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Do children really eat what they *like?* Relationships between liking and intake across laboratory test-meals

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ABSTRACT

Liking plays a primary role in determining what and how much children eat. Despite this, the relationship between liking and intake of foods and beverages served as part of a meal is not often reported, even though pediatric feeding studies frequently collect such data. In addition, few studies have reported on the test-retest reliability of both hedonic ratings and laboratory intake among children. To address these gaps, this study was designed to assess the relationship between children's liking of items at a meal and subsequent intake. 61, 4-6 year-olds were recruited to participate in two identical laboratory sessions where liking of 7 foods (i.e., chicken nuggets, ketchup, potato chips, grapes, broccoli, cherry tomatoes, cookie) and 2 beverages (i.e., fruit punch, milk) was assessed (5-point hedonic scale) prior to *ad libitum* consumption of the same items at a meal. Spearman's correlations tested the relationship between liking and intake and intra-class correlations assessed inter-session reliability of both measures. Liking for potato chips ($p < 0.01$), grapes ($p < 0.05$), cherry tomatoes ($p < 0.001$), and fruit punch ($p < 0.001$) was positively associated with amount consumed, but no associations were found between liking and intake of other meal items. For the majority of meal items, test-retest reliability of liking and intake were significant (ranging from 0.34 for cookies to 0.93 for tomatoes). At a multi-component meal, children's hedonic ratings were both reliable and modestly predictive of subsequent intake, and the relationships were stronger for lower energy, less well-liked foods. Rather than eating what they like, these data are more consistent with the notion that children do not eat what they dislike.

1. Introduction

"In the absence of adult control and coercion, young children eat what they *like* and leave the rest" (Birch, 1996). Versions of this quote are found throughout the child feeding literature (Cooke & Wardle, 2007) as well as in public health guidance for pediatricians and parents (Galvin, 2014). Given the near ubiquity of this claim, it is perhaps surprising that there is a lack of empirical evidence to directly support it. Accordingly, the goal of the present paper is not to dispute the central role liking plays in driving consumption, but rather to provide a more nuanced examination of the empirical relationship between hedonic ratings made by children and what and how much they eat in a multi-component meal.

Birch first reported on the importance of hedonic ratings in determining what preschool children eat in 1979. In her foundational study, children's ranked preference for sandwich fillings were highly predictive (i.e., $r = -0.80$) of how much they consumed in the childcare setting. However, a critical yet often overlooked methodological detail is that Birch measured *ranked preference*, not liking (Birch, 1979). While often used interchangeably in the literature, liking and preference are operationalized differently, and this distinction can strongly impact interpretations. Liking is an affective evaluation for one or more foods/-beverages, typically made on a rating scale (e.g., 5-point smiley face scale in children; 9-point verbal hedonic scale in adults) in response to either tasting or seeing a picture of a food/beverage. Preference, on the other hand, requires making a choice between multiple available options, and these behavioral choices are then used to rank affective responses on an implicit continuum. Because participants are forced to choose, rank order preferences may be sensitive to distinctions between affective responses that are not detected with liking scales (e.g., a child

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may give equal hedonic ratings to cookie and apple, but when asked to select one, might choose the cookie over the apple) (Meilgaard, Civille, & Carr, 2016). Despite the widespread use of hedonic scales to measure liking in pediatric feeding studies, it is not well-established whether they are meaningful predictors of subsequent food intake. Here, we specifically designed a study to assess the relationship between children's hedonic ratings and intake at two identical, multi-item test-meals.

To our knowledge, only a few prior studies have reported the relationships between children's liking and intake for foods or beverages. While the current study focuses on objective measures of food consumption, survey based methods can provide some insight here. For example, in a secondary data analysis Raynor and colleagues (Raynor et al., 2011) found that 4-9 year-olds liking of vegetables was associated with reported vegetable consumption (assessed with a 3-day, 24 h dietary recall completed by parents for children <8 years-old). They found no relationship, however, between children's liking and intake of other food groups, like fruit, dairy, snacks, and sweetened beverages. Other studies have used more objective methods to measure or estimate amount of food consumed. For example, De Graaf and Zeinstra (De Graaf & Zandstra, 1999) found that liking ratings on a 5-point scale for orange lemonade were modestly predictive (rho = 0.49–0.60) of the amount of beverage 8-10 year-olds consumed. In a low-income population, Scarmo and colleagues found that parental ratings of children's fruit and vegetable liking associated with a non-invasive biomarker of children's habitual F&V intake ((Scarmo et al., 2012). Additionally, in an Italian cohort of 4–5 year-olds, Carporale and colleagues (Caporale, Policastro, Tuorila, & Monteleone, 2009) showed a strong relationship between school children's ratings of tasted foods on a 7-point scale and estimates of the percentage of food left uneaten at lunch. As hedonic ratings increased, amount of food waste decreased. However, this relationship was strongest for vegetables which had the lowest hedonic ratings and the greatest plate waste at the meals. In other words, children avoided consumption of foods they disliked.

