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Review Article

Visual Perception Cues, Emotional Responses, and Children's Health: A Systematic Review

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ABSTRACT

Children's well-being and health have received significant social attention. Given the increasing prevalence of food neophobia, obesity, and related health challenges in children, it is critical to understand the importance and urgency of raising children to choose healthy foods.This review explores the complex relationships among children's visual cues, emotion, liking and food choices, providing important insights into potential health interventions. A systematic search was conducted using three databases: PubMed, Scopus, and Web of Science. Studies published up to December 25, 2023 (from the start of each database) were included. To ensure that the studies were of good quality, the Mixed Methods Appraisal Tool (MMAT) was used for assessment. 17 eligible studies that used different research methods, six used a within-subject design, one used a discrete choice experiment, one used a pretest-post test design, four used mixed methods research, three used observational studies, and one used a longitudinal design. These studies examined topics ranging from visual perception to emotional response, with six studies examining all three aspects. This study investigated the complex effects of children's visual cues, emotions, and food choices, thereby providing important insights into potential health interventions. The shape of the food elicited a more positive emotional response than unvarying shapes. Several studies have also shown that children not only have preferences for the food itself but also consider factors such as the type, shape, and color of the food. Future research should draw new conclusions to guide relevant interventions aimed at promoting healthy food choices among children.

Keywords: Visual perception; shape; color; size; liking; emotion; food choice.

1. Introduction

Children's well-being and health have consistently attracted societal attention. Given the increasing prevalence of childhood food neophobia, obesity, and associated health challenges, it is crucial to understand the significance and immediacy of fostering a nutritious diet in children. Research indicates that extended periods of lack of vegetable and fruit intake during childhood can result in negative health outcomes, such as food neophobia (Cooke et al., 2003; Birch, 1999), obesity (Ogden et al., 2003), diabetes, cardiovascular diseases, and other chronic conditions, until adulthood (Mikkila et al., 2004; Magarey et al., 2003; Berenson et al., 1992). In addition, unhealthy eating behaviours may affect academic achievement and cognitive development (Murphy et al., 1998). Furthermore, the naturally bitter taste of vegetables, which leads to human instincts to avoid food poisoning (Cooke et al., 2003; Birch, 1999), means that vegetables remain the least popular food group, especially among school-aged children (Lanfer et al., 2011; Phillips & Kolasa, 1980; Beyer & Morris, 1974). Considering that fruit and vegetable consumption patterns continue into adulthood (Lien et al., 2001;

Krebs-Smith et al., 1996), investigating the influence of children's perceptions of healthy foods such as vegetables and fruits is of prime importance.

Research on the intersection of children's emotions and healthy eating is a growing field. The role of food as an emotion regulator can be understood by examining the impact of emotions on individuals (Hamburg et al., 2014). Emotional responses affect the choice of food (Moss et al., 2021; Gutjar et al., 2015; Gibson, 2006), which in turn affects children's health. The relationship between emotions and diet has received theoretical and empirical support (Prinyawiwatkul, 2020; Canetti et al., 2002). Studies have indicated that positive and negative emotions have significant effects on food choices and dietary intake, especially in children. Additionally, research suggests that negative emotions such as anxiety and sadness may contribute to unhealthy eating habits, whereas positive emotions are linked to a more nutritious diet. Frequent emotions such as happiness and anger appear to have a greater effect on food intake (Canetti et al., 2002). Patel and Schlundt (2001) found that individuals tended to consume larger meals when experiencing either positive or negative emotions than when experiencing a neutral mood. In particular, the influence of positive emotions on food intake was more pronounced than that of negative emotions. Similarly, motivation to eat increases during happy states, as opposed to sad states (Gardner et al., 2014; Macht et al., 2002; Macht,1999). Macht et al. (2002) reported that chocolate is perceived as more enjoyable when individuals experience positive emotions. Taken together, these findings suggest a significant relationship between emotional state and eating behaviour, with positive emotions playing a prominent role in influencing both the amount and enjoyment of food consumption. Exposure to yoghurt triggers stronger positive emotions such as pride, hope, happiness, contentment, and fascination (Yao,2016). White and gold dinner plates trigger positive dining emotions (Chen et al. 2020). Food on a white plate appears to produce more pleasant emotions than food on red or green plates (Zhao et al., 2018). Observing someone exhibiting disgust is likely to evoke a sense of disgust in individuals, consequently resulting in diminished inclination among participants to consume the presented food (Barthomeuf, 2009).

Visual cues in this research refer to those related to food and micro-landscapes, which include the food itself, its shape, color, portion size, and plating (Zampollo et al., 2012a, 2012b). Additionally, external cues of food, such as packaging color and shape, tableware shape, size, and color, are also considered (Zhao et al., 2018; Stewart & Goss, 2013). Visual cues, including color, and shape (Piqueras-Fiszman et al., 2012) have received considerable research attention in the field of food. Color and shape have been the subject of frequent investigations (Spence & Van Doorn, 2022; Chen et al., 2020). Researchers have manipulated and studied color and shape within the food itself (Harrar & Spence, 2013) and in the context of packaging design (Veflen et al., 2023).

These findings strongly indicate a relationship between visual cues and eating behaviours as well as emotions. However, few previous scientific studies have conducted systematic literature reviews, particularly in the context of children. Therefore, there is a lack of research on the potential influence of visual cues and emotions on healthy food choice in children. Consequently, a systematic literature review is necessary to determine the significant correlations between visual cues, emotions, and healthy food choices in children.

2. Methods

2.1 Protocol registration

The current systematic review protocol has been registered with the International Prospective Register of Systematic Reviews (PROSPERO) under registration number (CRD42024497158). This review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, ensuring rigorous and transparent reporting throughout the systematic review process.

2.2 Search strategy

Studies published until December 25, 2023, from three electronic databases: PubMed, Scopus, and Web of Science.

