



A nudge in the right direction? How emoticons and labels shape children's food choices

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ABSTRACT

Promoting healthy eating in childhood is a key public health objective, and nudges represent a low-cost strategy to influence behavior without limiting choice. However, evidence regarding their effectiveness among children remains limited. Two randomized experiments examine whether simple visual (emoticons) and textual (labels) cues can promote healthier food choices in Croatian children aged 6–9, adjusting for children's (associative and factual) food knowledge and (implicit and explicit) attitudes. In Study 1, children completed a food choice task in which the healthy option was paired with descriptive labels (healthy, tasty, popular) or emoticons (heart, muscle, smile). Study 2 examined the effects of specific emoticons (green smileys on healthy options alone, or both green smileys on healthy options and red smileys on unhealthy ones) on food choices. Results indicate that visual and textual nudges can significantly increase the selection of healthy options by children. Specifically, “healthy” and “tasty” labels were effective, and green and both green–red emoticons increased the likelihood of choosing the healthier option. However, while nudges deliver an incremental shift at the point of decision, the magnitude of this shift depends on children's underlying explicit and implicit attitudes.

1. Introduction

Promoting healthy food habits in early childhood is critical, as dietary behaviors formed during a person's formative years often persist into adulthood and shape long-term health outcomes (Beckerman et al., 2017). In response, behavioral interventions, especially nudges that alter the presentation or framing of choices, have emerged as promising tools to improve the likelihood of socially desirable decisions without restricting freedom (Spence & Pillay, 2025; van der Molen et al., 2021). Yet, children's everyday food environments are dominated by powerful commercial influences, billions of dollars are spent each year marketing sugary, energy-dense products, and children are constantly exposed to advertising, packaging, and visual cues that steer them toward unhealthy food (Boyland et al., 2025; Harris et al., 2009).

Against this backdrop, progress has been limited. Despite decades of

interventions, childhood obesity has risen tenfold globally (UNICEF, 2023). Most strategies aimed at improving school-aged children's food habits rely on explicit education or restriction-based techniques, such as mass media campaigns, school-based food literacy lessons, and policy limiting access to sugar-sweetened beverages and other energy-dense snacks in schools (Dudley et al., 2015; Marteau et al., 2011; Marteau et al., 2012; Taber et al., 2012). While these approaches can increase knowledge of what constitutes healthy versus unhealthy food choices, evidence suggests their effects on actual food choice are often modest or inconsistent (Thakur & Mathur, 2022; Walls et al., 2009), underscoring the need to examine complementary, low-cost nudges that can shift behavior beyond what children already know. Food choice is a complex behavior shaped by cognitive, emotional, and environmental influences (Leng et al., 2017). For some age groups, such as preschool-aged children, choices are rarely rational or knowledge-based; instead, they are

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driven by taste preferences, prior experiences, and the presentation of options (Maimaran & Fishbach, 2014).

Nudges are subtle changes to the choice environment that steer decisions without restricting freedom (Thaler & Sunstein, 2008). They are particularly suited to food decision-making, where choices are frequent, habitual, and often made with limited deliberation. This is especially relevant for children, who may lack the cognitive capacity or motivation to process complex nutritional information and therefore rely more on intuitive and affective cues. In the present study, we focus on two nudge strategies commonly used in child-directed food environments. *Informational nudges*, such as labels, provide health-related messages, and *visual nudges*, such as emoticons, leverage intuitive decision-making (Barahona et al., 2023; Kokkorou et al., 2024).

However, the effectiveness of nudges remains inconsistent. While some studies uncover strong and immediate effects on children's food choices (Marcano-Olivier et al., 2020; Siegel et al., 2015), others report limited success, with nudges failing to overcome existing preferences and habits (DeCosta et al., 2017; Huang et al., 2006). Moreover, most existing evidence on the effect of nudges on food choices comes from adult populations (Lozano-Casanova et al., 2025), despite notable differences in how adults and children process food-related cues (van Meer et al., 2016b). Specifically, van Meer et al. (2017) found that health messages increase healthy choices in adults but reduce them in children, while Ikink et al. (2023) demonstrated that adults rely on deliberation, whereas children often make impulsive choices even when a healthier option is available. Although nudges such as emoticons, labels, and symbols offer low-cost, scalable interventions (Vecchio & Cavallo, 2019), their effectiveness for children thus remains underexplored and inconclusive (Lycett et al., 2017). Moreover, most extant studies focus on adolescents (Arrúa et al., 2017; Greene et al., 2017; Siegel et al., 2015) or preschoolers (Maimaran & Fishbach, 2014). This leaves a notable evidence gap for elementary school-aged children (ages 6–9 years old), a key, developmental period when children begin forming more autonomous food choices. Since elementary school aged children may respond more strongly to affective cues than to cognitive information, research that integrates nudges with measures of children's attitudes and knowledge is needed (Hawkes et al., 2020; Pechmann et al., 2020; Williams & Suchdev, 2017). This is important, because attitudes are key determinants of intentions and behavior (Ajzen, 1991). Evidence suggests that children's nutritional knowledge is often weakly related to food choices (Thakur & Mathur, 2022). Measuring both knowledge and attitudes allows us to test whether nudges shift choices beyond baseline differences in what children know and feel, and to examine whether effects vary systematically by these pre-existing characteristics.

Food marketing cues are often effective because they operate as primes. These are stimuli, that can bias evaluations and choices automatically and below conscious awareness, and are known to be linked to unhealthy food choices (Harris et al., 2009). Building on this logic, we conceptualize manipulations as nudges, implemented via simple cues (labels/emoticons), which may influence choice through associative priming at the point of decision. Associative priming theory proposes that subtle cues in the environment (e.g. images, odors, or words) can trigger related concepts and shape evaluations and choice (Berger & Fitzsimons, 2008; Lindsey et al., 2020; McNamara, 1992). According to this view, a nudge does not provide new information: it can influence choice simply by making certain associations easier to retrieve at the moment of decision.