The latter study highlights what Hayes pointed out in a recent review (Hayes, 2020); the relationship between liking and intake is heteroscedastic. That is, the variance in the liking-intake relationship is not constant across the range of liking. At lower levels of liking, the variance is smaller, and at higher levels of liking, the variance is larger. In adults, this occurs because individuals may resist eating foods that are highly liked due to health concerns, dietary restraint, or simply because they like other available foods better (e.g. (Duffy, Hayes, Sullivan, & Faghri, 2009),). These reasons may be less likely to apply in children, whose consumption decisions are more strongly driven by taste hedonics than adults (Anliker, Bartoshuk, Ferris, & Hooks, 1991; Drewnowski, Mennella, Johnson, & Bellisle, 2012; Nguyen, Girgis, & Robinson, 2015). However, there may be other reasons to also suspect the existence of a heteroscedastic relationship between liking and intake in children. For one, the between-subjects variance in liking ratings at the higher end of the scale might be truncated due to a ceiling effect, which would make higher liking potentially less predictive of intake than lower liking. Second, even though children in the preoperational stage of cognitive development lack understanding of the health effects of foods on the body (Contento, 1981), girls as young as 5 years report understanding concepts such as dieting and weight restriction, particularly if they have mothers who are trying to lose weight (Abramovitz & Birch, 2000). Additionally, Sharafi and colleagues (Sharafi et al., 2015) found discordance between liking and intake of high-energy dense foods (i.e., high liking but low intake) which was predictive of higher body mass index among 3-5 year-olds, suggesting that even among young children, dietary restraint may influence whether children eat the foods that they like. On the lower end of the liking scale, disliking a food is strongly associated with neophobia (Russell & Worsley, 2008) and disliked foods are often completely avoided by children and adults (Shafe & Bernstein, 1996). Thus, the conclusion reached by Hayes – that *disliking is a strong determinant of non-consumption* – likely applies to both children and adults, although objective data directly supporting this assertion in children is still lacking; presently, we begin to address this lack of evidence.

In addition to examining the liking-intake relationship under controlled laboratory conditions, there is also a lack of evidence on the reliability of such measures in children. Consumption of *ad libitum* test-meals under controlled laboratory conditions is the gold standard methodology for measurement of satiation (Blundell et al., 2010). In adults, test-retest reliability of *ad libitum* intake from single foods consumed under identical laboratory conditions exceeded 80% (Hubel et al., 2006; Laessle & Geiermann, 2012). Arvaniti and colleagues also found high intraclass correlations (0.82 and higher) for total and macronutrient intake consumed by young adult men at a laboratory multi-item buffet meal. In addition, consumption at laboratory meals that were tailored to participant's food preferences was highly reproducible among adolescent boys (Bellissimo, Thomas, Pencharz, Goode, & Anderson, 2008) and girls (Thivel, Genin, Mathieu, Pereira, & Metz, 2016). However, it is unclear how reliable measures of *ad libitum* intake are for younger children, and studies that have assessed inter-session repeatability of liking have generally found poor consistency in 4–5 year-olds (Leon, Couronne, Marcuz, & Koster, 1999). Therefore, studies are needed to investigate the test-retest reliability of hedonic ratings and laboratory food intake in children in order to better understand the strengths and limitations of these measures.

The present work addresses several gaps in the literature. Foremost, the primary goal of this study was to determine the extent to which children's hedonic ratings of foods and beverages predicted how much they consumed at a multi-item, laboratory test-meal. We hypothesized that the relationship between liking and intake would be heteroscedastic, and would be stronger for foods that were less well-liked (e.g., low energy dense vegetables). In addition, because we assessed liking and intake across two identical sessions that were separated by 1–2 weeks, we also examined the reproducibility of these measures.

2. Methods

2.1. Participants

Sixty-one (n = 61) children were recruited to participate in this study, but 3 children were lost to follow-up, so complete data are included for 58 children (32 males, 26 females; 5.0 ± 0.8 years-old). Families were recruited by posting flyers online and around the university community. Interested parents called and completed screening questions over the phone to determine study eligibility. Children were required to be in overall good health, no food allergies, not taking medications known to affect appetite, and between the ages of 4–6 years-old on the first visit. We selected this age group because they had the attention span to complete a ~60–90 min laboratory visit and have well-developed food preferences. The majority of the sample was White (86.0%), consistent with regional demographics, and were in the healthy weight range (BMI-for-age % between 5 and 85th). Descriptive characteristics for the children who completed the study and their parents are detailed in Table 2.

2.2. Study design and procedures

A cross-sectional study was conducted with 61, 4–6 year old children and their parents at the Metabolic Kitchen and Children's Eating Behavior Lab. Children attended two laboratory visits, scheduled 1–2 weeks apart, accompanied by the parent who reported making the majority of feeding decisions for the household (typically mothers). Each laboratory visit lasted between 60 and 90 min, and was scheduled either during lunch (11:00–1:00 p.m.) or dinner (4:30–6:30 p.m.) time, depending on the family's availability. Family visit times were kept consistent within families and counter-balanced across families. At each visit, parents completed a range of questionnaires on child feeding practices, eating behaviors, and demographics (see 2.4.2.). Children

Table 1
Foods and beverages presented to children.

Item	Brand/Type	Serving Size (gm)	Energy (Kcal)	Energy Density (Kcal/g)
Chicken Nuggets[a,b]	Tyson 100% natural	90	270	3.00
Potato Chips	Lay's Original	50	290	5.71
Cookies	Chips Ahoy Original	34	160	4.71
Broccoli[a]	Birdseye	75	26	0.34
Cherry tomatoes	Fresh cherry	75	15	0.20
Grapes	Red seedless	75	93	0.75
Fruit Punch	Hawaiian Punch	200	62	0.31
Milk	Non-Fat	200	74	0.37

[a] Broccoli and chicken nuggets prepared as suggested on packaging.
[b] Chicken nuggets served with ~55 g of ketchup.

Table 2
Child characteristics (n = 58).

Child Characteristics	Mean	± SD	Range
Age (years)	4.98	0.8	4–6
BMI percentile[a]	50.5	28.2	4.0–99.0
BMI Z-score[a]	0.05	0.9	−1.7–2.4
Maternal BMI – kg/m^2	26.3	7.7	16.8–49.6
Paternal BMI - kg/m^2	26.7	5.2	20.4–40.7
Parental education - years	17.4	2.5	13.0–21.0
Estimated family income (K)	61.1	35.1	10–120
		(n)	**(%)**
Race	Asian	2	3.4
	Black	1	1.7
	Multiracial	5	8.6
	White	50	86.2
	Total	**58**	**100**
BMI-for-age Percentile[a]	<5th %	1	1.8
	5th – 85th %	48	84.2
	85th – 95th %	6	10.5
	95th – 100%	2	3.5
	Total	**57**	**100**
Sex	Male	32	54
	Female	26	46
	Total	**58**	**100**

[a] Missing data due to 1 child refusing to be measured. BMI percentile and BMI Z-score reported for n = 57.

rated liking of foods (see 2.4.3.) and consumed *ad libitum* from a multi-item buffet of common foods (see 2.4.4.). Parents signed informed consent on the first visit to allow their children to participate in the study and children gave verbal assent. Following the consent procedures, parents were separated from children and asked to remain in the waiting room and refrain from talking with children about what they ate during the study visit. This was done to minimize potential sources of bias. Parents were provided with modest monetary incentives for participation, and children were allowed to pick a small prize (e.g., toys, books) at the end of each visit. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Institutional Review Board at Penn State.