2.3 Study Eligibility Criteria

The following eligibility criteria were applied: (a) inclusion of original, peer-reviewed research conducted in either the general or clinical population and published in English; (b) studies involving children reporting measures related to visual perception, visual cues, emotion, or affect; (c) research focused on a sample of children between the ages of 4 and 14 years; and (d) studies specifically involving children without concurrent medical conditions. Exclusion criteria were as follows: (a) articles published in languages other than English; (b) reviews, conference proceedings, books, chapters, and commentaries; (c) studies conducted on infants and adults; (d) reliance on parental reports; and (e) investigations conducted on non-human samples. The keywords used for the literature search are shown in Table 1.

Table 1 The keywords used for the systematic review.

"child*" OR "school child*"
AND
"Visual cues" OR "visual clues" OR "colour" OR "color" OR "shape" OR "size" or "tableware" OR "plate*" OR "Cutlery" OR" dish*" OR "bowl" OR "cup" OR "glass"
AND
"emotion" OR "mood" OR "feelings" OR "emotion measurement" OR "emotion recognition" OR "emotional design" OR "emotional eating" OR "affect*"
AND
"choice" OR "food choice" OR "food" OR "vegetable"

2.4 Study selection

Two reviewers, XQT and SKG, independently gathered information by searching three electronic databases and trial registries, then organized the records using EndNote. After removing duplicate entries, they screened the relevant studies by looking at the titles and abstracts. They then reviewed the full texts to check if the studies were suitable for inclusion. Any differences in their opinions were discussed between the two reviewers. If they could not agree, a third reviewer, SFAS, was consulted for help.

2.5 Synthesis and Analysis of Data

Data from eligible studies were extracted into a standardised data collection form by two researchers (XQT and SKG) and any differences were adjudicated by the supervisor (SFAS). Each included study provided information on heterogeneity concerning the study design, population, and outcome measures. Subsequently, a synthesis was undertaken to summarise the findings on the relationships among children's eating experiences, food choices, visual cues, and emotions. Patterns and trends in the results were identified. Additionally, details such as age range, gender, emotion type (e.g. positive or negative emotions), and emotion measurement were identified to enhance the understanding of the relationship between visual cues, healthy food choices, and emotion/affect in childhood. Finally, the study's evidence strength and consistency were assessed to ensure a rigorous and transparent systematic review process adhering to the PRISMA.

2.6 Risk of bias in individual studies

Two reviewers XQT and SKG, independently assessed the risk of bias of the included studies. The methodological quality of all included studies was assessed using the Mixed Methods Appraisal Tool (MMAT) (Hong et al., 2018), which was designed to evaluate empirical studies using quantitative, qualitative, and mixed methods. The quality of each study was assessed by two independent reviewers, and disagreements were resolved by discussion, consensus, or consultation with a third reviewer for the final assessment.
The checklist includes two initial questions common to all study designs, and five quality-related questions specific to each study type. These questions assessed aspects such as the representativeness of participants concerning the target population, appropriateness of measures for both outcomes and interventions, and the effective integration of different study components to address the research question. Each criterion was scored as 'yes,' no', or 'not applicable', with guidance on identifying the study type and item specifications provided.

According to Hong et al. (2018), if either or both eligibility criteria are not answered affirmatively, proceeding with the evaluation of the article might be deemed inappropriate. Additionally, only questions pertinent to the specific design of each study were evaluated.

3. Results

Figure 1 shows that of the 4,260 potential articles found in electronic databases and trial registers, 2,325 duplicate records and 6 non-English articles were removed. This left only 1,929 articles, but 1,881 of them were excluded based on title and abstract. After reviewing the full text, 31 articles were excluded from the original 48. Finally, 17 studies met all the criteria for this review. PRISMA guidelines were followed to select and extract articles.

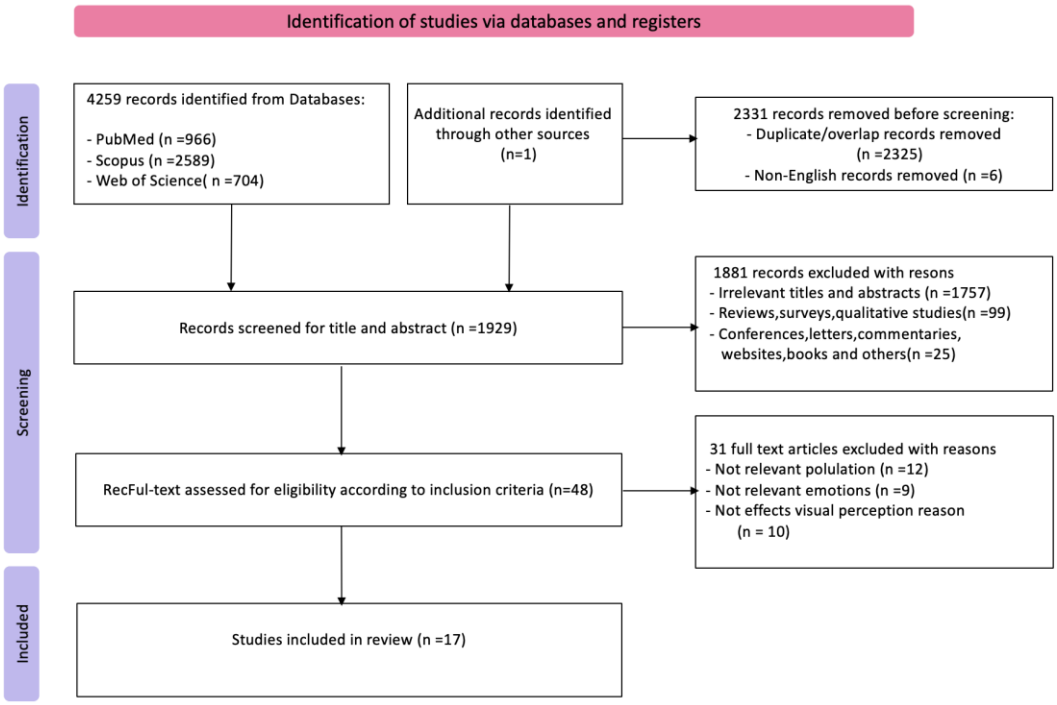

Fig. 1. PRISMA flow diagram of the study selection process.