Priming can operate through different routes. Goal priming, for example, can activate health-related goals and guide behavior toward congruent outcomes without explicit deliberation (Förster et al., 2007). More broadly, priming can be cognitive or affective in nature (Kay et al., 2025). Cognitive priming involves informational or semantic cues that activate knowledge structures. For example, labels like “healthy” or “tasty” can act as informational primes that make nutrition-related associations more accessible when children make choices (Minton et al.,

2017). In particular, informational priming improves the “speed or accuracy to respond to a stimulus, such as a word or a picture, when it is preceded by a semantically-related stimulus” (McNamara & Holbrook, 2003). Applied to child-directed food environments, informational nudges such as labels (“healthy,” “tasty”) can be understood as semantic primes: they anchor a particular evaluative dimension (health vs. taste) and can shift attention and evaluation when children decide what to choose (Minton et al., 2017). Priming is especially relevant for children because their food choices are often not fully deliberative and are strongly shaped by salience, familiarity, and affective reactions to how options are presented (Maimaran & Fishbach, 2014). Importantly, priming effects may influence choice even when children possess nutrition knowledge, because accessible associations at the moment of choice can overpower reflective consideration.

A complementary mechanism concerns how preferences may develop over time. Although children are biologically inclined to prefer sweet and reject bitter tastes (Wardle & Cooke, 2008), food preferences are also malleable through associative experiences (Nicklaus, 2016). Associative conditioning, for instance, pairing healthy foods with positively valenced cues, may foster more favorable perceptions and increase consumption (Halbeisen & Walther, 2021). Although evidence with children is still emerging, some studies show that associative conditioning can increase the liking and intake of vegetables (Capaldi-Phillips & Wadhwa, 2014).

Descriptive labels are commonly used in the marketing of food products targeted at children, and can also enhance the appeal of healthier options (Elliott, 2008). For instance, picture books about vegetables encourage consumption among children, mainly by engendering more favorable attitudes toward vegetables. More favorable attitudes toward vegetables may matter more for food choice than just knowing the food is healthy (de Droog et al., 2014). Consistent with this, semantic framing at the point of choice can shift children's selection by changing which attribute becomes more salient.

Goal priming theory posits that environmental cues can activate mental representations of goals outside conscious awareness, subsequently shaping cognition, and choices (Papies, 2016). Accordingly, a “healthy” label increases the salience of the goal-relevant attribute and provides a simple heuristic that helps children identify the “better-for-you” option at the moment of choice (Nguyen, 2008; Nguyen et al., 2015). However, evidence on health framing is mixed. Health labels can reduce anticipated pleasantness for novel products by activating the “healthy = less tasty” inference (Wardle & Huon, 2000) and some work suggests that children's behavior may reflect avoidance of foods described as “unhealthy” rather than a robust attraction to foods described as “healthy” (DeJesus et al., 2019). Nonetheless, evidence amongst adults suggests that healthy labels can effectively nudge consumers towards healthier foods (Global Food Research Program, 2025), so that:

H1a: A “healthy” label increases the likelihood of children choosing healthy foods

Choice of healthy foods may suffer from consumers subscribing to an “unhealthy = tasty” intuition (Raghunathan et al., 2006). Such an intuition can lead to a goal conflict an aversive state that consumers often resolve by rejecting the object causing the conflict (Ramanathan & Williams, 2007). A “tasty” label directly counters the common inference that healthy foods are less palatable. According to goal conflict theory (Belei et al., 2012), a tasty label reduces the tension by aligning two goals (healthy and enjoyable), thereby reducing conflict and making a particular choice more appealing, so that:

H1b: A “tasty” label increases the likelihood of children choosing healthy foods

Beyond hedonic and health framing, the “popular” label captures a descriptive norm cue that makes others' behavior salient at the point of choice. Descriptive norms guide behavior by signaling what is typical or adaptive and by reducing uncertainty (Aldrovandi et al., 2015). Empirical evidence suggests that norm-based messages affect food

choices and can increase children's vegetable and fruit-and-vegetable intake (Sharps & Robinson, 2017). Building on this logic, we test that:

H1c: A "popular" label increases the likelihood of children choosing healthy foods

Affective priming involves emotional cues that elicit positive or negative feelings, which then bias judgments and behavior (McNamara, 1992). In child-directed food environments, emoticons (e.g. smiling faces, hearts) can be considered affective primes because they appeal to multiple senses, trigger immediate emotional reactions, and bias children toward approach behaviors (Edwards, 1990; Fabrigar & Petty, 1999; Haddock et al., 2008; Spruyt et al., 2002).

Evidence across domains such as physical activity (Conner et al., 2011), substance avoidance (Lawton et al., 2009), and eating behavior (Walsh & Kiviniemi, 2014), suggest that affective primes demonstrate stronger effects than purely cognitive primes. This is because health-related decisions are closely tied to affective, developmentally early cues rather than exclusively cognitive judgements (Conner et al., 2015; Dunlop et al., 2010; Lawton et al., 2009). In the food context, olfactory primes, like subtle fruity scents, increase fruit and vegetable choices (Gaillet et al., 2013), and visual primes, such as emoticons, can shift preferences toward healthier options (Forwood et al., 2015). Empirical evidence regarding the effect of emoticons on food choices is limited; however one study with women prisoners found that attaching a smiley face emoticon significantly increased, albeit modestly, the likelihood of selecting a healthy food option from a menu of options (Fennessy et al., 2024).

