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Tactile and smell/taste sensitivity and accepted foods according to sensory properties: a cross-sectional study with children from a reference center in feeding difficulties

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Abstract

Introduction: Children with feeding difficulties are more likely to present sensory sensitivities and detect meaningful changes in the sensory properties of foods and reject new foods. **Objective:** The aims of the study were to identify the top food sources of energy according to children sensitivity profile, and investigate whether there are differences between children sensitivity profile and number of food categories consumed according to their sensory properties. **Methods**: This was a cross-sectional study with 65 children recruited from an outpatient clinic for children with feeding difficulties, Brazil. Socio-demographics and weight status were included to characterize the sample. Sensory processing using the adapted and validated Short Sensory Profile (SSP) and included the tactile and smell/taste processing domains. Parents reported the number and sources of foods/preparations accepted/consumed by their children. Foods accepted were classified according to the adapted "What We Eat in Latin American - WWELA" classification system. Four aspects of sensory properties were subjectively evaluated for all foods accepted in taste, color, consistency, and texture. **Results**: Most of the children with tactile and smell/taste sensitivities were classified as combined probable/definite differences, with 52.3% and 92.3%, respectively. Average number of foods categories accepted was 18.81. Rice, whole milk, and banana were among the top food sources for each of sensory processing domains examined. Only children in smell/taste sensitivity showed significant differences for consuming more fibrous foods, with children under typical performance accepting more foods (28.50 2.12) than combined probable/definite differences (16.86± 5.25). **Conclusion**: Child sensory processing aspects are important when considering the exposure in relation to child acceptance of foods.

Keywords: Food fussiness. Child. Smell. Taste.

Introduction

Feeding difficulties consists of any complaints on the process to supply and consume foods, leading to nutritional deficits and social damages. This dependents on the duration, complexity level, food group limitations,

and, variations on the same group **[1-2]**. The prevalence on feeding difficulties is more common among children at pre-school age, i.e., at the age range from 2 to 5 years of age. Evidence hasshown a prevalence of feeding difficulties up to 45% in healthy children and 80-90% in children that have any condition that might affect their health, for example, autism and children with cleft lips **[1-4]**.

Parents provide a central role in early sensory experiences that cultivate children's preferences **[5]**. The process of perceiving, integrating, and responding to the multitude of sensory information presented during daily environment is defined as sensory processing **[6,7]**. Eating involves the processing of sensory information through various modalities; vision, touch, taste, and, smell. At the early ages of childhood, variations can be seen in their responses to tastants such as bitter, which have been found to be associated with consumption of cruciferous vegetables **[8]**. In some extent, certain aspects of sensory experiences of taste are genetic determined and may affect the variety of foods that individuals eat **[9,10]**. Moreover, early age children vary their responses to different aspects (i.e., taste, color, consistency, and texture) of foods based on the sensory properties. For example, some children may experience problems when consuming more texture fibrous foods (e.g., leaf vegetables, and beef), and consequently **[11]**, increasing their level of food selectivity (and other feeding difficulty types).

Findings at clinical samples have shown that children provide a tactile defense for avoiding or accepting certain foods based on their sensory proprieties **[12,13]**. Children who presented more sensitive sensory have lower bounds for detecting sensory information and are more able to detect meaningful changes in the sensory properties of foods and more likely to reject new foods (i.e., number of foods accepted/consumed). They are more vulnerable to differences in their sensory properties (i.e., differences in how the food look or taste) **[8,12]**. This is a condition more common among children with feeding difficulties, especially among those being picky/fussy eater due to their sensitivities and refuse to eat more new foods, or foods that they have tasted before **[13]**.

This study has two aims: (1) identify the top food sources of energy according to the children sensitivity profile; (2) investigate whether there are differences between children sensitivity profile and number of foods consumed according to their sensory properties. Four main sensory properties were investigated: taste, color, consistency, and texture.

Methods

Participants

Sixty-five children (Mean age 4.53, 95%CI 3.82-5.25years; 36.23% female) were recruited from an outpatient clinic for children with feeding difficulties. Children were eligible to participate if they seek for treatment at the center, had any feeding difficulty complaint, and resided in Brazil. Details on the outpatient clinic protocol can be found elsewhere **[14]**. All study procedures were administered after parents and children ≥7years old gave written consent/assent. The study was approved by the Institutional Review Board from the research institute (CAAE 14668819/1.0000.5567).

Measures

Measures included in the current analysis were pulled from the child's medical record from 2014 to 2019. All the data was collected by clinical dietitian, speech-pathologist and pediatrician following the protocol service of care.