2.3. Measures

2.3.1. Child anthropometrics

On the first session, children were weighed and measured to collect information on height and weight. Anthropometric measures were collected in light clothing without shoes or coats. Height was measured to the nearest tenth of a centimeter with a portable stadiometer (SECA, Chino CA), and weight was measured to the nearest tenth of a pound using a digital scale (Tanita, Arlington Heights IL). Measurements were performed twice and the mean was calculated and converted to body mass index (BMI), BMI percentile, and BMI Z-score using the standardized curves from the Center's for Disease Control (Cole, Bellizzi, Flegal, & Dietz, 2000).

2.3.2. Parental surveys

Across the two sessions, parents completed a series of questionnaires to assess demographics, family food practices, feeding practices (Birch et al., 2001), appetitive traits (Wardle, Guthrie, Sanderson, Birch, & Plomin, 2001), and nutrition knowledge (Parmenter & Wardle, 1999). These measures were assessed as possible covariates that could influence children's liking, food intake, or the relationship between the two. Associations between these measures are reported in the manuscript, with additional details in the Supplementary Material.

2.3.3. Child liking of test-meal

In both laboratory sessions, children rated liking for 8 samples of foods and beverages (see Table 1) using a 5-point hedonic scale (the Peryam & Kroll Five Point Smiley Face Scale) which has shown to be developmentally appropriate for this age group (Chen, Resurreccion, & Paguio, 1996). To teach children to make ratings with the scale, we used a procedure developed in a prior study (Keller, Steinmann, Nurse, & Tepper, 2002). In brief, children were provided with a training script to explain the meaning of each of the five faces on the scale which corresponded to verbal descriptors *Super Bad*, *Bad*, *Maybe Good Maybe Bad*, *Good*, and *Super Good*. After the explanation, children were asked to think of their "most favorite" food. The researcher then asked the child to point to the correct face if we brought them a hypothetical serving of their favorite food. If they pointed to the face matched with "*Good*" or "*Super Good*," their responses were assumed correct. The procedure was repeated for their least favorite food, and if children pointed to the face corresponding to "*Bad*" or "*Super Bad*", they were assumed to understand the scale. Children who made incorrect responses were given additional instructions until they used the scale correctly. A majority of children correctly understood the use of the scale without additional training beyond the initial instructions.

Following the training, children were presented with ~5 g samples of the nine test-meal foods and beverages served in 1-ounce plastic soufflé cups. Foods included chicken nuggets, broccoli, red seedless grapes, tomatoes, potato chips, cookies, skim milk, and fruit punch (Table 1). Sample cups were presented to children one at a time, and children were asked to taste the food/beverage and point to the corresponding smiley face. Children were instructed to sip water between each sample to cleanse their palates. Children were also were trained to assess their feelings of perceived fullness using a validated analog scale called the Freddy Fullness Scale [see training and validation details in ref (Keller et al., 2006)]. Children rated liking of all foods/beverages prior to the test-meal and fullness was assessed both before and after the meal.

2.3.4. Child intake of test-meal

Following the assessment of food liking and fullness, children were presented with a multi-item meal consisting of the same foods/beverages (see Table 1, Fig. 1). The foods and serving sizes were selected based on experience from previous studies with this age group (Fearnbach, Thivel, Meyermann, & Keller, 2015; Keller et al., 2014) and by consulting the Continuing Survey of Food Intake for Individuals (Smiciklas-Wright, Mitchell, Mickle, Goldman, & Cook, 2003). All foods (chicken nuggets w. ketchup, broccoli, red seedless grapes, cherry tomatoes, potato chips, cookies) and beverages (low-fat milk and fruit punch) were prepared and weighed immediately before the child's session and presented on a tray using identical preparation, serving temperature, and placement at each meal (Fig. 1). To ensure that we could accurately determine the amount of food children consumed in the lab, all foods and drinks were served and weighed on separate plates or bowls. When children wanted additional servings, a researcher would

Fig. 1. Food and beverage items served to children as part of a multi-component meal. On the left part of the tray, items included chocolate chip cookies, red grapes, potato chips, and cherry tomatoes. In the middle, items include fruit punch and milk. On the right side of the tray, items include broccoli, chicken nuggets, and ketchup. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

weigh another portion of the food or drink in its serving container and then present that to the child. This allowed us to calculate total amount consumed or not consumed (i.e., plate waste) by simply calculating the total weight of the serving containers after consumption and subtracting this from the weight of all items prior to consumption.

Children were then given *ad libitum* access to the foods and beverages for a 30-min meal. Children were instructed that they could "eat as much or as little as they wanted" and were told they could have additional servings of any food they wanted at any point in the meal. Because some children can be reluctant to ask for additional servings in this environment, we asked children once they finished an item during the meal if they would like another portion. While children ate, a research assistant read to them from a selection of age-appropriate stories that contained no references to food or other sensitive topics. We use this approach to create a neutral and consistent distraction for children, and to increase their comfort level with eating a meal in a laboratory environment. To calculate amount of each meal item consumed, we post-weighed each food and beverage separately in the same serving vessel as used for the pre-weight. Prior to post-weighing, we separated all remaining food items into their original corresponding containers (e.g., scraped remaining ketchup off of chicken nuggets or plates, picked up any foods that had fallen on the table or floor) to be able to determine both consumption and plate waste as accurately as possible. Nutritional information from the food labels and/or from online nutritional databases (United States Department of Agriculture) was used to calculate meal energy intake.