For children, affective primes such as emoticons or characters may increase healthy food selection (Gwozdz et al., 2020; Letona et al., 2014; Privitera et al., 2014; Siegel et al., 2015). However, not all visual cues are equally effective and their impact may not be uniform across all children. Gallo et al. (2017a) found that symbolic icons require semantic interpretation. In contrast, visual nudges, particularly those that use facial expressions (e.g., smiley or frowning emoticons), are processed more intuitively and are emotionally salient, making them especially effective for younger children (Lagomarsino & Suggs, 2018; Siegel et al., 2015). This suggests that emoticons may be a particularly relevant affective prime for children because they are simple, nonverbal cues that can be processed without reading skills (Schouteten et al., 2018). Developmental differences suggest that pre-adolescent children, who are more responsive to emotional and intuitive stimuli, may be especially susceptible to such affective nudges (de Brabandere et al., 2022; Lagomarsino & Suggs, 2018). Taken together, this reasoning suggests that:

H2: Emoticons increase the likelihood of children choosing healthy foods

Visual color cues can further shape perceptions and choice by altering meaning and motivational force of affective symbols. Green is symbolically associated with "go," health, and naturalness, which can skew health-related judgments even for unhealthy foods, leading to more favorable perceptions and choices (Schuldt, 2013). Conversely, red is commonly associated with "stop," danger, or avoidance, potentially discouraging selection (Akyol et al., 2018; Genschow et al., 2012; Mehta & Zhu, 2009; Pravossoudovitch et al., 2014). Evidence from colour-coded front-of-pack schemes (including traffic-light labels) suggests that red-coded cues can discourage, and green-coded cues can encourage, healthier choices in children (Arrúa et al., 2017). These color-emotion links may be especially strong in children, who often respond more to affective than abstract informational cues (de Droog et al., 2014). We consequently expect that:

H3a: Green, smiling emoticons applied to healthy foods increase the likelihood of children choosing healthy foods

H3b: Green, smiling emoticons applied to healthy foods, in combination with red, unsmiling emoticons applied to unhealthy foods, increase the likelihood of children choosing healthy foods

While nudges are designed to influence behavior, healthy food choices in children may also reflect underlying knowledge and attitudes (Galler et al., 2022). Knowledge refers to children's understanding of

nutrition and the health consequences of food (Anliker et al., 1990; Slaughter & Ting, 2010). Attitudes capture emotionally valenced tendencies that influence behavior through both implicit and explicit processes, which relate to what Kahneman (2011) calls fast and slow thinking. Implicit processes are spontaneous and fast, and mental contents are not available to introspection (Greenwald & Banaji, 1995). Explicit processes are controlled and slow, and mental contents are accessible to verbal self-report and introspection. Attitudes are evaluative in nature, typically stored in long-term memory (Phipps et al., 2019). Food attitudes can be conceptually differentiated from *food liking* (i.e., the pleasure derived from eating a food), and *food preferences* (i.e., relative choice of one food over another) (Eertmans et al., 2001).

The relations between children's food knowledge and attitudes on the one hand and food choices on the other are unclear. While some studies report that greater food knowledge supports healthier eating (Kandiah & Jones, 2002; Wardle et al., 2000), others report weak or non-significant relations (Thakur & Mathur, 2022). Even when children recognize which foods are "healthy," this reflects only *factual food knowledge*. This type of knowledge is often superficial and preferences for sugar- and fat-rich snacks may override *factual food knowledge* (DeCosta et al., 2017; Lanigan, 2011; Tarabashkina et al., 2016). However, factual knowledge remains a necessary foundation for more advanced, *functional food knowledge* - the ability to apply nutrition understanding in everyday situations, like choosing products or interpreting labels (Schultz & Danford, 2016).

Both implicit and explicit attitudes may predict food choices, with implicit attitudes, shaped by automatic preferences, driving intuitive decisions (Greenwald & Banaji, 1995; Panzone et al., 2016). However, these two types of attitudes often diverge. Younger children may openly state they enjoy sweets or dislike vegetables, yet show more positive unconscious associations with healthy foods (DeJesus et al., 2020). This mismatch can lead to choices that contradict stated beliefs—such as choosing a snack high in sugar despite valuing health (Jones et al., 2012; Kay et al., 2025).

The relative importance of implicit and explicit attitude appears to depend on age and a child's level of cognitive development (Goldstein et al., 2014). Younger children's food choices are more influenced by implicit attitudes, while older children rely more on explicit attitudes that reflect health knowledge and social norms (DeJesus et al., 2020; Monnery-Paris et al., 2016). Together, these findings suggest that both types of attitudes contribute to children's food choices but how they affect the effectiveness of nudging based interventions remains under-explored and poorly understood (Marcano-Olivier et al., 2020; Metcalfe et al., 2020). In our study, we examine both explicit and implicit attitude as predictors and adjust for them to isolate the effect of nudges.

Including two types of knowledge (factual and associative) and two types of attitudes (implicit and explicit), will allow us to assess whether the effects of nudges operate independently of what children already know or how they may feel about healthy food. Therefore, we pose two main questions: (1) Do *simple, developmentally appropriate* nudges increase the likelihood of children choosing healthier food options? (2) Do these effects persist after accounting for children's knowledge of, and attitudes toward, healthy and unhealthy foods?

2. Methods

2.1. Overview of studies

We conducted two complementary experiments with children aged 6–9 to test whether simple nudges influence healthy food choice beyond children's existing attitudes and knowledge. In Study 1, children completed a classroom draw-and-write task (associative knowledge) and then tablet-based exercises ascertaining their level of food knowledge, Child IAT, and explicit attitudes, followed by seven repeated choices between an apple and chocolate pudding. The nudge manipulation was within-subject and presented in a fixed sequence (baseline/no cue first,

then label trials, then emoticon trials; see Table 1). In Study, 2 children completed Child IAT and an explicit liking task before being randomly assigned to one of three emoticon conditions (control, green, green–red) for sixteen repeated choices between tomatoes and a chocolate cake; where the trial order was randomized. Both studies utilized repeated food choice tasks embedded in a structured, school-based setting. Measures of food knowledge and implicit and explicit attitudes were included as covariates to control for individual differences in children's predispositions toward healthy eating. Figure 1 presents the task order for each study's design, with the subsequent two sections discussing procedures in greater depth