Socio-Demographic Characteristics

Socio-demographic characteristics included in the study were child and parents age, child sex, child place of birth, and, parents' education background. Gestational, neonatal and maternal health issues were asked and included: problems during pregnancy or the first days of infant's life, breastfeeding duration and time of weaning, postpartum depression. Parent's history of feeding difficulties and parent's weightstatus were also included for analysis.

Child Weight Status

Child weight and height were measured and then used to calculate the body mass index (BMI). BMI z-scores were calculated according to age and sex of the child using WHO growth charts reference and standards **[15]**. Child were classified as underweight with a cut-off point ≤ -2 z-score, normal weight >-2 to <1 z-score, overweight >+1 to <+2, and obesity ≥ +2 z-score.

Sensory Processing

The Short Sensory Profile (SSP) is 38-item questionnaire which measures sensory processing in six different domains: auditory, visual, vestibular, touch (tactile), multisensory, and smell/taste processing **[6,7]**. For the purpose of this study, it was only used tactile and smell/taste processing. Evidence has shown that these two domains have been associated with lower intake for fruit and vegetables and to be more reluctant to eat new food **[8]**. It has been validated with both typically developing and neurotypical Brazilian children (

α=0.76 for tactile sensitivity, and α =0.86 for smell/taste sensitivity) **[16]**. Each domain is scored on a 5-point Likert scale, with higher scores indicating better functional and adaptive behaviors. The SSP uses a classification system with cut off values to describe a child's sensory processing abilities into three categories: typical performance, probable, and definite difference. Typical performance indicates that the child performed at or above 1SD below the mean. A value in the "probable difference" category indicates that the child scored at or above 2SD below the mean, but lower than 1SD below the mean. Child classified as "definite difference" scored below 2SD below the mean. The total score for "typical performance", "probable difference", and "definite difference" in children under the domain for tactile sensitivity ranged between 35-30, 29-27, and 26-7 respectively. For the smell/taste sensitivity domain the total score for "typical performance" ranged from 20-15, "probable difference" from 14-12 and "definite difference" from 11-4 **[6,7,17]**. For the purpose of this study, it was combined probable and definite differences given that the lowest % of children in each category. Studies supported the use of combining these categories **[17,18]**.

Sensory Properties

Four aspects of sensory properties were subjectively evaluated by a trained registered dietitian for all foods accepted/consumed by the children. Taste, color, consistency, and texture were evaluated. The five basic tastes were identified as sweet, salty, sour, bitter, and umami **[19]**. Four different colors were identified: (i) yellow/white/orange; (ii) brown; (iii) red/purple/pink; and (iv) green. These characteristics were based on the foods most consumed on these population group **[20,21]**. Consistency was identified based on the level of food thickness in liquid, homogenous pasty, heterogenous pasty, soft, and thick **[22]**. Texture was based into five categories: runny/smooth puree; smooth puree with round lumps; naturally soft; dissolvable hard solids; hard, non-dissolvable; fibrous food; and chewy or sticky foods **[23]**.

Dietary Assessment

Parents completed a food record with three specific columns to report the number and sources of foods/preparations: (i) accepted/consumed, (ii) tried, but not eaten, and (iii) offered by the family, but rejected by the children. This record was developed and validated for the children from the Excellence Center in Feeding Difficulties **[24]** and included comprehensive instructions and examples to help parents understand the level of detail required. Upon completion, food record was reviewed by a registered dietitian (RD) for completeness, detail, and clarity. When necessary, families were contacted by RD to obtain additional information. All participants that completed the SSP were included in the analysis (n=65). This food record was evaluated using the "What We Eat in Latin America (WWELA)" food categorization system for each child as an indicator of energy contribution of the food and beverage categories accepted/consumed **[25,26]**.

The WWELA is an adaptation of the "What We Eat in America" – designed by the NHANES/United States Department of Agriculture to calculate the contribution of energy and nutrients from the food categories **[27]**. Previous consent was given to adapt the WWEIA system to the Latin America context (including Brazil). A database was developed to provide the energy and nutrients of all foods and beverages consumed by both US **[27]** and the Latin American populations **[25,26]** and previous detail on the adaptations can be found elsewhere **[26]**. These databases contain more than 8,000 food items, that is, unique food codes. Under the food category classification system, each food code is assigned to one of the 131 food categories (e.g., "milk, whole", "soups", and "popcorn"), which were organized within subgroups (n=46, e.g., "milk", "mixeddishes – soups", "savory snacks"), and major groups (n=15, e.g., "milk and dairy", "mixed dishes", and "snacks and sweets"). Differently from the Latin American population that target individuals older than 15 years old, the NHANES and the current population target younger children, hence why, three major groups were maintained in the analysis: (i) baby foods; (ii) baby beverages; and (iii) human milk. For the purpose of this study, it was opted to use the "categories" to identify the number of foods accepted/consumed by children according to their sensory processing **[27-29]**.