2.4. Power and statistical analyses

We powered the current study based on the correlations between liking and intake reported in (De Graaf & Zandstra, 1999) using Power Analysis & Sample Size (PASS 2021 for Windows by NCSS). We estimated that we would need a sample of at least 50 children to achieve 80% power at an alpha of 0.05. Because we anticipated slightly smaller effect sizes than those reported by De Graaf and Zandstram (De Graaf & Zandstra, 1999), as children were consuming the foods as part a multi-item meal (i.e., where competition between items may exist), we recruited an additional 10–15 children. Descriptive statistics were performed to determine means, range, and standard deviations for continuous variables, and frequencies for categorical variables. Before completing the primary analyses, normality of the outcome measures (i.e., food liking and intake) was evaluated by examining Q-Q plots and calculating the Shapiro-Wilks value. We also examined skewness and kurtosis of the variables using cut-offs defined by West et al., (West, Finch, & Curran, 1995). As these exploratory plots generally showed data for liking and intake that were skewed and non-normally distributed, we used non-parametric statistics for our primary analyses.

To determine the test-retest reliability of liking and intake, we calculated the Intraclass Correlation Coefficient (ICC) between measurements at Visit 1 and Visit 2. The strength of the relationship between food liking and intake was determined using Spearman rank order correlations for food liking vs. both weight and kcal of food consumed. In addition to individual foods, we also calculated mean liking and intake values between Visit 1 and Visit 2 and calculated Spearman rank order correlation coefficients on these mean values. Intraclass Correlation Coefficients between mean liking and mean intake of the meal as a whole, as well as high-energy dense foods (high-ED; chicken nuggets, cookies, and potato chips) and low-energy dense foods (low-ED; tomatoes, grapes, and broccoli). The significance level was set at $p \leq 0.05$. All analyses were performed using SPSS 26 (SPSS Inc., Chicago, IL). All data and analysis code will be made available upon request by contacting the corresponding author.

3. Results

3.1. Participants

Child characteristics are presented in Table 2. Fifty-eight (58) children (26 girls and 32 boys) between ages 4 and 6 years (mean: 4.98 ± 0.8 years) are included. The majority of children in this study were white (86%), consistent with demographics of the local region (central Pennsylvania). Most (84.2%) of the children were in the normal weight range (i.e., BMI-for-age % between 5th – 85th), 10.5% were considered overweight (i.e., BMI-for-age % between 85th – 95th and only 3.5% were obese (i.e., BMI-for-age % between 95th – 100th). On average, both mothers (26.3 ± 7.7 kg/m^2) and fathers (26.7 ± 5.2 kg/m^2) were classified as overweight. Household incomes varied from less than $20,000 to over $100,000 per year.

3.2. Food liking

Mean liking ratings for the foods rated on each visit and the Intraclass Correlation between liking ratings for Visit 1 and Visit 2 are

Table 3
Mean liking ratings and test-retest reliability of liking ratings across test sessions.

Foods and Drinks	Mean ± SD Liking Visit 1	Mean ± SD Liking Visit 2	Intraclass Correlation
Chicken nuggets	4.5 ± 0.7	4.5 ± 0.6	0.50*
Potato chips	4.6 ± 0.6	4.5 ± 0.6	0.37*
Cookies	4.9 ± 0.3	4.8 ± 0.5	0.34
Broccoli	3.6 ± 1.3	3.7 ± 1.3	0.81**
Cherry tomatoes	2.9 ± 1.5	2.8 ± 1.5	0.93**
Grapes	4.5 ± 0.7	4.4 ± 0.7	0.67**
Fruit punch	4.3 ± 0.9	4.3 ± 0.9	0.55*
Milk	3.8 ± 1.2	3.8 ± 1.1	0.78**
High-ED foods[a]	4.7 ± 0.4	4.6 ± 0.4	0.54*
Low-ED foods[b]	3.7 ± 0.8	3.7 ± 0.8	0.89**

*$P < 0.01$.
**$P < 0.001$.
[a] Average liking rating for high-ED foods chicken nuggets, cookies, and chips.
[b] Average looking rating for low-ED foods broccoli, grapes, and cherry tomatoes.

displayed in Table 3. Among individual foods, cookies had the highest mean liking rating (4.9 ± 0.3, out of a possible range of 1–5) and tomatoes had the lowest mean liking rating (2.8 ± 1.50, on a scale where the mid-point of *Maybe Good, Maybe Bad*, was a 3). Overall, high-ED foods were more well-liked than low-ED foods, with a mean difference in ratings of 1.0 unit on the 5-pt scale ($t = -10.3$ (df 57); $p < 0.001$). Intraclass correlation coefficients were significant for the majority of items and ranged from 0.34 for cookies to 0.93 for cherry tomatoes. The relationships between children's liking of the various foods (average across Visit 1 and Visit 2) and family and parental characteristics were also examined and are presented in the Supplementary Text.

3.3. Food intake

Mean test meal intake in grams and kcal for each visit and Intraclass Correlation coefficients between these values are presented in Table 4. Overall intake varied considerably between individuals, with some children eating as few as 110 kcal and others eating over 1100 kcal (mean intake across the two meals 619.8 ± 206.5 kcal). Paired t-tests showed no differences in intake between foods consumed on visit 1 and visit 2 except for broccoli [$t = 2.2$ (df 57); $p < 0.05$)] and cherry tomato [$t = 2.6$ (df 57); $p < 0.05$)]. Intraclass correlations comparing intake across the visits were significant for all the foods, and ranged from 0.58 for cookies to 0.93 for cherry tomatoes. On average, children consumed more high-ED than low-ED foods (t = 7.94, p < 0.001).