2.2. Study 1 design

Study 1 was a broad screening study: it consisted of a hypothetical food choice task in which children were shown a pair of snack items—one healthy (an apple) and one unhealthy (a chocolate pudding). The healthy item was paired with either a descriptive label (“healthy,” “tasty,” or “popular”) or an emoticon (heart, muscle, or smiley face), with children answering the same sequence. The tags were designed as salient, packaging-like badges to be easily readable for 6–9-year-olds. Because tag color may communicate meaning in its own right, we note that the “popular” tag was presented in red in our materials, which may have introduced an additional signal beyond the word itself. Children repeatedly chose between a healthy and an unhealthy snack (apple vs. chocolate pudding) while we experimentally varied multiple text labels (“healthy,” “tasty,” “popular”) and positive emoticons (“smiley, heart, muscle”). The emoticons were chosen as simple, non-branded symbols that 6–9-year-olds routinely encounter and that convey an unambiguous, positive or approach-oriented meaning (approval/liking; care; strength). The goal was to compare the relative effectiveness of different label types versus emoticons and to examine whether implicit and explicit attitudes predict choice. Children selected which item they would like following the prompt “Choose the item you would like” (“Izaberi proizvod po želji”). This phrasing encouraged children to make a choice based on general preference, without referencing health, taste, or a specific consumption context.

We assessed baseline cognitive (two types of knowledge) and affective (implicit and explicit attitudes) constructs. In addition, children completed a draw-and-write activity, and a food categorization task to measure nutrition knowledge, followed by a Child Implicit Association Test (IAT) and explicit attitude scales to capture their implicit and explicit attitudes toward healthy food respectively.

2.3. Study 2 design

Study 2 was a targeted follow-up designed to sharpen understanding of mechanisms and heighten policy relevance: we focused only on the most promising approach from Study 1—emotionally valenced visual cues—and tested a simplified, contrastive design (green positive vs. red negative vs. green–red combination) in a more controlled choice task with a different healthy option. This second study therefore reduced the number of cues, isolated emotional valence/color signaling, and tested whether these visual cues remain effective when accounting for explicit

and implicit attitudes. We switched the healthy option from fruit (Study 1) to a vegetable-based option (Study 2) to test whether the nudge effects generalize beyond fruit. This choice was also intended to provide a more conservative test, because qualitative evidence consistently shows that children tend to prefer fruit over vegetables largely due to fruit's sweet flavor, whereas vegetables are more often associated with negative taste descriptors (e.g., bitter) and lower liking (Rasmussen et al., 2006). In addition, sensory research indicates that children show heightened preference for sweet tastes and stronger rejection of bitter tastes than adults (Mennella & Bobowski, 2015) which can make vegetables (especially bitter vegetables) more challenging targets for behavioral change. This design thus isolates a minimal, affective cue and avoids confounds tied to licensed or brand characters, which can change perceived taste and snack choice through familiarity and brand liking even when the food is identical (McGale et al., 2016; Roberto et al., 2010) and often exert stronger effects for energy-dense foods than for fruits and vegetables (Kraak & Story, 2015). Consistent with this rationale, prior studies showed that placing smiley/emoticon cues next to healthier options increases children's selection of those options in school settings (Gwozdz et al., 2020; Siegel et al., 2015), and can promote healthier choices in controlled choice tasks (Privitera et al., 2015).

As before, children were asked to select the item they would like, using the prompt “Choose the item you would like” (“Izaberi proizvod po želji”).

Study 2 again measured implicit and explicit attitudes and introduced intuitive nudges via emoticons during food choice tasks. This study tested whether specific emoticons influence choices, while controlling for differences in both implicit and explicit attitudes toward healthy food.

2.4. Ethical considerations

The study was approved by the Ethics Committee of the Faculty of Economics and Business, University of Zagreb (approval no. 643-01/22-01/015; date: 25 October 2022). All procedures were conducted in accordance with the ethical standards of the Committee and the 1964 Helsinki Declaration and its later amendments. The study focused on children in the first, second, or third years of primary school (ages 6–9) from Croatian families living in three largely middle-class areas of the capital city (Zagreb)¹.

The children attended two schools. Consent was obtained at three levels: first from the schools, then from the children's caregivers (typically parents), and finally from the children themselves. Participation was entirely voluntary and was not linked to any assessments or grades. This study was not pre-registered. The hypotheses and analysis plan were developed prior to data collection; exploratory analyses are noted where applicable.

3. Study 1

3.1. Design and method

Study 1 took place in May 2022, partway through the second semester of the school year. Children were tested individually in a quiet room in their school using a tablet with a 25-cm screen. The experimenter provided verbal instructions throughout the test, including a short introduction in which the children were told they would be playing

Table 1
Summary characteristics of the two studies

Parameter	Study 1	Study 2
Date	May 2022	January 2023
Sample size	196	419
Nudge	Labels & emoticons	Emoticons
Task	Choice of apple vs chocolate pudding	Choice of tomatoes vs chocolate cake
Constructs	- Knowledge - Implicit attitudes - Explicit attitudes	- Implicit attitudes - Explicit attitudes

¹ The three districts of Zagreb were Trešnjevka-Jug, Črnomerec, and Donji Grad. The headcount poverty rate (proportion of the population living below the poverty line) is 6.8% in Trešnjevka-Jug and Črnomerec, and 6.9% in Donji Grad. See World Bank. (2018). *Small area estimates of income poverty in Croatia: methodological report*. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/307961530044451676/small-area-estimates-of-income-poverty-in-croatia-methodological-report> p.24.