Data Analysis

Analyses were conducted using SAS on Demands for Academics Dashboard (SAS Institute Inc., 2021). Descriptive statistics of the study sample were calculated as means (standard error) for continuous variables, and frequency (%) for categorical variables. The normality of the distribution was assessed using the skewness distribution for sensory processing variables and distribution was normal. Therefore, ANOVA test was used to test the differences between sensory processing and properties. Mean (95% Confidence Interval - CI) for sensory processing variables were presented. The proportion of the children food sources of energy were calculated. Mean per capita of energy consumed from each food group were expressed as percentage of the total to allow relatively across sensory processing. For all tests, a significant level of 5% ($p<0.05$) were established.

Results

Characteristics of children participating in the study

The characteristics of the children participating in the study are listed in Table 1. A considerable percentage of tactile sensitivity children (52.3%) were classified as combined probable and definite difference and 47.7% were classified as typical performance. The majority of smell/taste sensitivity children (92.3%) were classified as combined probable and definite difference and only 7.7% were typically performed. Average number of food categories accepted/consumed was 18.81 (95%CI 19.90, 20.72) for the overall study sample. Significant differences were only found for those with smell/taste sensitivity, with combined probable and definite difference accepting/consuming more foods (M=17.91, 95%CI 16.07, 19.74) as compared to typical performance (M= 26.60, 95%CI 17.88, 35.32).

Table 1. Socio-demographic characteristics of the study population. Center for Excellence in Nutrition and Feeding Difficulties (n=65), São Paulo, Brazil, 2014-2019.

	Total (n=65)	Tactile sensitivity		Smell/taste sensitivity	
		Typical performance (n=31)	Combined probable and definite difference (n=34)	Typical performance (n=5)	Combined probable and definite difference (n=60)
		Mean (95%CI)			
Maternal Age, years	37.45 (36.29, 38.61)	37.07 (35.46, 38.69)	37.78 (36.05, 39.52)	38.80 (34.20, 43.39)	37.33 (36.09, 38.56)
Child Age, years	4.58 (3.82, 5.36)	4.52 (3.34, 5.70)	4.63 (3.60, 5.66)	7.02 (2.99, 11.04)	4.38 (3.61, 5.15)
Maternal Weight, kg	66.69 (63.74, 69.64)	68.45 (63.50, 73.41)	65.19 (61.49, 68.89)	63.00 (37.79, 88.21)	66.93 (63.86, 70.01)
Maternal Height, cm	1.64 (1.62, 1.66)	1.64 (1.61, 1.67)	1.64 (1.62, 1.66)	1.62 (1.55, 1.68)	1.64 (1.62, 1.66)
Maternal BMI, kg/m^2	24.83 (23.61, 26.04)	25.72 (23.56, 27.89)	24.07 (22.69, 25.44)	24.23 (16.66, 31.79)	24.87 (23.59, 26.15)
Total time breastfeeding, months	11.07 (7.79, 14.35)	12.23 (6.03, 18.43)	10.13 (6.63, 13.62)	**29.20 (-1.39, 59.79)**	**9.36 (6.76, 11.96)** **
EBF time, months	3.15 (2.49, 3.80)	2.78 (1.83, 3.74)	3.48 (2.54, 4.41)	4.20 (1.51, 6.89)	3.06 (2.36, 3.75)
Number of food categories accepted/consumed	18.81 (16.90, 20.72)	17.52 (14.61, 20.44)	19.81 (17.18, 22.45)	**26.60 (17.88, 35.32)**	**17.91 (16.07, 19.74)** *
		Frequency (%)			
History of feeding difficulties, yes	20 (45.45)	11 (50.00)	9 (40.91)	1 (50.00)	19 (45.24)
Siblings, yes	43 (67.19)	17 (56.67)	26 (76.47)	2 (50.00)	41 (68.33)
Child sex, female	22 (33.85)	13 (41.94)	9 (26.47)	2 (40.00)	20 (33.33)
Abortion, yes	6 (33.33)	3 (30.00)	3 (37.50)	0.00	6 (33.33)
Stress pregnancy, yes	17 (32.08)	10 (41.67)	7 (24.14)	4 (100.00)	17 (34.69)
Post-partum depression, yes	5 (11.11)	2 (10.53)	3 (11.54)	4 (100.00)	5 (12.20)
Child place of birth, São Paulo	55 (87.30)	26 (86.67)	29 (87.88)	3 (60.00)	52 (89.66)
Maternal Education Background					
≤ high school	4 (6.35)	3 (10.00)	1 (3.03)	0.00	4 (6.90)
Some college/undergraduate degree	58 (92.06)	27 (90.00)	31 (93.94)	5 (100.00)	53 (91.38)
Graduate degree	1 (1.59)	0.00	1 (3.03)	0.00	1 (1.72)
Parental styles					
Authoritarian	11 (23.40)	3 (15.00)	8 (29.63)	2 (100.00)	9 (20.00)
Authoritative	14 (29.79)	6 (30.00)	8 (29.63)	0.00	14 (31.11)
Indulgent	16 (34.04)	7 (35.00)	9 (33.33)	0.00	16 (35.56)
Uninvolved	6 (12.77)	4 (20.00)	2 (7.41)	0.00	6 (13.33)
Weight status					
Underweight	3 (4.69)	2 (7.41)	1 (2.94)	0.00	3 (5.36)
Normal weight	53 (82.81)	22 (81.48)	30 (88.24)	4 (80.00)	48 (85.71)
Overweight	4 (6.25)	2 (7.41)	2 (5.88)	1 (20.00)	3 (5.36)
Obesity	4 (6.25)	1 (3.70)	1 (2.94)	0.00	2 (3.57)
Type of feeding difficulty					
Picky/fussy eaters	54 (83.08)	25 (80.65)	29 (85.29)	3 (60.00)	51 (85.00)
Food phobia	1 (1.54)	---	1 (2.94)	0.00	1 (1.67)
Poor Appetite	10 (15.38)	6 (19.35)	4 (11.76)	2 (40.00)	8 (13.33)