3.1 Study Characteristics

Of the 17 eligible studies that used different research methods, six used a within-subject design, one used a discrete choice experiment, one used a pretest-post test design, four used mixed methods research, three used observational studies, and one used a longitudinal design. These studies examined topics ranging from visual perception to emotional response, with six studies examining all three aspects. In addition, research in this area has been conducted in various countries, including Australia, the USA, the UK, Denmark, Turkey, Spain, France, Belgium, Brazil, and Italy. The characteristics of these studies are summarised in Table 2.

3.2 Sample Characteristics

The sample size varied among studies, ranging from a minimum of 23 participants to a maximum of 2112 participants. The studies were sex-balanced. The age range of the participants varied, but each study included students aged between five and 12 years (Table 2). Of the 17 articles, 13 examined sex differences.

Table 2 Study Characteristics

Authors	Year	Country	Aim	Sample			key Findings
				N	Age	Gender	
Liem and Zandstra	2009	Turkey	Investigate the shape and flavour influence Children's liking and wanting of snack products	242	7-12	120 boys, 122 girls	Children's preference for large-sized snack foods is more likely to decrease after daily consumption than for identically flavoured small-sized snacks.
de Droog et al.	2012	Netherlands	Investigate whether unfamiliar characters are as effective as familiar characters in stimulating children's affective responses toward healthy foods.	166	4-6	51% boys, 49% girls	Unfamiliar characters were as effective as familiar characters in enhancing children's automatic affective responses.
Zampollo et al.	2012a	USA	Test the degree to demonstrate different preferences for various ways in which food can be presented on plates.	23	5-12	8 boys, 15 girls	Children tended to prefer seven different items and 6 different colours on their ideal plates.
Zampollo et al.	2012b	USA	Assess importance of microenvironmental cues that impact childhood food consumption.	23	5-12	8 boys, 15 girls	Children appear to favor significantly more items and colors on a given plate compared with adults.
Harrist et al.	2013	USA	Examine the associations between 2 types of emotion regulation and 2 types of non–hunger-based eating.	740	Grade 2-3	51% boys, 49% girls	Examined emotion regulation with emotional and external eating in children. Links between negative effects and unhealthy eating patterns.
Bergamaschi et al.	2016	Denmark	Investigate if the CV and PV choice varieties influence acceptance and intake of snack servings in a similar way in Danish school-aged children.	132	9-11	69 boys, 63 girls	Fruits, nuts, and vegetables at school may enhance children's familiarity, liking, and intake. Positively impact consumption in children and promote healthy eating.
Gallo et al.	2017	USA	To compare children's liking and emotional responses to food images and actual foods.	111	7-11	balance	Actual foods showed increased positive emojis and decreased negative for food appearance and post-taste emotions.
Schouteten et al.	2018	Belgium	Examine whether emoji can be applied to obtain discriminating emotional profiles for traditional Belgian biscuits.	149	11-13	18% boys, 82%girls	Emoji can be used as an alternative means of emotional profiling with children and their inclusion helps to better predict actual food choice.

Authors	Year	Country	Aim	Sample			key Findings
				N	Age	Gender	
Van et al.	2019	14 countries Asia, America, and Europe	Evaluate the 2016 International Chefs Day cooking workshops Art on a Plate.	433	4-14	45% boys, 55% girls	Cooking a meal increased intake and willingness to choose, taste foods unfamiliar with vegetables. Children enjoyed cooking and stimulated positive feelings.
Lima et al.	2019	Brazil	Compare children's emotional associations with food products featuring different front-of-pack (FOP) nutrition labelling schemes	492	6-12		Evaluated products featuring both the TLS and nutritional warnings tended to use emojis associated with positive.
Lange et al.	2020	France	Study how food sensory imagery influences portion size selection of foods varying in energy density children.	171	7-11		Food sensory imagery influences the portion size selection of foods that vary in children with energy density.
Schwartz et al.	2020	France	Investigate potential anticipation errors related to the effects of portion size on hunger, eating enjoyment, and healthiness ratings.	83	8-11		A larger portion reduced anticipated hunger, experienced residual hunger, and increased anticipated but did not experience eating enjoyment for either snack.
Sick et al.	2022	Italy	Develop an emoji-based self-report measurement tool to measure emotional responses to food products in preadolescents.	Study 1 96 Study 2 162 Study 3 92 Study 4 85 Study 5 19	9-13 9-13 9-13 9-13 12-13	55 boys, 41girls 75boys, 87 girls 40 boys, 52 girls 39 boys, 46 girls 10 boys, 9 girls	17 emoji pairs associated with specific linguistic semantic and dimensional (valence, power, and arousal) meanings.
Rigo et al.	2023	Australia	Examine food affecting preferences and perceptions of healthiness and tastiness. Determine the portion size related to children's perceptions and preferences.	2112	5-12		Children used the type/flavour of the breads and smoothies to form their preferences and perceptions, and the other attributes (portion size and food form), had minimal influence.
da Quinta et al.	2023a	Spain	Identify emojis appropriate to describe food experiences in studies with schoolchildren and to evaluate applicability expressing food-evoked emotions.	154 95	6-12 6-12	52% boys, 48% girls 54% boys, 46%girls	Study1: 14 food-specific emojis convey the emotions elicited by evoked contexts Study2: 6 food names elicited four emotional responses that could be discriminated.
da Quinta et al.	2023b	Spain	Determine the influence of food shapes on the holistic emotional response of schoolchildren.	50	7-12	54% boys, 46%girls	Apple shape evoked more positive emotions than triangular . Employing 3 approaches to measure emotion allowed discrimination of the evoked emotional response.
da Quinta et al.	2023c	Spain	Evaluate the dimensional and semantic meanings of emoji absence of context as well as in a food-related context.	312	6-12	51% boys, 49% girls	Positively valanced emojis may perceive as appropriate in food-related situations. A significant impact was only found for individuals.