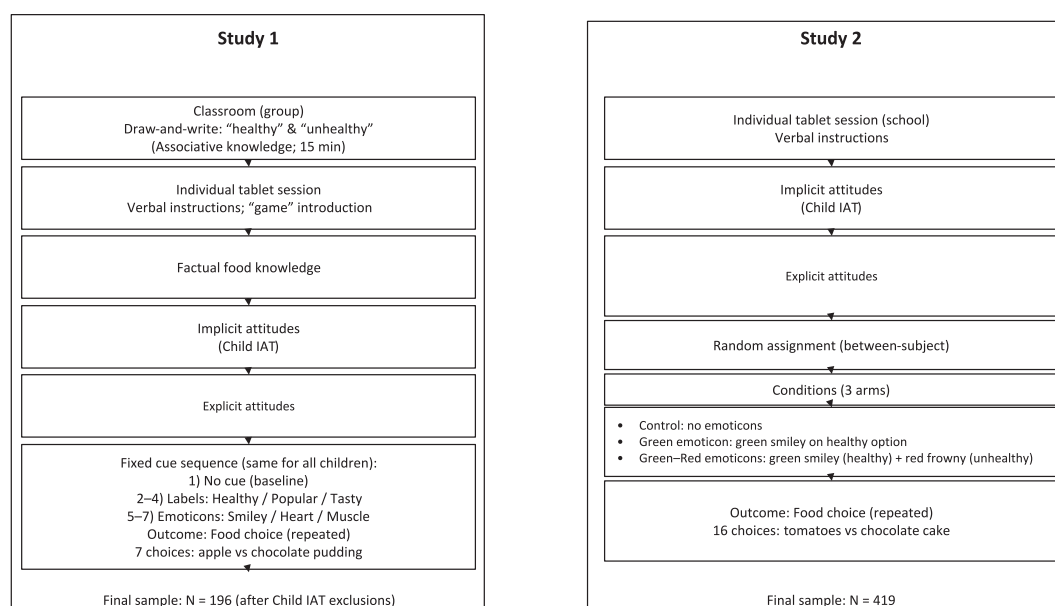


Figure 1. Overview of the two studies and task order

a game on the tablet and answering questions. We approached 365 children, and 220 were given and gave permission to participate (60% consent rate). The IAT responses of 24 children were excluded because they met any of the following standard exclusion criteria for the Child IAT (Cvencek et al., 2011): (a) the student responded too quickly in too many trials (< 300 ms in $> 10\%$ of trials, reflecting anticipatory responses; Greenwald et al., 2003); (b) the student responded too slowly (average response latency was three standard deviations larger than the mean); or (c) the student made too many errors ($> 35\%$). These exclusions resulted in a final sample of 196 children, with a mean age of 7.68 (SD 0.9) years (Table 3). Tables 2 and 3 report the final characteristics of the sample. Note sex (male/female) was self-reported by children using the question "Spol" (Croatian for "sex"), with binary response options: M (male) and Ž (female).

3.2. Study 1 measures

We adopted an operational definition based on nutrient density and public-health guidance: healthy foods were operationalized as minimally processed or unprocessed core foods (e.g., fruits and vegetables) that are low in free sugars, unhealthy fats, and/or salt/sodium, consistent with the World Health Organization's *healthy diet* fact sheet.² Unhealthy foods were operationalized as products high in fat, salt, and/or sugar and classified as "*not permitted*" for marketing to children in the WHO Regional Office for Europe Nutrient Profile Model, including "*chocolate and sugar confectionery ... and sweet toppings and desserts*" and

Table 2
Number of children by age and biological sex in Study 1 and Study 2

Age (years)	Study 1			Study 2		
	Female	Male	Total	Female	Male	Total
6	9	10	19	16	11	27
7	38	24	62	67	68	135
8	39	38	77	78	57	135
9	18	20	38	61	61	122
Total	104	92	196	222	197	419

Table 3

Summary characteristics of the sample of children (Study 1 and Study 2)

Variable	Metric	Study 1		Study 2	
		Mean	S.D.	Mean	S.D.
Age	Mean	7.68	0.90	7.84	0.92
Implicit attitudes	Mean	0.06	0.48	0.06	0.49
Explicit attitudes	Mean	2.29	0.53	0.16 [†]	0.81
Factual knowledge	Mean	20.85	2.50	-	-
Associative knowledge – Fruit	% drawing	0.64	0.48	-	-
Associative knowledge – Sweets	% drawing	0.81	0.39	-	-
Gender	% males	46.94%		47.02%	
Observations (N)		196		419	
Healthy choice	% healthy choices	80.39%		67.91%	
Total choices (N*choices)		1,372		6,704	

[†] : N = 246.

"cakes, sweet biscuits and pastries; other sweet bakery wares." ³

3.2.1. Food choice

Children were presented with the task of making seven choices between one healthy food item (an apple) and one unhealthy food item (chocolate pudding). Always seeing the same pair of images, as shown in Figure 2, children made choices, with the apple presented with either labels ("healthy," "popular," "tasty") or visual messaging (emoticons, e.g., heart, smiley or muscle). The order did not change across children, with the unlabeled options appearing first. Left/right placement of healthy vs unhealthy option was randomized on each trial (or counter-balanced across trials).

3.2.2. Implicit attitudes

Children completed a child-friendly Implicit Association Test (Child IAT). The Child IAT is a sorting task in which students rapidly allocate stimuli belonging to four categories using two response buttons. The

² https://www.who.int/news-room/fact-sheets/detail/healthy-diet?utm_

³ https://www.nutris.org/images/datoteke/Nutrient-Profile-Model_Version-for-Web.pdf?utm_ World Health Organization.