Note: CI= Confidence Interval
T-tests and chi-square tests showed non-significant associations between groups for most of the variables, with exception for number of foods accepted/consumed and total breastfeeding time and smell/taste sensitivity (* p<0.05)

Source: Own Authorship.

Energy Top Food Sources

Table 2 shows the dietary sources of energy consumed from the food categories system. The top three food sources in the tactile sensitivity domains spectrum consumed by typical performance children were rice (17.47%), milk, whole (12.30%), and banana (10.29%) and for combined probable and definite difference children were beef, exclude ground (10.64%), milk, whole (10.21%), and rice (9.82%). Foods consumed in the smell/taste sensitivity were for the typical performance beef, exclude ground (28.82%), banana (22.98%), and nuts and seeds (20.75%) and for combined probable and definite difference were rice (13.54%), milk, whole (12.59%), and formula prepared concentrated (8.11%).

Table 2. Top five food sources* of energy (kcal)† consumed by children with feeding difficulties according to their sensorial profile. Excellence Center in Nutrition and Feeding Difficulties, São Paulo, Brazil, 2014-2019.

Rank	Main group	Sub-group	Category	Cons	PCT
		Total Sample (n=65)			
1	Sweets and snacks	Candy	Candy, not containing chocolate	57	5.48
2	Sweets and snacks	Sweet bakery products	Cookies and brownies	54	4.63
3	Grains	Bread, rolls, tortillas	Yeast breads	42	3.76
4	Fruits	Fruits	Other fruits/fruit salads	44	3.56
5	Milk and dairy	Yogurt	Yogurt, regular	23	3.21
		Tactile Sensitivity			
		Typical Performance (n=31)			
1	Grains	Cooked grains	Rice	4	17.47
2	Milk and dairy	Milk	Milk, whole	3	12.30
3	Fruits	Fruits	Banana	2	10.29
4	Vegetables	White Potatoes	French fries and other fried potatoes	1	10.02
5	Baby food and formulas	Infant formula	Formula prepared from concentrated	2	9.28
		Combined probable and definite difference (n=34)			
1	Protein foods	Meats	Beef, exclude ground	2	10.64
2	Milk and dairy	Milk	Milk, whole	3	10.21
3	Grains	Cooked grains	Rice	3	9.82
4	Beverages non-alcoholic	100% Fruit Juices	Citrus juice	1	6.43
5	Fruits	Fruits	Banana	2	6.19
		Smell/taste Sensitivity			
		Typical Performance (n=5)			
1	Protein foods	Meats	Beef, exclude ground	1	28.82
2	Fruits	Fruits	Banana	1	22.98
3	Protein foods	Plant-based proteins	Nuts and seeds	1	20.75
4	Condiments and sauces	Condiments and sauces	Olives, pickles, and pickled vegetables	1	15.72
5	Grains	Cooked grains	Rice	1	11.73
		Combined probable and definite difference (n=65)			
1	Grains	Cooked grains	Rice	6	13.54
2	Milk and dairy	Milk	Milk, whole	6	12.59
3	Baby food and formulas	Infant formula	Formula prepared from concentrated	3	8.11
4	Fruits	Fruits	Bananas	3	6.18
5	Grains	Cooked grains	Pasta, noodles, cooked grains	2	5.53

Cons: number of times foods have been consumed by the entire population;
PCT: percentage of contribution. The five highest ranked food categories according to percentage of contribution to total energy intake. †To convert to KJ, multiple kcal values by 4.184.