The number of servings requested also varied by food type, and is presented in detail in the Supplementary Materials. Across the two meals, children tended to request additional servings of the foods that had the highest liking ratings. For example at the first visit, 41.3% of children had more than one serving of chicken nuggets, 34.5% had more than one serving of cookies, and 12.1% had more than one serving of fruit punch. Similar breakdowns were observed for the second visit, with 39.6% requesting additional servings of chicken nuggets, 34.4% requesting additional servings of cookies, and 8.6% requesting additional fruit punch. In contrast to the additional servings requested of these well-liked foods and beverages, no children requested additional servings of cherry tomatoes or milk.

3.4. Correlations between food liking and food intake

As shown in Table 5 and Fig. 2, positive liking/intake correlations were found for potato chips (p < 0.01), grapes (p < 0.05), cherry tomato (p < 0.001), and fruit punch (p < 0.001). No significant relationships between food liking and intake were found for cookies, chicken nuggets, broccoli, and milk. The relationships between liking and intake were still significant after adjustment of the models for potential covariates. For example, linear regression models showed that cherry tomato liking was still a significant predictor of cherry tomato intake after adjusting for Hispanic ethnicity and pre-meal fullness ($t = 3.77$; $p < 0.001$). Similarly, fruit punch liking was still associated with fruit punch intake after adjusting for infant feeding method, pre-meal fullness, parent education and nutrition knowledge ($t = 2.94$; $p < 0.01$).

In general, correlations were stronger for low-ED foods than for high-ED foods. Mean liking and mean intake of low-ED foods (grapes, tomatoes, and broccoli) was positively associated (rho = 0.38 p = 0.004), but no significant relationship was found between mean liking and mean intake of high-ED foods ($p > 0.05$). A moderate, positive relationship was found between mean liking scores for all test meal items and total meal intake (rho = 0.29; p < 0.05), and between mean liking and combined intake of just the six food items (rho = 0.34; p < 0.05).

To examine whether hedonic ratings were a better predictor of lack of consumption, we also investigated the correlations between children's liking ratings and amount of food waste. Table 6 shows the relationships between children's liking and the percentage of food and drink items left uneaten. Liking ratings were negatively associated with percent uneaten of potato chips (p < 0.01), grapes (p < 0.05), cherry tomato (p < 0.001), fruit punch (p < 0.01), milk (p < 0.05), and low-ED foods when combined as a group (p < 0.01). No significant relationships were found for cookies, chicken nuggets, broccoli, and for high-ED foods as a group. For illustration, Fig. 3 shows the relationship between hedonic ratings of the foods and percent uneaten, both computed as a mean across both visits. As liking ratings of the foods increased, percent of food waste decreased (r = −0.53; p < 0.05).

Table 5
Associations between children's rated liking and *ad libitum* intake.

Spearman's rho values between liking and intake			
Food	Visit 1	Visit 2	Average across both visits
Chicken nuggets	−0.11	0.13	−0.04
Potato chips	0.24	0.28*	0.36**
Cookies	0.02	0.15	0.14
Broccoli	0.19	0.22	0.23
Cherry tomatoes	0.52***	0.44**	0.60***
Grapes	0.28*	0.19	0.33*
Fruit punch	0.41**	0.24	0.48***
Milk	0.34**	0.23	0.24
High-ED foods	−0.13	0.12	0.02
Low-ED foods	0.28*	0.33*	0.34*

***p < 0.05.**
****p < 0.01**.
*****p < 0.001**.

Table 4
Mean intake and test-retest reliability of intake across test sessions.

Foods and Drinks	Intake Visit 1 – grams	Intake Visit 1- kcal	Intake Visit 2 – grams	Intake Visit 2- kcal	Intraclass Correlation
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Chicken nuggets	96.2 ± 49.8	288.6 ± 149.5	93.5 ± 59.5	280.4 ± 178.6	0.67**
Potato chips	12.6 ± 15.6	72.1 ± 89.7	12.4 ± 14.8	70.7 ± 84.7	0.85**
Cookies	36.0 ± 31.8	169.7 ± 149.7	38.1 ± 24.4	179.3 ± 115.1	0.58*
Broccoli	19.1 ± 27.8	6.5 ± 9.5	13.3 ± 19.4	4.5 ± 6.6	0.79**
Cherry tomatoes	10.3 ± 20.5	2.1 ± 4.1	6.9 ± 19.0	1.4 ± 3.8	0.93**
Grapes	23.1 ± 32.6	17.3 ± 24.4	25.7 ± 39.8	19.3 ± 29.9	0.78**
Fruit punch	101.4 ± 90.9	31.4 ± 28.2	105.4 ± 100.5	32.7 ± 31.2	0.65**
Milk	25.3 ± 43.6	8.1 ± 14.9	22.0 ± 40.3	9.3 ± 16.1	0.66**
High-ED foods[a]	144.8 ± 55.4	530.4 ± 204.4	143.9 ± 65.0	530.4 ± 219.9	0.70**
Low-ED foods[b]	52.5 ± 53.6	25.9 ± 28.1	45.9 ± 53.7	25.2 ± 32.1	0.84**
Total meal	340.2 ± 131.7	618.8 ± 219.2	339.7 ± 155.2	620.4 ± 245.2	0.73**

*$P < 0.01$.
**$P < 0.001$.
[a] Average intake for high-ED foods chicken nuggets, cookies, and chips.
[b] Average intake for low-ED foods broccoli, grapes, and cherry tomatoes.