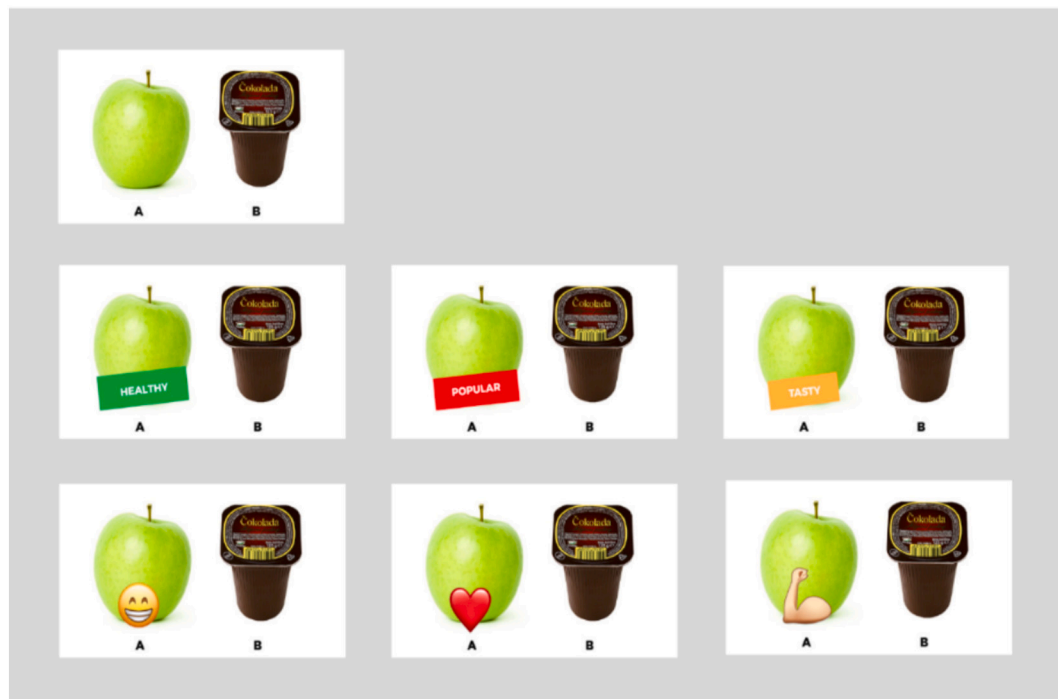


Figure 2. Study 1 food choice task (choosing between an apple and chocolate pudding)

underlying principle of the Child IAT is that participants respond faster when the paired categories are mentally associated (“congruent”) than when they are not (“incongruent”). Based on previous applications of the Child Food IAT (DeJesus et al., 2020), children in the present study responded to stimuli in four categories: “Healthy food,” “unhealthy food,” “tasty,” and “not tasty.” Healthy food was represented by pictures of a tomato, lettuce, pepper, and kale; while unhealthy food was represented by pictures of a cookie, cake, ice cream, and lollipops (Figure 3). Five Croatian words as text with an accompanying audio recording of a female voice speaking each word: “flavorful,” “appetizing,” “yummy,” “lip-smacking,” and “tasty” (*sočno, primamljivo, njami, fino, ukusno*) represented the tasty category. The not tasty category was represented by the Croatian words and recordings for “stale/flavorless,” “unappetizing,” “unpalatable,” “yucky,” and “less tasty” (*nije fino, bljak, nepri-mamljivo, bljutavo, neukusno*).

The healthy and unhealthy stimuli used in the Child IAT were taken from Raghunathan et al. (2006).⁴ The Child IAT was administered using Inquisit Version 6 (Millisecond Software). The structure of the IAT followed that of previous research into children’s implicit attitudes towards foods: seven total blocks (136 total trials) consisting of two single-task blocks (16 trials each), followed by two combined-task blocks (16 practice and 24 test trials, respectively), one single-task block (24 trials) reversing the side of the screen of the *tasty* and *not tasty* categories, and two more combined-task blocks (16 practice and 24 test trials) with the opposite pairing as the first two combined-task blocks. There was a 500 ms inter-trial pause between every two trials. In-person Child IAT procedures such as the one reported here, take children, on average, between 15 and 18 minutes to complete (Cvencek et al., 2025). Children were given age-appropriate oral instructions by the experimenter in line with published protocols (Brecic et al., 2022) and instruction scripts (Cvencek et al., 2025).

A pilot study with three translators and two teachers confirmed that

all words were familiar to Croatian children in the age range under study. The speed of response was measured automatically using touch-screen technology. IAT scores were defined as the difference in response time (in milliseconds) between congruent and incongruent blocks of trials. Raw scores were converted into *D*-scores as an index of association strength analogous to effect size (Baron & Banaji, 2006; Cvencek et al., 2011). Age differences in response speed are an established finding across a wide range of cognitive tasks in developmental and cognitive psychology (Ratcliff et al., 2012). Since the publication of the seminal Greenwald et al. (2003) paper reporting the development of the IAT *D*-measure, the *D*-score has become the standard unit of analysis of IAT data with both adult and child populations (in part, because of its resistance to correlation with response latency, which makes it especially useful when comparing different age groups of children as reported here). Higher *D*-scores correspond to implicit attitudes that are more favorable to healthy food.

3.2.3. Explicit attitudes

Explicit attitudes were assessed based on a child’s strength of agreement with eight statements related to healthy food: (1) I enjoy eating vegetables, (2) I wish I didn’t have to eat vegetables, (3) I like all dishes that contain vegetables, (4) Vegetables are tasteless, (5) Vegetables make me strong, (6) Vegetables make me happy, (7) Vegetables are healthy, and (8) Vegetables are one of my favorite foods. Questions 2 and 4 were reverse-coded. The final score was the average of the eight answers to these questions. Higher scores correspond to explicit attitudes that are more favorable to healthy food. Agreement was measured on a 4-point Likert scale without a neutral midpoint (forced-choice format), including smiley/frowny faces: 0, strongly disagree; 1, somewhat disagree; 2, somewhat agree; 3, strongly agree. We adopted this approach to minimize the cognitive burden for young respondents and to discourage non-committal midpoint responding when a neutral category is not theoretically central to the measures; evidence indicates that 3–4 point Likert-type scales are suitable for use with children (Alan & Kabasakal, 2020; Chyung et al., 2017).