Sensorial Profile And Accepted/Consumed Foods

Although non-significant differences for the majority of the variables, children had a preference for sweet taste, yellow/orange/white color, and solid foods for each sensitivity profile. Typical performance children were consuming a higher number of food categories for each sensitivity profile. None of the children had a preference for bitter and sour tastes, and green foods. Only children in the smell/taste sensitivity profile showed significant differences for number of accepted foods, with typical performance children accepting more fibrous foods (M=28.50± SD 2.12) as compared to combined probable/definite category (M=16.86± SD 5.25) ($p<0.05$) (Table 3).

Table 3. Sensorial profile and accepted/consumed foods by children with feeding difficulties according to their sensory process. Center for Excellence in Nutrition and Feeding Difficulties, PENSI Institute, São Paulo, Brazil, 2014-2019.

	Tactile Sensitivity				Smell/taste sensitivity			
	Typical Performance		Combined probable and definite difference		Typical Performance		Combined probable and definite difference	
	N of children accepted food categories	N of foods accepted ±SD	N of children accepted food categories	N of foods accepted ±SD	N of children accepted food categories	N of foods accepted ±SD	N of children accepted food categories	N of foods accepted ±SD
Taste								
Sweet	9	17.44±4.76	14	16.71±3.77	1	25.00	22	16.64±3.79
Savory	7	18.86±9.19	7	22.71±9.60	2	25.00±13.44	12	20.00±8.94
Sour	0	0.00	0	0.00	0	0.00	0	0.00
Bitter	0	0.00	0	0.00	0	0.00	0	0.00
Umami	5	15.80±5.12	5	24.00±5.66	2	28.50±2.12	8	17.75±5.49
Color								
Yellow/Orange/White	19	16.58±5.25	17	18.00±4.81	2	20.50±6.36	34	17.06±5.01
Brown	1	18.00	5	22.00±6.40	2	28.50±2.12	4	17.75±2.50
Red/Purple/Pink	1	35.00	5	23.80±10.62	1	35.00	5	23.80±10.62
Green	0	0.00	0	0.00	0	0.00	0	0.00
Consistency								
Liquid	5	15.20±3.89	7	16.71±4.27	0	0.00	12	16.08±4.01
Puree homogenous	5	15.20±4.96	3	25.33±5.68	1	30.00	7	17.43±6.02
Puree heterogenous	4	15.25±5.74	3	22.33±4.16	0	0.00	7	18.29±6.05
Soft	2	24.00±1.41	4	13.25±5.85	1	25.00	5	15.20±6.68
Solid	9	18.67±7.97	12	22.33±6.51	3	26.00±9.54	18	19.89±6.71
Texture								
Runny and smooth puree	5	15.20±3.89	7	16.71±4.27	0	0.00	12	16.08±4.01
Smooth puree and rounded lumps	2	16.50±2.12	2	14.00±9.90	0	0.00	4	15.25±6.02
Naturally soft	4	22.75±5.56	2	18.00±2.83	1	25.00	5	20.40±5.32
Dissolvable "hard" solids	1	18.00	2	24.50±13.44	0	0.00	3	22.33±10.21
Hard non-soluble	3	21.33±11.93	4	23.25±8.26	2	25.50±13.43	5	21.20±8.49
Fibrous foods	1	9.00	8	20.75±6.09	**2**	**28.50±2.12**	**7**	**16.86±5.27***
Chewy or sticky foods	5	15.40±4.98	2	23.00±5.66	0	0.00	7	17.57±5.97

SD: Standard Deviation
ANOVA tests were used to verify possible differences between sensorial profile and number of foods accepted/consumed according to foods sensory process.
* p<0.05; ** p<0.01; *** p<0.001

Discussion

The main purpose of this study was to examine whether child sensory processing was associated to their accepted/consumed foods according to its sensory profiles (i.e., taste, color, consistency, texture). Sensory processing was associated with the number of food categories that children accepted to eat, with significant association with one sensory processing domain on the SSP; smell/taste sensitivity. This result supports the hypothesis that children who are more sensitive to stimuli, might be less likely to eat adequate amounts for certain food groups. Moreover, children with feeding difficulties, especially those classified as picky/fussy eaters, have been shown to have variations in different sensory processing domains **[30,31]**.