Table 3 Emotion and visual perception potential correlate

Citation	Potential correlate	Study design	Instruments	
			Emotion	Visual perception
Liem & Zandstra 2009	Healthy snacks in smaller sizes are more preferred snacks in larger sizes	A within subject design		5-point facial scale
de Droog et al. 2012	Character–product congruence: conceptual congruence (the basis on a familiar link), and perceptual congruence (the basis on color similarity	A within-subjects (repeated measures) design	A dichotomous smiley scale (unhappy face, happy face)	
Zampollo et al. 2012a	Children tended to prefer seven different items and six different colours on their ideal plates.	Individually presented full-size photos of 48 different combinations of food on plates. The photos varied according to seven dimensions.		Children's self-reported preferences
Zampollo et al. 2012b	The differences between the preferences of adults and children align the goals of healthy nutrition with age-specific preferences.	Study 1 survey Study 2 online survey		Study 1: Children's self-reported preferences Study 2: Adults' self-reported preferences
Harrist et al. 2013	Children's emotion regulation was significantly related to external and emotional eating across grade levels, and reactivity was more consistently related to eating regulation.	A longitudinal study children were interviewed during one-on-one sessions	The Children's Emotion Management Scale (CEMS) The Dutch Eating Behavior Questionnaire (DEBQ)	
Bergamaschi et al. 2016	Consumption is more affected by acceptability and familiarity for the stimuli than by variety	A within subject design: Classical Variety (CV), Perceived Variety (PV)		7-point hedonic facial scale Child Eating Behavior Questionnaire (CEBQ) sub-scale
Gallo et al. 2017	Compare children's reported liking and emotional response: response to an image of the stimulus, response to appearance of the sample prior to tasting, and response after tasting the sample.	Study 1, Questionnaire ,questions about liking and emotions in response to food images. Study 2, check-all-that-apply format, children were asked liking and emotion.	A check-all-that-apply (CATA) format 9-point Peryam and Kroll super good/super bad scale	
Schwartz et al. 2020	Larger portions reduced anticipated and experienced residual hunger similarly.	A within-subject design		Scales to evaluate residual hunger (a), eating enjoyment (b), and healthiness (c), pre-intake and post-intake. The visual analog scales

Citation	Potential correlate	Study design	Instruments	
			Emotion	Visual perception
Van der Horst et al. 2019	The positive effect of a cooking workshop on children's liking across a selection. Through visual appeal, modeling, and participation in meal preparation.	Nonexperimental pretest-posttest design	The Self-Assessment Manikin (SAM) Teddy the Bear on a 5-point verbal pictorial scale	
Lange et al. 2020	Portion size selection effect of visual sensory for snacks varying in energy density	A within-subject design A 2 (intervention: food sensory imagery vs. nonfood sensory imagery) × 2 (food: brownie vs. applesauce) mixed design		Eating Behavior Questionnaire Questionnaire assessing liking of sweetness and fattiness Kids' Child Feeding Questionnaire
Rigo et al. 2023	The attribute of type/flavour was most evident in children's perceptions of food's tastiness and this attribute drove over 93% of their food decisions, while other attributes had a minimal influence.	The Discrete Choice experiment (DCE)		A 5-point Likert Teddy bear satiety/hunger scales 9-point hedonic scale
da Quinta et al. 2023c	Apple shape evoked a more positive emotional response compared to the triangle shape. Children's preferences and emotional response towards food shapes.	Individual sessions to observe Facial expressions and the skin conductance response (SCR)	7- point hedonic scale RATA (Rate-All-That-Apply) layout, using a 3-point scale	

3.3 Outcomes

Of the 17 articles, five studies were on emotions and children's diets, exploring how food shape can elicit more positive emotional reactions. Emotion regulation is significantly associated with external and emotional eating across grade levels and reactivity is more consistent with eating regulation (da Quinta et al. 2023c; Van der Horst et al. 2019; Gallo et al. 2017; Harrist et al. 2013; De Droog et al. 2012). Seven studies focused on visual perception, visual cues, and eating habits. Different food portions have been found to be stimulating and capable of producing portion-selection effects and reducing hunger. The ideal plate for children influences their preferences for different colors and types of food, as well as the type and familiarity of food, thereby influencing food decisions (Rigo et al., 2023; Lange et al., 2020; Schwartz et al., 2020; Bergamaschi et al., 2016; Zampollo et al., 2012a, 2012b; Liem & Zandstra, 2009). Particularly, after observations of children aged 5-12 years showed that apple shapes elicited more positive emotional responses than triangles, expression-based questionnaires were feasible for capturing children's freely reported emotions. Several studies have highlighted the positive impact of portion size on children's snacks (da Quinta et al., 2023c; Lange et al., 2020; Zampollo et al., 2012b). It has also been suggested that interventions to promote dietary diversity in children may benefit from the presentation of significantly more diverse foods (Table 3).

Table 4 The CATA Emoji Measurement

Citation	Aim	Measurement	Stimuli /Emoji	Study design	Emotion of Dimensions		
					Positive	Negative	Neutral
Schouteten et al. 2018	Examine whether emoji can be applied to obtain discriminating emotional profiles for traditional Belgian biscuits.	CATA	2 samples of premium brands and 3 samples of private label brands 33 emoji	Questionnaires	15	16	2
Lima et al. 2019	Compare children's emotional associations with food products featuring different front-of-pack (FOP) nutrition labelling schemes	CATA	6 packages 3 unpackages 17 emoji	A between-subjects design	7	8	1
Sick et al. 2022	Develop an emoji-based self-report measurement tool to measure emotional responses to food products in preadolescents.	CATA	Study 1: 92 Study 2 :46 Study 3 :46 Study 4: 46 Study 5: 28	An emoji-based self-report questionnaire Study 1: select emoji to describe food experiences; Study 2 :mapping technique; Study 3 and 4: a CATA questions Study 5: one-on-one interviews	17 emoji pairs associated with specific semantic and dimensional (valence, power, and arousal) meanings 7	8	2
da Quinta et al. 2023a	Evaluate the dimensional and semantic meanings of emoji in the absence of context as well as in a food-related context.	CATA	Study 1: 41→24 Study 2 :24 +6	Study 1 – a qualitative pre-test using focus groups Study 2 – an online survey	12	10	8
da Quinta et al. 2023b	Identify a group of emoji appropriate to describe food experiences in studies with schoolchildren and to evaluate their applicability expressing food-evoked emotions.	CATA	Study 1: 30 Study 2 :14 Six food products	Study 1 – an online survey Study 2 – an online survey	6	5	3