⁴ We obtained the original stimulus files directly from the authors of the earlier work (available upon request), ensuring we used the established set rather than recreating ad hoc stimuli.

a) Graphical stimuli in the Child IAT

HEALTHY 	STIMULUS 1 	STIMULUS 2 	STIMULUS 3 	STIMULUS 4 
UNHEALTHY 	STIMULUS 1 	STIMULUS 2 	STIMULUS 3 	STIMULUS 4 
TASTY 	STIMULUS 1 appetizing	STIMULUS 2 flavourful	STIMULUS 3 yummy	STIMULUS 4 tasty
NOT TASTY 	STIMULUS 1 yucky	STIMULUS 2 not tasty	STIMULUS 3 insipid	STIMULUS 4 unpalatable

b) Visual representation of the Child IAT on a tablet

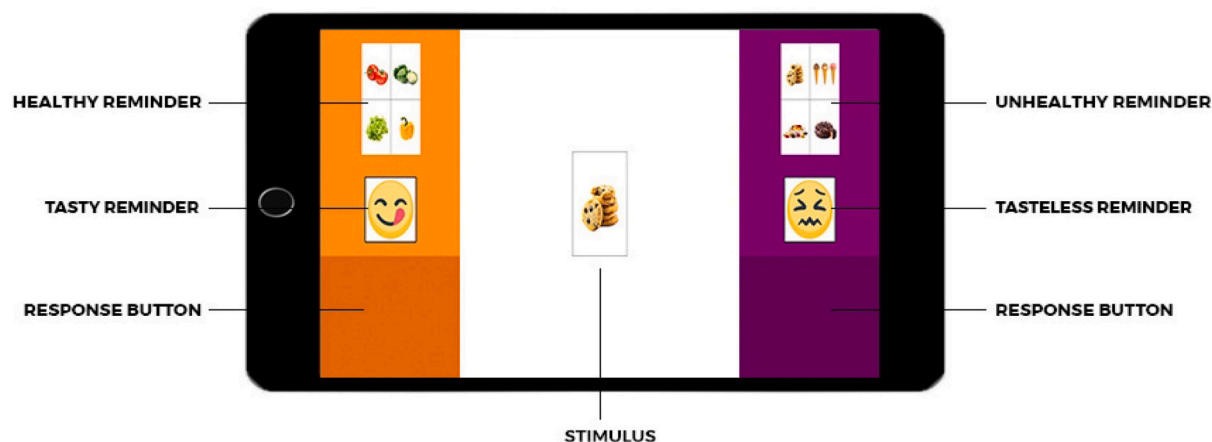


Figure 3. Implicit Test – Child Implicit Association Test / Child IAT Labels and Stimuli a) Graphical stimuli in the Child IAT b) Visual representation of the Child IAT on a tablet

3.2.4. Associative knowledge

Children's *associative knowledge* was captured in the form of open-ended responses to what the words “healthy” and “unhealthy” meant to them through a “draw-and-write” exercise, which allows children to participate in an easily accessible, enjoyable way (Bradding & Horstman, 1999). This technique elicits rich data about children's own ideas (Horstman et al., 2008). The draw-and-write exercise occurred in the children's classrooms. With help from the classroom teachers, the researchers presented blank sheets of paper to the children, asking them to draw any associations they had with the words “healthy” and “unhealthy.” Children had 15 minutes to complete the exercise, after which the papers were collected. Researchers then coded the drawings using

the terms in Table 4 (below). Appendix 1 provides illustrative examples of drawings.

Drawings from the “draw-and-write” exercise were coded independently by two researchers. Drawings of *healthy* associations were classified into fruit; vegetables; other foods, such as fish, meat, milk; sports; friendship/social relations; nature and the environment; and “other,” such as water and sleep. Drawings of *unhealthy* associations were classified into foods high in salt; foods high in sugar and/or fat; drugs or alcohol; being unwell; overeating; lack of exercise or sedentary leisure activities, such as watching TV and playing video games; and “other,” such as COVID-19, accidents, or war. Each drawing could be assigned to multiple categories, such as if the child drew an apple and a football

Table 4

Count of drawings by children in response to healthy or unhealthy prompts and their association with implicit and explicit attitudes toward healthy food (Study 1)

Prompt	Subject of the drawing	N	Association with		
			Age (6-7 vs 8-9)	Implicit attitude	Explicit attitude
			Pearson χ^2	K-W χ^2	K-W χ^2
Healthy	Fruit	126	23.672***	0.244	0.013
	Vegetables	97	8.564***	5.294**	0.001
	Generic healthy diet	19	0.175	2.009	2.853*
	Animal products	16	5.971**	0.139	6.142**
	Water/Tea/Soup	6	8.766***	1.252	0.039
	Cereals	4	0.127	3.399*	1.402
	Sport	30	5.094**	0.019	1.655
	Nature	14	2.462	0.937	3.129*
	Social relationship	9	0.788	0.232	0.659
	Hygiene	5	3.614*	0.023	0.113
Unhealthy	Sweets	159	0.401	1.380	0.046
	Fast food	32	0.008	1.200	0.156
	Soft drinks	18	4.971**	0.133	0.164
	Generic unhealthy diet	12	0.001	0.783	3.442
	Alcohol	3	2.146	1.833	0.210
	Technology	6	0.192	1.464	0.023
	Idleness	5	0.004	0.340	0.411
	Poor hygiene	4	0.449	0.411	0.200

Significance level is as follows: * = 0.10, ** = 0.05, *** = 0.01. N indicates the number of children who drew something within the category; children could include multiple categories, and the sum of N will be larger than the total sample). K-W = Kruskal–Wallis. Associations with age group (6–7 vs. 8–9) are tested using a Pearson χ^2 . Associations with implicit and explicit attitudes are tested using Kruskal–Wallis χ^2 .

pitch. The analysis focused on food-related associations, and children were aggregated into two age groups (6-7 or 8-9 years) in order to compensate for the relatively smaller numbers of 6- and 9-year-olds and to increase statistical power in the analysis.