The current study presents similar results with a previous one with parents of 95 British children of 2-5years old **[8]**, that demonstrated the parental reports of selective eating associated with sensitivity in smell/taste and tactile domains, but not in the domain of visual/auditory processing. This does not align with the theory that children may notice small visual changes in foods and reject foods according to these changes. Questions in the visual/auditory domain of the SSP might not accurately measure differences in the ability to focus on small local changes in objects, rather sensitivity to light perceptions. Children that reject foods according to visual changes, for example, color differences, will also accept food based on color similarities (e.g., rice, milk, and banana) **[32-34]**. The ability to detect changes may not influence on the acceptance of foods, but the cognitive expectation of what these changes mean **[32]**.

There current study showed associations between children's sensory processing and textures preferences, i.e., soft/smooth or lumpy foods (e.g., Baby cereals, French fries/other fried potatoes, and pasta). The association between texture preference and food selectivity corroborates with previous studies **[33,34]** and seems reasonable for what is in line with previous literature. Hard-liker children are predominantly characterized by neophobic attitudes towards food[34]. Thus, further studies are needed to better understand the interplay between perceptive, psychological, and environmental factors underlying PFDs differences in texture perception and preferences.

Children with feeding difficulties sensory processing sensitivities may be influenced by the way that they approached sensory properties of the foods through scrutiny different sense modalities. Evidence has found a link between children with an increased sensory sensitivity and choosing foods with similar patterns (e.g., foods with same colors, texture, and flavor) leading to aversion to other foods **[33,35]**. It is well known that sensory processing have a deep influence on the children's lives, leading them to place control over their sensory input and their sensory world **[36]**. Thus, children under these conditions might have the ability to distinguish subtle differences in food types, that most people would not be able to discriminate, which are mostly a source of amazement and disbelief among parents **[35]**. Child choosing similar patterns of foods have been found in studies focusing on sensory sensitivity investigating the textures of food, and tactile sensitivity **[37]**. Perceiving subtle differences in food, despite it appearing and looking the same to most of the child, is one aspect of sensory sensitivity that frequently led parents somewhat frustrated. Sensory play interventions, for example, messy play therapy **[38]** might provide potential solutions to these issues and help improve mealtime interactions and provide much-

needed parent support.

Whilst the findings of this study add to the important body of knowledge concerning the causes and development of feeding difficulties in children, this study is not without limitations. The sample size is small and the data collected was cross-sectional and based on parental report, further research is needed using large sample sizes **[22]**, observational longitudinal **[39]** and clinical trials **[40]** to replicate these findings and develop an understanding of these associations. Moreover, the sample was from participants with a particular clinical condition (i.e., feeding difficulties), and thus may be biased by a greater interest in child eating than the general population. Despite these limitations, this research does strengthen the finding that there are child contributors to problematic feeding behaviors, and may be based in inherent, cognitive, and other features of the child. Little is known about how children with feeding difficulties acts in terms of different sensory stimulus and accepted/consumed foods based on sensory properties. Future work is needed to explore how and why accepted/consumed foods and sensory process may develop and how their development may be informed by specific experiences with food or exposure to parents' feeding practices (e.g., force-eating, and chocking)

Conclusion

Although non-significant results for most of the variables evaluated, findings from the present study indicate that child sensory processing aspects are important when considering the exposure in relation to child acceptance/consumption of foods. These findings, whilst interesting required further investigation, with validation from behavioral measures, before we can fully understand the role of sensory processing style in the acceptance or rejection of foods in children with feeding difficulties.

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Ethical Approval

The study was approved by the Institutional Review Board from the research institute (CAAE 14668819/1.0000.5567).

Informed consent

All study procedures were administered after parents and children ≥7years old gave written consent/assent.

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Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

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References

1. Kerzner B. Clinical Investigation of Feeding Difficulties in Young Children: A Practical Approach. Clinical Pediatrics. 2009;48(9):960-5. doi: 10.1177/0009922809336074.
2. Kerzner B, Milano K, MacLean WC, Berall G, Stuart S, Chatoor I. A Practical Approach to Classifying and Managing Feeding Difficulties. Pediatrics. 2015;135(2):344. doi: 10.1542/peds.2014-1630.
3. Bryant-Waugh R, Markham L, Kreipe RE, Walsh BT. Feeding and eating disorders in childhood. International Journal of Eating Disorders. 2010;43(2):98-111. doi: https://doi.org/10.1002/eat.20795.
4. Hubbard KL, Anderson SE, Curtin C, Must A, Bandini LG. A Comparison of Food Refusal Related to Characteristics of Food in Children with Autism Spectrum Disorder and Typically Developing Children. Journal of the Academy of Nutrition and Dietetics. 2014;114(12):1981-7. doi:10.1016/j.jand.2014.04.017.
5. Forestell CA. You Are What Your Parents Eat: Parental Influences on Early Flavor Preference Development. Nestle Nutr Inst Workshop Ser. 2020;95:78-87. doi:10.1159/000511516.
6. Dunn W, Brown C. Factor analysis on the Sensory Profile from a national sample of children without disabilities. Am J Occup Ther. Jul-Aug 1997;51(7):490-5; discussion 496-9. doi:10.5014/ajot.51.7.490.
7. Dunn W. Performance of typical children on the Sensory Profile: an item analysis. Am J Occup

