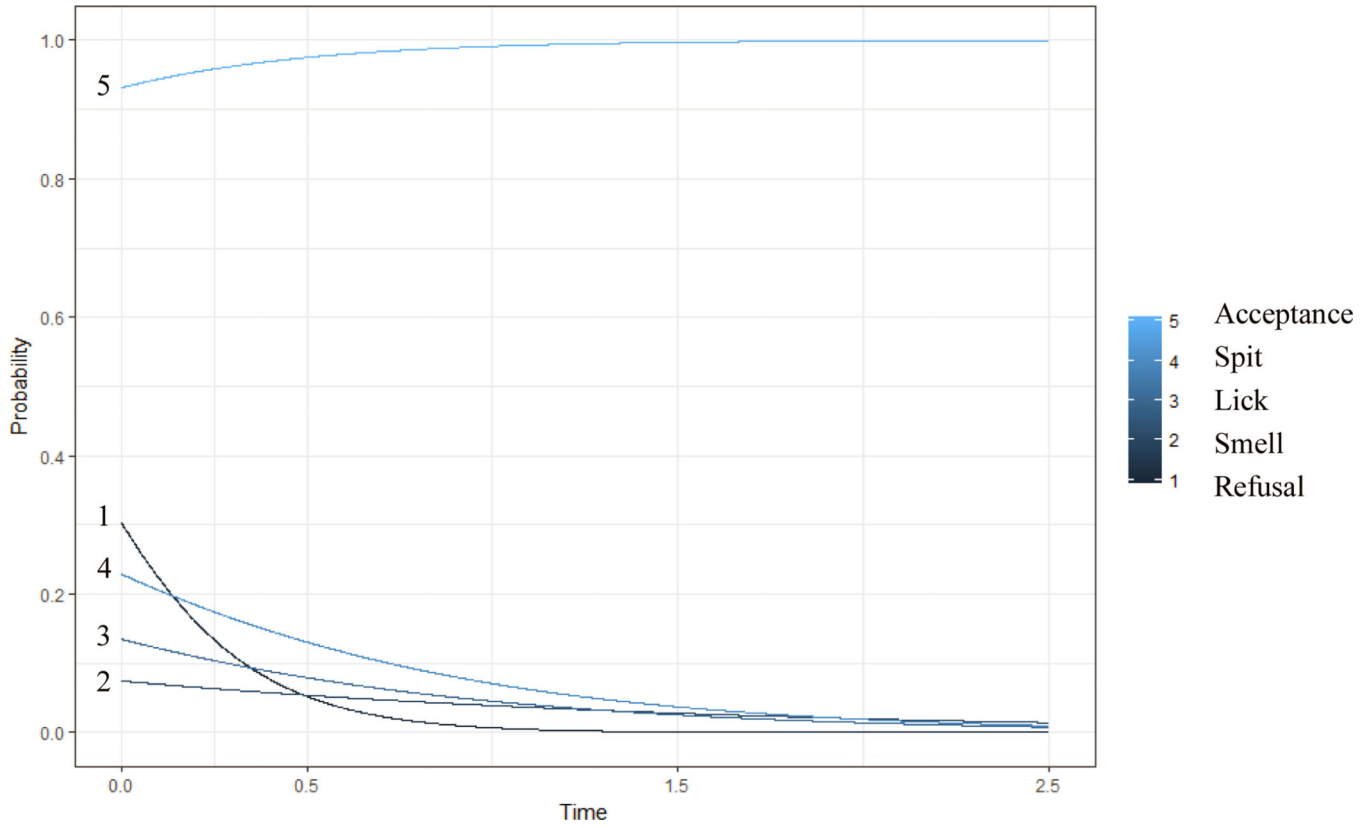

Figure 3.
Probability curves for accepting, spitting, licking, smelling, or refusing at least one of the new foods across the study period.

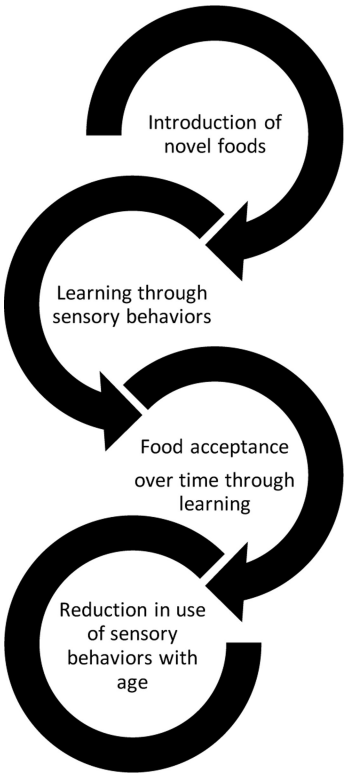

Figure 4.
Conceptual model of the role of children's sensory exploratory behaviors during early childhood.