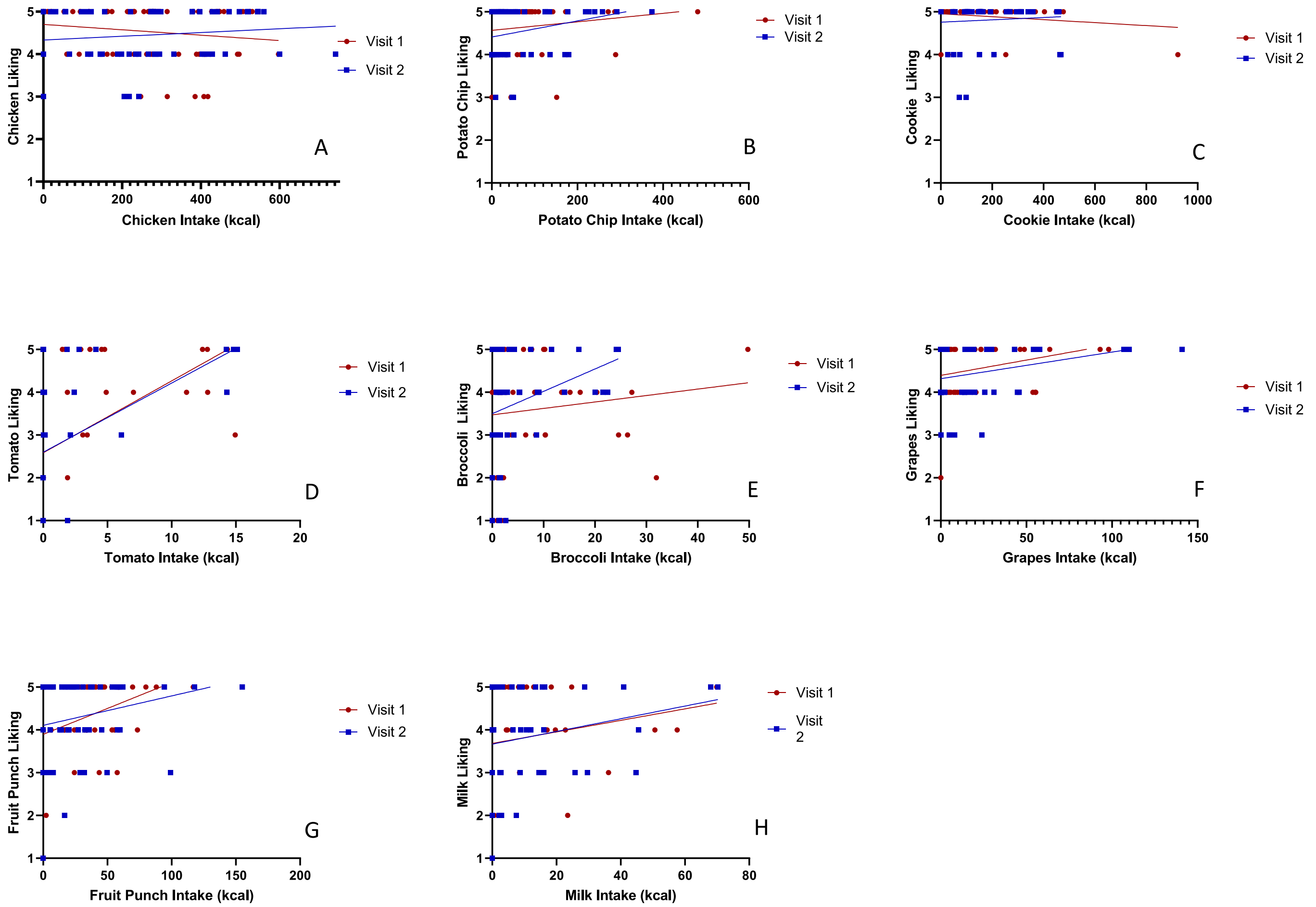

Fig. 2. Relationship between children's rated liking on a 5-point hedonic scale (y-axis) and intake (x-axis) of the meal components on visit 1 (red circles) and visit 2 (blue squares). Data points reflect individual subjects and lines are the regression line of best fit. Spearman's rho correlations were computed between liking and intake. A) Chicken nugget liking was not associated with chicken nugget intake on visit 1 or visit 2 ($p > 0.05$ for both). B) Potato chip intake liking was not associated intake for visit 1 ($p > 0.05$) but was for visit 2 (rho = 0.28, $p < 0.05$). C) Chocolate chip cookie liking was not associated with cookie intake for visit 1 or visit 2 ($p > 0.05$ for both). D) Cherry tomato liking was positively associated with cherry tomato intake for visit 1 (rho = 0.53, $p < 0.001$) and visit 2 (rho = 0.44, $p < 0.01$). E) Broccoli liking was not associated with broccoli intake on visit 1 or 2 ($p > 0.05$ for both). F) Grape liking was associated with grape intake at visit 1 (rho = 0.28; $p < 0.05$) but not visit 2 ($p > 0.05$). G) Fruit punch liking was associated with fruit punch intake at visit 1 (rho = 0.41,$p < 0.01$) but not visit 2 ($p > 0.05$). H) Milk liking was associated with milk intake at visit 1 (rho = 0.34, $p < 0.01$) but not visit 2 ($p > 0.05$). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 6
Associations between children's rated liking and percentage of food and drink uneaten at the meal.

Spearman's rho values between liking and percentage of food/drink uneaten			
Food	Visit 1	Visit 2	Average across both visits
Chicken nuggets	−0.07	0.08	−0.06
Potato chips	−0.37**	0.26	−0.36**
Cookies	−0.19	−0.21	−0.22
Broccoli	−0.24	0.19	−0.22
Cherry tomatoes	−0.55	−0.53**	−0.57***
Grapes	−0.29*	−0.27*	−0.31*
Fruit punch	−0.20	−0.35**	−0.35**
Milk	−0.28*	−0.34**	−0.33*
High-ED foods	−0.15	−0.17	−0.21
Low-ED foods	−0.31*	−0.42**	−0.41**

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

4. Discussion

This study provides insight on children's eating behaviors by showing that hedonic ratings are reliable and are associated with objective measures of food intake at a multi-item meal. Overall, correlations between rated liking and intake were higher for low-ED than high-ED foods, which supports the hypothesis that relationships between liking and intake are strongest among foods that are liked less. These results support observations from adults (de Graaf et al., 2005; Mustonen, Hissa, Huotilainen, Miettinen, & Tuorila, 2007) and a prior study conducted with preschool children which demonstrated stronger correlations between hedonic ratings and food waste in the cafeteria setting that were driven by lack of consumption of less well-liked vegetables (Caporale et al., 2009). A second take home message from this study is that children's hedonic ratings and laboratory intake were highly consistent across the two sessions. Obtaining accurate measures of energy intake has been a perpetual problem for nutrition researchers (Schoeller et al., 2013), especially when the target population is children (Livingstone & Robson, 2007). The observation that children's intake at a laboratory meal is reproducible supports the use of this measure more broadly to characterize dietary patterns and eating behaviors.