Ther. Nov-Dec 1994;48(11):967-74. doi:10.5014/ajot.48.11.967

8. Coulthard H, Blissett J. Fruit and vegetable consumption in children and their mothers. Moderating effects of child sensory sensitivity. Appetite. Apr 2009;52(2):4105. doi:10.1016/j.appet.2008.11.015.
9. Chamoun E, Mutch DM, Allen-Vercoe E, et al. A review of the associations between single nucleotide polymorphisms in taste receptors, eating behaviors, and health. Crit Rev Food Sci Nutr. Jan 22 2018;58(2):194-207. doi:10.1080/10408398.2016.1152229.
10. Chamoun E, Carroll NA, Duizer LM, et al. The Relationship between Single Nucleotide Polymorphisms in Taste Receptor Genes, Taste Function and Dietary Intake in Preschool-Aged Children and Adults in the Guelph Family Health Study. Nutrients. Jul 29 2018;10(8)doi:10.3390/nu10080990.
11. Hormann-Wallner M, Krause R, Alfaro B, et al. Intake of Fibre-Associated Foods and Texture Preferences in Relation to Weight Status Among 9-12 Years Old Children in 6 European Countries. Front Nutr. 2021;8:633807. doi:10.3389/fnut.2021.633807.
12. Farrow CV, Coulthard H. Relationships between sensory sensitivity, anxiety and selective eating in children. Appetite. Jun 2012;58(3):842-6. doi:10.1016/j.appet.2012.01.017.
13. Cunliffe L, Coulthard H, Williamson IR. The lived experience of parenting a child with sensory sensitivity and picky eating. Matern Child Nutr. Feb 23 2022:e13330. doi:10.1111/mcn.13330.
14. Maximino P, Machado RHV, Junqueira P, et al. How to monitor children with feeding difficulties in a multidisciplinary scope?: Multidisciplinary care protocol for children and adolescents. Journal of Human Growth and Development. 2016;26:331-340.
15. De Onis M. Curvas de Referência da Organização Mundial da Saúde. 2015.
16. Mattos JC, D'Antino MEF, Cysneiros RM. Evidences of reliability and validity of the sensory assessment instrument Sensory Profile: a preliminary study. Psicologia: teoria e prática. 2019;21:99-121.
17. Crasta JE, Salzinger E, Lin M-H, Gavin WJ, Davies PL. Sensory Processing and Attention Profiles Among Children With Sensory Processing Disorders and Autism Spectrum Disorders. Original Research. Frontiers in Integrative Neuroscience. 2020-May-05 2020;14doi:10.3389/fnint.2020.00022.
18. van der Linde J, Franzsen D, Barnard-Ashton P. The sensory profile: Comparative analysis of children with Specific Language Impairment, ADHD and autism. South African Journal of Occupational Therapy. 2013;43:34-40.
19. Hartley IE, Liem DG, Keast R. Umami as an 'Alimentary' Taste. A New Perspective on Taste Classification. Nutrients. 2019;11(1):182. doi:10.3390/nu11010182.
20. Reedy J, Krebs-Smith SM. Dietary sources of energy, solid fats, and added sugars among children and adolescents in the United States. J Am Diet Assoc. Oct 2010;110(10):1477-84. doi:10.1016/j.jada.2010.07.010.
21. Keast DR, Fulgoni VL, 3rd, Nicklas TA, O'Neil CE. Food sources of energy and nutrients among children in the United States: National Health and Nutrition Examination Survey 2003-2006. Nutrients. Jan 22 2013;5(1):283-301. doi:10.3390/nu5010283.
22. Faerber EC, Stein AD, Webb Girard A. Portion size and consistency as indicators of complementary food energy intake. Matern Child Nutr. Apr 2021;17(2):e13121. doi:10.1111/mcn.13121.
23. Cichero JAY. Unlocking opportunities in food design for infants, children, and the elderly: Understanding milestones in chewing and swallowing across the lifespan for new innovations. J Texture Stud. Aug 2017;48(4):271-279. doi:10.1111/jtxs.12236
24. Ribeiro LW, Ricci R, Maximino P, et al. Clinical use of a food inventory to identify maternal underreport on children's food intake: Experience of a reference center in Brazil. Nutricion Clinica y Dietetica Hospitalaria. 01/01 2018;38:81-89. doi:10.12873/381LRibeiro.
25. Leme ACB, Fisberg RM, Mello AV, et al. Food Sources of Shortfall Nutrients among Latin Americans: Results from the Latin American Study of Health and Nutrition (ELANS). Int J Environ Health Res Pub Health. 2021.
26. Fisberg RM, Leme ACB, Previdelli A, et al. Contribution of food groups to energy, grams and nutrients-to-limit: the Latin American Study of Nutrition and Health/Estudio Latino Americano de Nutricion y Salud (ELANS). Public Health Nutr. Jun 2021;24(9):2424-2436. doi:10.1017/S136898002100152X.
27. Rhodes DG, Adler ME, Clemens JC, Moshfegh AJ. What we eat in America food categories and changes between survey cycles. Journal of Food Composition and Analysis. 2017/12/01/ 2017;64:107-111. doi:https://doi.org/10.1016/j.jfca.2017.07.018