Additionally, five other studies focused on measuring children's emotional reactions to food using emotional expressions, consistently utilising the CATA measurement method to classify positive, negative, and neutral emotions (da Quinta et al., 2023a, 2023b; Sick et al., 2022; Lima et al., 2019; Schouteten et al., 2018). Emojis have evolved as an attractive instrument for measuring emotions elicited by food. The check-all-that-apply (CATA) emotion measurement method was chosen to assess children's food choices and eating emotions consistently. The CATA approach is the most used method. In this approach, participants were presented with a food stimulus and asked to select all emojis that reflected how they felt. This method has the advantages of being intuitive, easy to understand, and quick to apply. The integration of emoticons into the CATA approach has been used with pre-adolescents to measure food-elicited emotions. Several studies (Da Cruz et al., 2021; Schouteten et al., 2018; Gallo et al., 2017) have shown that various emoticons can effectively discriminate between different foods (Table 4).

4. Discussion

This systematic review explored the intricate links between visual perception, emotion, and food choice among children aged 4–14 years. Only one study focused specifically on children aged 4–14 years, whereas the other 16 studies targeted children aged 5–13 years. Understanding these relationships is critical because they have a significant impact on children's overall health and well-being. These findings have practical implications for parents, educators, the restaurant service industry, chefs, tableware designers, and nutritionists in developing interventions to promote healthier habits in children. While there is a substantial body of literature on human emotions, visual cues/perception, and food choices, literature specifically focusing on children is limited. This indicates that little attention has been paid to children's emotions, visual cues/perception, and food choices, highlighting a significant research gap.

The variety and shape of snacks (containing vegetables, fruits, and nuts) are determinants of acceptance among school children (Bergamaschi et al., 2016). The importance and attention drawn by visual cues can vary

between studies, even if they use similar colors and shapes. Previous research shows that basic effects of how color and shape relate to taste often come from simple images, like color patches and geometric shapes (Wan et al., 2014). However, variations in how colors and shapes are manipulated in studies can lead to different outcomes. For instance, the degree of roundness can differ in studies focusing on round shapes (Becker et al., 2011; Piqueras-Fiszman et al., 2012). This inconsistency highlights the need for careful consideration of stimulus design in research examining the relationship between visual cues and taste perceptions.

Children typically like their ideal plates to have seven different items and six different colors, according to the study by Zampollo et al. (2012c). This shows that having a mix of colors and food types can make meals more appealing to kids, which might encourage them to eat healthier.In addition, children show a preference for a significantly greater number of items and colors on a given plate (Zampollo et al., 2012a, 2012b). It was found that all children tended to underestimate how much they enjoyed smaller portion sizes. Portion size did not affect the health ratings for either snack, as reported by Schwartz et al. (2020). Interventions that incorporate food sensory imagery, such as that proposed by Lange et al. (2020), may be useful in encouraging children to choose healthier portion sizes. This is because it reduces the portion size chosen for energy-dense snacks without affecting that chosen for healthier snacks. Additionally, researchers have noted that more positive emotional responses were observed for familiar products (De Droog et al., 2012; Gallo et al., 2017). Specifically, familiar characters elicit the most positive and elaborate emotional responses (De Droog et al., 2012).

Several studies (Da Cruz et al., 2021; Schouteten et al., 2018; Gallo et al., 2017) have shown that various emoticons can effectively discriminate between different foods. The use of emoticons may serve as an alternative method to gather more information about how children experience food samples compared to traditional hedonic measures. The CATA and rating scales can be used to measure children's emotional responses to different food categories. Difficulty level can also be adjusted according to the child's cognitive development. Children are not only familiar with emojis, but they also find them funny and express things that no words need to express. The intuitive nature of emoticons enhances children's participation in senses and emotions. In fact, facial expressions of emotions are stable across cultures (Elfenbein & Ambady, 2002).

The observation of various food shapes can elicit diverse implicit and explicit emotional responses in school children. Notably, apple shapes have been found to evoke more positive emotions than triangles (da Quinta et al., 2023c). Sensory images depicting food could be valuable tools for encouraging children to opt for healthier portion sizes (Lange et al. 2020). Nutritional warnings significantly influence emotional associations (Lima et al., 2019). It has been observed that children's preference for larger-sized snacks is more likely to diminish after repeated consumption, in contrast to smaller snacks that possess an equivalent taste. However, it remains to be investigated whether these principles apply to less popular food items, such as vegetables (Liem,& Zandstra, 2009).

When conducting tests with children unfamiliar with the study sample, it is advisable to employ actual food stimuli and include mood assessments (Gallo et al., 2017). It has been noted that choice has a negative emotional impact on liking. Consequently, it is recommended to offer children limited choices rather than unrestricted options (Liem, & Zandstra, 2009).

The complexity and significance of the research findings once again highlight the stark disparity between visual perception from a child's perspective and perceptions or imaginings of adults. This underscores the pivotal role of emotion as a crucial aspect that permeates food choices and preferences, making it a vital focal point for interventions aimed at promoting healthy eating habits among children. This comprehensive review significantly advances our understanding of the intricate interplay among children's food choices, visual perception, and emotional responses. Therefore, this lays the groundwork for more effective evidence-based interventions aimed at cultivating healthier eating habits and promoting overall well-being. The importance of addressing the interactions among these factors underscores the need for a comprehensive approach to promote healthy eating behaviours in children.