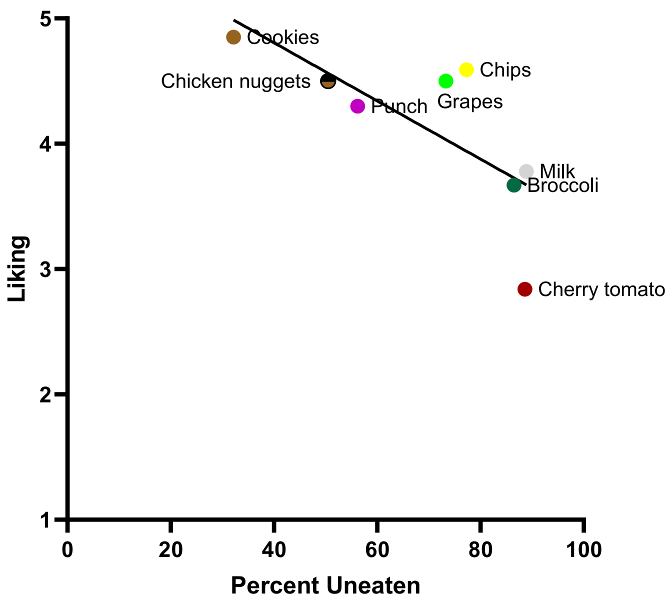

Fig. 3. Relationship between mean rated liking (y-axis) and percent uneaten (x-axis) across visit 1 and visit 2 for children. Overall, liking ratings were associated with percent of food waste ($r = -0.53$; $p < 0.05$). This relationship was more heavily driven by less well-liked, lower energy density foods (i.e., cherry tomatoes and broccoli).

It is widely accepted that liking is an important determinant of intake. Given that, what does the current study add to our understanding of the drivers of children's eating behaviors? First, it is notable that liking *was* a significant predictor of children's intake for almost half of the items children were presented with at the meal. These results were found despite methodological limitations of a 5 point hedonic scale which resulted in a ceiling effect at higher levels of liking. As a result, at higher levels of liking, variance was constrained. Further, in the current study, we compared children's liking of individual foods/beverages to their intake of these items at a combined meal where foods directly competed against one another (i.e., a functional measure of *preference*). Thus, in the context of these measurement constraints, the observation that hedonic ratings were still reasonably predictive of children's intake for some of the meal items is noteworthy. Collecting additional data on rank order preferences for the well-liked items may potentially increase measurement sensitivity. However, this also would have lengthened the protocol substantially and exposed children to a non-inconsequential amount of pre-meal tasting that would subsequently limit *ad libitum* consumption in this age group. Therefore, under circumstances that limit the ability to collect information on rank-order preferences, the Peryam & Kroll 5-point hedonic scale was a reasonably good predictor of the consumption of some test-meal items.

The second contribution this study makes to our understanding of the relationship between liking and intake in children is that it varies by food type, and for some foods, was heteroscedastic. In general, liking was a better determinant of intake of low-ED foods than it was for highly liked main entrée items and cookies (potentially due to the ceiling effects discussed previously). As a result, and as hypothesized, the relationship between liking and intake was heteroscedastic; the variance at the lower end of the liking-intake relationship was lower than the variance at the higher end. In other words, rather than higher liking driving greater intake, these data are most consistent with the interpretation that lower liking ratings led children to avoid some foods and leave them on the plate. The findings presented in Fig. 3 are largely consistent with those reported by Caporale and colleagues (Caporale et al., 2009) in Italian children, where they demonstrated a strong relationship between low liking of vegetables and plate waste in a school cafeteria. The heteroscedastic nature of this relationship may help to explain more broadly why hedonic ratings are a better predictor of children's vegetable intake than they are for intake of other foods, even when accounting for socioeconomic factors and maternal nutrition knowledge (Gibson, Wardle, & Watts, 1998). Because children in the United States continue to consume insufficient amounts of vegetables (Ramsay, Eskelsen, Branen, Armstrong Shultz, & Plumb, 2014), the current findings support intervention strategies to increase vegetable acceptance (de Wild, de Graaf, & Jager, 2015; Farrow et al., 2019). Several effective approaches to increase children's liking of vegetables were reviewed recently by DeCosta and colleagues (DeCosta, Møller, Frøst, & Olsen, 2017), and include social modeling, gardening and cooking programs, and increasing vegetable accessibility within a child's environment. Additional research is needed to identify the most potent strategies for making these interventions more sustainable.

Previous research from Domel and colleagues (Domel et al., 1996) and from Resnikow and colleagues (Resnikow et al., 1997) used self-reported surveys in elementary school aged children (i.e., 7-11 years-old) and found that only 10–13% of reported intake depended on how much children reported liking the fruits and vegetables. These correlations are not as strong as those reported in the present study or in a similar aged population of Italian school children (Caporale et al., 2009). These discrepant findings could be due to differences in the age of children across studies. As children develop more autonomy over their food choices, social influences from peers and the media might supersede the influence of liking on intake. Despite this, the method for assessing both hedonic response and intake is also likely to influence responses across studies. Correlations between liking and intake have been lower in studies that used surveys (Domel et al., 1996; Resnikow et al., 1997) compared to those that measured or estimated intake directly (Caporale et al., 2009; De Graaf & Zandstra, 1999). Even stronger correlations with intake have been reported in studies that measured rank order preference (Baxter & Thompson, 2002; Birch, 1979). This aligns well with research in adults showing that liking of a food relative to other foods at the meal is the strongest determinant of consumption when the portion sizes of all meal components are increased (Roe, Kling, & Rolls, 2016). The practical implication of this is that if the goal is to predict consumption or plate waste, collecting rank order food preferences will allow investigators to more closely achieve this goal than will hedonic ratings of foods presented one at a time.