28. Leme AC, Baranowski T, Thompson D, et al. Top food sources of percentage of energy, nutrients to limit and total gram amount consumed among US adolescents: National Health and Nutrition Examination Survey 2011-2014. Public Health Nutr. Mar 2019;22(4):661-671. doi:10.1017/S1368980018002884.
29. Leme AC, Baranowski T, Thompson D, et al. Food Sources of Shortfall Nutrients Among US Adolescents: National Health and Nutrition Examination Survey (NHANES) 2011-2014. Fam Community Health. Jan/Mar 2020;43(1):59-73. doi:10.1097/FCH.0000000000000243.
30. Taylor CM, Emmett PM. Picky eating in children: causes and consequences. Proc Nutr Soc. May 2019;78(2):161-169. doi:10.1017/S0029665118002586.
31. Walton K, Kuczynski L, Haycraft E, Breen A, Haines J. Time to re-think picky eating?: a relational approach to understanding picky eating. The international journal of behavioral nutrition and physical activity. 2017;14(1):62-62. doi:10.1186/s12966017-0520-0.
32. Nicklaus S. The role of food experiences during early childhood in food pleasure learning. Appetite. Sep 1 2016;104:3-9. doi:10.1016/j.appet.2015.08.022.
33. Smith AM, Roux S, Naidoo NT, Venter DJ. Food choice of tactile defensive children. Nutrition. Jan 2005;21(1):14-9. doi:10.1016/j.nut.2004.09.004.
34. Laureati M, Sandvik P, L. Almli V, et al. Individual differences in texture preferences among European children: Development and validation of the Child Food Texture Preference Questionnaire (CFTPQ). Food Quality and Preference. 2020/03/01/ 2020;80:103828. doi:https://doi.org/10.1016/j.foodqual.2019.103828.
35. Cunliffe L, Coulthard H, Williamson IR. The lived experience of parenting a child with sensory sensitivity and picky eating. Matern Child Nutr. Feb 23 2022:e13330. doi:10.1111/mcn.13330.
36. Green SA, Ben-Sasson A. Anxiety disorders and sensory over-responsivity in children with autism spectrum disorders: is there a causal relationship? Journal of autism and developmental disorders. 2010;40(12):1495-1504. doi:10.1007/s10803010-1007-x.
37. Nederkoorn C, Jansen A, Havermans RC. Feel your food. The influence of tactile sensitivity on picky eating in children. Appetite. Jan 2015;84:7-10. doi:10.1016/j.appet.2014.09.014.
38. Chiatto F, Coletta R, Aversano A, Warburton T, Forsythe L, Morabito A. Messy Play Therapy in the Treatment of Food Aversion in a Patient With Intestinal Failure: Our Experience. JPEN J Parenter Enteral Nutr. Mar 2019;43(3):412-418. doi:10.1002/jpen.1433.
39. Li Z, Sturge-Apple ML, Davies PT. Family context in association with the development of child sensory processing sensitivity. Dev Psychol. Dec 2021;57(12):2165-2178. doi:10.1037/dev0001256.
40. Tournier C, Bernad C, Madrelle J, et al. Fostering infant food texture acceptance: A pilot intervention promoting food texture introduction between 8 and 15 months. Appetite. Mar 1 2021;158:104989. doi:10.1016/j.appet.2020.104989.

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