5. Limitations and future directions

This study had some limitations that should be acknowledged. The original purpose was to conduct a meta-analysis; however, the purposes and results of the studies were complex and diverse, and the consistency was insufficient. Therefore, they were not suitable for inclusion in the present study. Furthermore, even though the selected studies had sufficient sample sizes and a balanced distribution of sexes, most were cross-sectional. Only the study by Harrist et al. (2013) used a longitudinal design. One other study employed an experimental pretest-posttest design (Van der Horst et al., 2019). In addition, the research parameters excluded books, chapters, conferences, and articles that were not yet published or were published in a language other than English. This practice may result in the omission of the relevant materials. In addition, limiting the database searches to PubMed, Scopus, and Web of Science may limit the number of articles eligible for review. Furthermore, the study had limited cultural and geographic diversity, which limited the generalisability of the

results to other countries and populations. Therefore, our findings should be cautiously interpreted. A notable limitation of this study is our focus on self-reporting. Although self-reports are a convenient and widely used method for gathering data on emotions and eating habits, they can be affected by recall and response bias. This means that participants might not accurately remember or report their actual eating patterns and emotional states. As a result, the reliance on self-reported data restricted the number of studies that met our inclusion criteria, as not many studies effectively utilized this method.

Future studies should prioritise several key areas to overcome the limitations identified in this systematic review. First, more longitudinal studies are needed to unravel the complex relationship between visual cues and perceptions, emotions, food choices, and children's health. This would allow for more definitive conclusions and provide substantial evidence to support or challenge the effectiveness of interventions that target visual cues and emotions. Future studies should include a wider age range and a more diverse sample, including children from different cultural and socioeconomic backgrounds. This would facilitate the generalisation of the findings of the current review to a broader range of populations.

Furthermore, systematic reviews should broaden their literature searches to include articles published in languages other than English and utilize a wider range of databases. This approach would provide a more comprehensive view of the relevant literature and could lead to more reliable conclusions. By addressing these aspects in future research, we can improve our understanding of the complex relationships between visual cues, emotions, and the promotion of healthy food choices among children.

6. Conclusion

This study investigated the intricate the complex effects of children's visual cues, emotions, and food choices, thereby providing important insights into potential health interventions. Certain findings indicate significant impacts of color and shape on taste perception and liking, aligning with shape/color-taste correspondences. Moreover, the study uncovered a notable influence of food consistency and personality on children's preference for healthy food. Additionally, the shape of the food elicited a more positive emotional response than the non-varied shapes. Several studies have also demonstrated that children not only have preferences for the food itself, but also consider factors such as the type, location, and color of the food. Valid evidence supports the effects of portion size on food cues. This review presents the latest literature and aims to contribute to future research by drawing new conclusions, which can guide relevant interventions aimed at promoting healthy eating habits in children. The hope is that this information will be valuable for governmental agencies, catering services, food companies, caregivers, food designers, and even parents when making decisions regarding children’s choices.

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Author contributions

XQT, SFAS and SKG conceived and designed this review. XQT performed literature search, screening, quality assessment, and data extraction. SKG contributed to full-text screening. XQT synthesized the results and wrote the original manuscript, and SFAS provided the input and editing. All the authors approved the final version of the manuscript.

Reference

1. Barthomeuf, L., Rousset, S., & Droit-Volet, S. (2009). Emotion and food. Do the emotions expressed on other people's faces affect the desire to eat liked and disliked food products? *Appetite*, 52(1), 27-33. https://doi.org/10.1016/j.appet.2008.07.002
2. Becker, L., van Rompay, T. J., Schifferstein, H. N., & Galetzka, M. (2011). Tough package, strong taste: The influence of packaging design on taste impressions and product evaluations. *Food quality and preference,* 22(1), 17-23. https://doi.org/10.1016/j.foodqual.2010.06.007
3. Berenson, G. S., Wattigney, W. A., Tracy, R. E., Newman III, W. P., Srinivasan, S. R., Webber, L. S., ... & Strong, J. P. (1992). Atherosclerosis of the aorta and coronary arteries and cardiovascular risk factors in persons aged 6 to 30 years and studied at necropsy (The Bogalusa Heart Study). *The American journal of cardiology*, 70(9), 851-858. https://doi.org/10.1016/0002-9149(92)90726-F