Whereas intake of some of the meal items was related to liking, it is worth noting that we did not find a significant relationship between children's liking and intake of chicken nuggets, cookies, broccoli, and milk. For both chicken nuggets and cookies, a lack of variance [i.e., the vast majority of children rated them as either a 4 (good) or 5 (super good)] likely explains their weak correlations with intake. Conversely, for both broccoli and milk, the relationship between liking and intake was attenuated by several children who expressed ratings of neutral (3) or lower, yet still showed substantial consumption at the meal. The reasons for this are unclear, but we can offer some speculations. First, there are presumably "health halos" around these two foods, and even though we attempted to limit parental influences by having children eat in a private observation room, it is possible children were still influenced by notions of what their parents would want them to consume at the meal, especially if they may have received such prompts previously (e.g., "finish your milk, Johnny"). Second, intake of both items was relatively low compared to other meal options, and milk specifically competed against another, more popular beverage (i.e., fruit punch). Previously, we found intake of sugar sweetened beverages displaced children's intake of milk at a multi-item, laboratory buffet meal (Keller, Kirzner, Pietrobelli, St-Onge, & Faith, 2009). Here, we found children's liking of milk was negatively associated with percentage of milk left unconsumed, which supports the notion that children who disliked milk simply did not consume it. On a practical note, these data provide additional support that serving competing beverages at a meal may have the unintended consequence of driving down consumption of the lesser liked, potentially more nutritious, choice.

The present study showed moderate to high test-retest reliability for both hedonic ratings and amount and type of food consumed. Laboratory food intake studies are considered to be more objective methods of measuring food intake than self-report questionnaires (Livingston & Black, 2003). A critique of this approach, however, is that it only captures short-term food intake of a limited number of items, and it may not be representative of children's dietary patterns outside the laboratory. Prior to this study, our understanding of the consistency of these measures in younger children was lacking. Two prior studies in adolescents showed high reproducibility for laboratory test-meals in participants who were asked to maintain similar food intake and physical activity patterns for the two days prior to the study (Bellissimo et al., 2008; Thivel et al., 2016). Similar levels of control could not be expected among 4-6 year-old children. In addition to measures of intake, hedonic ratings for biscuits were shown to be unreliable in 4–5 year children (Leon et al., 1999), thus calling into question how informative these measures are in this age group. The current study demonstrated that across two identical laboratory meals conducted under similar (but not identical) conditions, both children's intake and rated liking were similar. This provides support for the notion that laboratory hedonic ratings and test-meals capture children's usual behavior, at least under the constraints presented in the laboratory.

There are a number of strengths and limitations that should be presented to appropriately interpret the present findings. Intake of a range of common foods was assessed under controlled laboratory conditions which is more objective than self-reported questionnaire data. Additionally, hedonic ratings were collected using age-appropriate scales (Chen et al., 1996) in response to children actually tasting small samples of the meal items. This may provide greater validity than having parents rate food liking for preschool-aged children (Stage et al., 2019). Aside from these strengths, there are some limitations to discuss. In regards to the hedonic ratings, we did not have children rank order preferences for the meal items, and it is likely this would have been more strongly related to consumption. In addition to rank order preference, other factors that were not measured that may have influenced results are food insecurity and children's familiarity with consuming the meal items at home. Both could influence children's hedonic ratings and the amount consumed in the lab. In addition, we cannot rule out that weighing children at the beginning of the visit (i.e., prior to the test meal), may have prompted some to think about health, thus altering their eating behavior. Although we had variability in socioeconomic status and education, the families enrolled in this study were predominantly Caucasian, and the findings cannot be generalized to other racial/ethnic groups. We also cannot generalize these findings to other foods, or to more naturalistic eating conditions. Related to this, we served children a limited number of main-meal items, and this may have limited competition between foods within the same category (e.g., different types of proteins). Despite these limitations, the study fills an important gap in regards to understanding of the reliability of laboratory eating behavior measures.

In conclusion, 4-6 year-old children's hedonic ratings are reliable and moderately associated with intake at a multi-item meal that included a limited range of food types. The relation between liking and intake was stronger for low-energy dense foods that are less well-liked. Rather than supporting that children eat what they like, these data are more consistent with the notion that young children avoid what they dislike. Additionally, children consumed consistent types and amounts of foods across two laboratory meals, providing support for the use of these measures to characterize usual eating behaviors in this population. Intervention programs to help increase acceptance of highly disliked foods, like vegetables, are needed to encourage children to consume them and to prevent excess plate waste.

Authors' contributions

Conceptualization, Kathleen Keller, Catherine Shehan and John Hayes; Data curation, Catherine Shehan and Terri Cravener; Formal analysis, Kathleen Keller, Catherine Shehan and Terri Cravener; Funding acquisition, Kathleen Keller; Methodology, Catherine Shehan, Haley Schlechter and John Hayes; Resources, Kathleen Keller; Supervision, Kathleen Keller; Writing – original draft, Kathleen Keller, Catherine Shehan and Terri Cravener; Writing – review & editing, Kathleen Keller, Catherine Shehan, Terri Cravener, Haley Schlechter and John Hayes.

Funding

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Ethics approval and consent to participate

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of The Pennsylvania State University (42708 and August 05, 2013).

Ethics statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of The Pennsylvania State University (42708 and August 05, 2013).

Declaration of competing interest

The authors declare that they have no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2022.105946.

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