4. Bergamaschi, V., Olsen, A., Laureati, M., Zangenberg, S., Pagliarini, E., & Bredie, W. L. (2016). Variety in snack servings as determinant for acceptance in school children. *Appetite*, *96*, 628-635. https://doi.org/10.1016/j.appet.2015.08.010
5. Beyer, N. R., & Morris, P. M. (1974). Food attitudes and snacking patterns of young children. *Journal of Nutrition Education*, 6(4), 131-133. https://doi.org/10.1016/S0022-3182(74)80006-3
6. Birch, L. L. (1999). Development of food preferences. *Annual review of nutrition*, 19(1), 41-62. https://doi.org/10.1146/annurev.nutr.19.1.41
7. Canetti, L., Bachar, E., & Berry, E. M. (2002). Food and emotion. *Behavioural processes*, 60(2), 157-164. https://doi.org/10.1016/S0376-6357(02)00082-7
8. Chen, Y. C., Tsui, P. L., Lee, C. S., & Chen, G. L. (2020). Can plate colour promote appetite and joy while dining? An investigative study in Chinese fine dining restaurants. *Asia Pacific Journal of Marketing and Logistics*, *32*(1), 105-116. https://doi.org/10.1108/APJML-07-2018-0247
9. Cooke, L., Wardle, J., & Gibson, E. L. (2003). Relationship between parental report of food neophobia and everyday food consumption in 2–6-year-old children. *Appetite*, 41(2), 205-206. https://doi.org/10.1016/S0195-6663(03)00048-5
10. da Cruz, M. F., Rocha, R. S., Silva, R., Freitas, M. Q., Pimentel, T. C., Esmerino, E. A., ... & Maia, L. C. (2021). Probiotic fermented milks: children's emotional responses using a product-specific emoji list. *Food Research International,* 143, 110269. https://doi.org/10.1016/j.foodres.2021.110269
11. da Quinta, N., Ríos, Y., Baranda, A., & de Marañón, I. M. (2023a). Identification and applicability of emoji appropriate to describe food experiences in child-centred studies: A comparison between food names and images. *Food Quality and Preference*, 105, 104781. https://doi.org/10.1016/j.foodqual.2022.104781
12. da Quinta, N., Santa Cruz, E., Rios, Y., Alfaro, B., & de Marañón, I. M. (2023b). What is behind a facial emoji? The effects of context, age, and gender on children's understanding of emoji. *Food Quality and Preference*, 105, 104761. https://doi.org/10.1016/j.foodqual.2022.104761
13. da Quinta, N., Ríos, Y., Llorente, R., Naranjo, A. B., & Baranda, A. B. (2023c). The effect of food shape on children's implicit and explicit emotional response. *Food Quality and Preference*, 104921. https://doi.org/10.1016/j.foodqual.2023.104921
14. De Droog, S. M., Buijzen, M., & Valkenburg, P. M. (2012). Use a rabbit or a rhino to sell a carrot? The effect of character–product congruence on children's liking of healthy foods. *Journal of health communication*, *17*(9), 1068-1080. https://doi.org/10.1080/10810730.2011.650833
15. Elfenbein, H. A., & Ambady, N. (2002). On the universality and cultural specificity of emotion recognition: a meta-analysis. *Psychological bulletin*, 128(2), 203. https://doi.org/10.1037/0033-2909.128.2.203
16. Gallo, KE, Swaney-Stueve, M., & Chambers, DH (2017). Comparing visual food images versus actual food when measuring emotional response of children. *Journal of Sensory Studies* , 32 (3), e12267. https://doi.org/10.1111/joss.12267
17. Gardner, M. P., Wansink, B., Kim, J., & Park, S. B. (2014). Better moods for better eating?: How mood influences food choice. *Journal of Consumer Psychology*, *24*(3), 320-335. https://doi.org/10.1016/j.jcps.2014.01.002
18. Gibson, E. L. (2006). Emotional influences on food choice: sensory, physiological and psychological pathways. *Physiology & behavior*, *89*(1), 53-61. https://doi.org/10.1016/j.physbeh.2006.01.024
19. Gutjar, S., de Graaf, C., Kooijman, V., de Wijk, R. A., Nys, A., Ter Horst, G. J., & Jager, G. (2015). The role of emotions in food choice and liking. *Food Research International*, *76*, 216-223. https://doi.org/10.1016/j.foodres.2014.12.022
20. Hamburg, ME, Finkenauer, C., & Schuengel, C. (2014). Food for love: the role of food offering in empathic emotion regulation. *Frontiers in psychology* , 5 , 32. https://doi.org/10.3389/fpsyg.2014.00032
21. Harrar, V., & Spence, C. (2013). The taste of cutlery: how the taste of food is affected by the weight, size, shape, and colour of the cutlery used to eat it. *Flavour*, 2(1), 1-13. https://doi.org/10.1186/2044-7248-2-21
22. Harrist, A. W., Hubbs-Tait, L., Topham, G. L., Shriver, L. H., & Page, M. C. (2013). Emotion regulation is related to children's emotional and external eating. *Journal of Developmental & Behavioral Pediatrics*, 34(8), 557-565. https://doi.org/10.1097/DBP.0b013e3182a5095f
23. Hong, Q. N., Pluye, P., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., ... & Vedel, I. (2018). Mixed methods appraisal tool (MMAT), version 2018. *Registration of copyright*, 1148552(10).
24. Krebs-Smith, S. M., Cook, D. A., Subar, A. F., Cleveland, L., Friday, J., & Kahle, L. L. (1996). Fruit and vegetable intakes of children and adolescents in the United States. *Archives of pediatrics & adolescent medicine*, 150(1), 81-86. https://doi.org/10.1001/archpedi.1996.02170260085014
25. Lanfer, A., Hebestreit, A., Ahrens, W., Krogh, V., Sieri, S., Lissner, L., ... & Pala, V. (2011). Reproducibility of food consumption frequencies derived from the Children's Eating Habits Questionnaire used in the IDEFICS study. *International Journal of Obesity*, 35(1), S61-S68. https://doi.org/10.1038/ijo.2011.36
26. Lange, C., Schwartz, C., Hachefa, C., Cornil, Y., Nicklaus, S., & Chandon, P. (2020). Portion size selection in children: Effect of sensory imagery for snacks varying in energy density. *Appetite*, *150*, 104656. https://doi.org/10.1016/j.appet.2020.104656
27. Lee, S. M., Lee, K. T., Lee, S. H., & Song, J. K. (2013). Origin of human colour preference for food. *Journal of Food Engineering,* 119(3), 508-515. https://doi.org/10.1016/j.jfoodeng.2013.06.021

28. Liem, DG, & Zandstra, LH (2009). Children's liking and wanting of snack products: Influence of shape and flavour. *International Journal of Behavioral Nutrition and Physical Activity* , 6 (1), 1-10. https://doi.org/10.1186/1479-5868-6-38
29. Lien, N., Lytle, L. A., & Klepp, K. I. (2001). Stability in consumption of fruit, vegetables, and sugary foods in a cohort from age 14 to age 21. *Preventive medicine*, *33*(3), 217-226. https://doi.org/10.1006/pmed.2001.0874
30. Lima, M., de Alcantara, M., Martins, I. B., Ares, G., & Deliza, R. (2019). Can front-of-pack nutrition labeling influence children's emotional associations with unhealthy food products? An experiment using emoji. *Food Research International*, *120*, 217-225. https://doi.org/10.1016/j.foodres.2019.02.027
31. Macht, M. (1999). Characteristics of eating in anger, fear, sadness and joy. *Appetite*, 33(1), 129-139. https://doi.org/10.1006/appe.1999.0236
32. Macht, M., Roth, S., & Ellgring, H. (2002). Chocolate eating in healthy men during experimentally induced sadness and joy. *Appetite,* 39(2), 147-158. https://doi.org/10.1006/appe.2002.0499
33. Magarey, AM, Daniels, LA, Boulton, TJ, & Cockington, RA (2003). Predicting obesity in early adulthood from childhood and parental obesity. International journal of obesity , 27 (4), 505-513. https://doi.org/10.1038/sj.ijo.0802251
34. Mikkilä, V., Räsänen, L., Raitakari, O. T., Pietinen, P., & Viikari, J. (2004). Longitudinal changes in diet from childhood into adulthood with respect to risk of cardiovascular diseases: The Cardiovascular Risk in Young Finns Study. *European journal of clinical nutrition*, *58*(7), 1038-1045. https://doi.org/10.1038/sj.ejcn.1601929
35. Moss, RH, Conner, M., & O'Connor, DB (2021). Exploring the effects of positive and negative emotions on eating behaviours in children and young adults. *Psychology, health & medicine* , 26 (4), 457-466. https://doi.org/10.1080/13548506.2020.1761553
36. Murphy, JM, Pagano, ME, Nachmani, J., Sperling, P., Kane, S., & Kleinman, RE (1998). The relationship of school breakfast to psychosocial and academic functioning: cross-sectional and longitudinal observations in an inner-city school sample. *Archives of pediatrics & adolescent medicine*, 152 (9), 899-907. https://doi.org/10.1001/archpedi.152.9.899
37. Ogden, C. L., Carroll, M. D., & Flegal, K. M. (2003). Epidemiologic trends in overweight and obesity. *Endocrinology and metabolism clinics*, *32*(4), 741-760.
38. https://doi.org/10.1016/S0889-8529(03)00074-4
39. Patel, K. A., & Schlundt, D. G. (2001). Impact of moods and social context on eating behavior. *Appetite*, 36(2), 111-118. https://doi.org/10.1006/appe.2000.0385
40. Piqueras-Fiszman, B., Alcaide, J., Roura, E., & Spence, C. (2012). Is it the plate or is it the food? Assessing the influence of the color (black or white) and shape of the plate on the perception of the food placed on it. *Food quality and preference*, 24(1), 205-208. https://doi.org/10.1016/j.foodqual.2011.08.011
41. Phillips, B. K., & Kolasa, K. K. (1980). Vegetable preferences of preschoolers in day care. *Journal of Nutrition Education*, 12(4), 192-195. https://doi.org/10.1016/S0022-3182(80)80160-9
42. Prinyawiwatkul, W. (2020). Relationships between emotion, acceptance, food choice, and consumption: Some new perspectives. *Foods* , 9 (11), 1573. https://doi.org/10.3390/foods9111573
43. Rigo, M., Mohebbi, M., Keast, R., Harrison, P., Kelly, M., Olsen, A., ... & Russell, C. G. (2023). An investigation into food choices among 5–12 years children in relation to sensory, nutritional, and healthy product cues. *Food Quality and Preference*, *111*, 104990. https://doi.org/10.1016/j.foodqual.2023.104990
44. Schwartz, C., Lange, C., Hachefa, C., Cornil, Y., Nicklaus, S., & Chandon, P. (2020). Effects of snack portion size on anticipated and experienced hunger, eating enjoyment, and perceived healthiness among children. *International Journal of Behavioral Nutrition and Physical Activity*, *17*(1), 1-14. https://doi.org/10.1186/s12966-020-00974-z
45. Schouteten, J. J., Verwaeren, J., Lagast, S., Gellynck, X., & De Steur, H. (2018). Emoji as a tool for measuring children's emotions when tasting food. *Food quality and preference*, *68*, 322-331. https://doi.org/10.1016/j.foodqual.2018.03.005
46. Sick, J., Monteleone, E., Dinnella, C., Pierguidi, L., & Spinelli, S. (2022). Development of an emoji-based self-report measurement tool to measure emotions elicited by foods in preadolescents. *Food Quality and Preference*, *100*, 104585. https://doi.org/10.1016/j.foodqual.2022.104585
47. Spence, C., & Van Doorn, G. (2022). Visual communication via the design of food and beverage packaging. *Cognitive Research: Principles and Implications*, 7(1), 42. https://doi.org/10.1186/s41235-022-00391-9
48. Stewart, P. C., & Goss, E. (2013). Plate shape and colour interact to influence taste and quality judgments. *Flavour,* 2, 1-9. https://doi.org/10.1186/2044-7248-2-27
49. Van der Horst, K., Mathias, K. C., Patron, A. P., & Allirot, X. (2019). Art on a plate: a pilot evaluation of an international initiative designed to promote consumption of fruits and vegetables by children. *Journal of nutrition education and behavior*, 51(8), 919-925. https://doi.org/10.1016/j.jneb.2019.03.009
50. Veflen, N., Velasco, C., & Kraggerud, H. (2023). Signalling taste through packaging: The effects of shape and colour on consumers' perceptions of cheeses. *Food Quality and Preference*, 104, 104742. https://doi.org/10.1016/j.foodqual.2022.104742

51. Wan, X., Velasco, C., Michel, C., Mu, B., Woods, A. T., & Spence, C. (2014). Does the type of receptacle influence the crossmodal association between colour and flavour? A cross-cultural comparison. *Flavour*, 3, 1-7. https://doi.org/10.1186/2044-7248-3-3
52. Yao, V. Y. (2016). Investigating consumption-related emotions elicited by selected dairy products using product emotion measurement. *International Journal of Marketing Studies*, 8(1), 86-97. https://doi.org/10.5539/ijms.v8n1p86
53. Zampollo, F., Kniffin, K. M., Wansink, B., & Shimizu, M. (2012a). Food plating preferences of children: The importance of presentation on desire for diversity. *Acta Paediatrica*, *101*(1), 61-66. https://doi.org/10.1111/j.1651-2227.2011.02409
54. Zampollo, F., Wansink, B., Kniffin, KM, Shimizu, M., Kniffin, KM, & Hall, W.(2012b). Children's Unique and Overlooked Preferences for Diverse Food Presentations*: Implications for Childhood Nutrition*.
55. Zhao, H., An, J., Spence, C., & Wan, X. (2018). Influence of the color and size of the plate on the subjective ratings of, taste expectations concerning, and willingness-to-pay for , Asian noodles. *Journal of Sensory Studies*, 33 (5), e12443. https://doi.org/10.1111/joss.12443