3.2.5. Factual food knowledge

Factual food knowledge was measured through a self-reported *categorization task*, where children evaluated whether specific foods were "healthy," "unhealthy," or "I don't know." The list of foods included (correct answer in parenthesis): chocolate cereals (unhealthy); banana (healthy); beans (healthy); apple (healthy); cake 1 (unhealthy); pie (unhealthy); cabbage stew (healthy); bread (healthy); pudding (unhealthy); yoghurt (healthy); salad (healthy); ice cream (unhealthy); chicken with wholegrain flatbread (healthy); biscuits (unhealthy); sandwich (healthy); cookie (unhealthy); cake 2 (unhealthy); pepper (healthy); candy (unhealthy); carrot (healthy); kale (healthy); tea (healthy); tomato (healthy); fish (healthy). Food pictures were obtained from free image libraries and selected to maximize recognizability for children aged 6–9. Images were displayed as same-sized thumbnails in a fixed grid layout (Appendix 2). Because the task measures categorization (healthy/unhealthy/I don't know) rather than preference, we prioritized recognizability over formal matching of low-level visual properties (e.g., background, lighting). The final knowledge score was the sum of the correct answers. Appendix 2 provides an example of the categorization task.

3.3. Estimation of treatment effects

To quantify the impact of the nudges on children's choices, we estimated a mixed-effects model with random intercept only. This model accounts for repeated observations nested within subjects, also allowing

for baseline preferences that differ across children. To understand the model, let y_{it} denote the outcome of the decision of child i in choice occasion t , with $y_{it} = 1$ if the child chose a healthy option, 0 otherwise. Then, let x_i represent a vector of child-specific characteristics (age, gender, knowledge, and attitudes), and z_{it} represent treatment variables, that is information provided as part of the treatment (keywords or emojis). The impact of the treatment on choice is estimated using the multi-level regression:

$$y_{it} = \alpha_i + \beta x_i + \delta z_{it} + \varepsilon_{it} \quad (1)$$

where α is a child-specific random intercept, β captures the relationship of personal characteristics on choice, and ε_{it} are the residuals, which we cluster at the level of the child. The parameter δ captures treatment effects.

In our analysis, we estimated both a linear and a logit mixed-effects model. The linear model, which estimates δ consistently but inefficiently, allows for autocorrelation correction: in particular, we allow the residuals ε_{it} to follow a first-order autoregressive structure in the form $\varepsilon_{it} = \rho \varepsilon_{it-1}$, therefore allowing within-subject dependence. This correction is important for this dataset, because children made sequential choices that could be correlated through, for example, personal preferences for apples. Because all children answered questions in the same order, the AR(1) structure helps attenuate temporal dependence arising from gradual, noisy processes such as learning or fatigue; but it does not remove systematic differences caused by order effects, as the approach does not capture deterministic level shifts associated with specific positions in the sequence. As a second step, we estimated equation (1) using a mixed-effects logistic regression model, which better accounts for the binary nature of the dependent variable and ensures that predicted probabilities lie between 0 and 1, but does not allow for explicit correction of potential serial autocorrelation in the error term.

4. Study 2

4.1. Design and methods

Study 2 sought to test whether affective nudges can promote healthy choices amongst children. We involved the same children from the two schools who participated in Study 1, as well as additional participants from a third school. To ensure adequate cell sizes for the three-condition between-subject design (control, green emoticons, green–red emoticons) after expected non-consent, absence, and exclusions, we expanded recruitment to an additional school drawn from the same urban, largely middle-class catchment area in Zagreb; procedures were identical across schools. As part of this task, we approached caregivers (e.g., parents) of 673 children⁵ (including those who had taken part in Study 1), 449 of whom consented to their child's participation (67% consent rate). Using the same criteria described for Study 1's IAT, we excluded the data from 10 children. We also excluded the data from another 10 children who did not undergo testing. The final sample consisted of 419 children with a mean age of 7.84 (SD 0.92) years (Table 5). $N = 246$ refers to children with complete (non-imputed) implicit and explicit attitude data.

4.2. Study 2 measures

Study 2 focused on the most influential elements of Study 1: attitudes and visual cues. We also narrowed the visual manipulation to two emoticons – one positive (green smiley) and one negative (red smiley) – to assess how contrasting emotional signals shape choices more precisely. This refined design allowed us to test the impact of emotionally

⁵ The minimal sample size was calculated using G power analysis with the following parameters: Cohen's $f = 0.25$, $\alpha = 0.05$, $\beta = 0.95$, and $F = 1.5574$. The calculation gave a minimal sample of 408 children aged 6–9 years.

Table 5

Multi-level regression models (random intercept only) predicting the choice of the healthy option (apple), with and without covariates – Study 1

	Linear model		Logit	
	Labels	Labels + demographics	Labels	Labels + demographics
Constant	0.7092***	0.1042	1.6568***	-4.9792**
S.E.	0.0325	0.1978	0.2979	2.0058
Apple – No label/No emoticon	Baseline	Baseline	Baseline	Baseline
Apple – Healthy label	0.1480***	0.1480***	1.5919***	1.5885***
S.E.	0.0342	0.0342	0.3673	0.3669
Apple – Popular label	-0.0408	-0.0408	-0.3444	-0.3428
S.E.	0.0361	0.0361	0.3048	0.3035
Apple – Tasty label	0.1276***	0.1276***	1.3170***	1.3134***
S.E.	0.0323	0.0323	0.3384	0.3376
Apple – Smile emoticon	0.1684***	0.1684***	1.8998***	1.8972***
S.E.	0.0313	0.0313	0.3511	0.3511
Apple – Heart emoticon	0.1173***	0.1173***	1.1893***	1.1858***
S.E.	0.0325	0.0325	0.3328	0.3318
Apple – Muscle emoticon	0.1429***	0.1429***	1.5204***	1.5169***
S.E.	0.0339	0.0339	0.3737	0.3736
Implicit attitudes		0.0764**		0.7454*
S.E.		0.038		0.404
Explicit attitudes		0.1325***		1.4551***
S.E.		0.0395		0.4162
Female		Baseline		Baseline
Male		-0.0468		-0.5351
S.E.		0.0374		0.3937
Age=6		0.0001		0.2059
S.E.		0.064		0.6912
Age = 7		Baseline		Baseline
Age=8		0.0565		0.7842
S.E.		0.0461		0.4922
Age=9		-0.0486		-0.4186
S.E.		0.0584		0.5689
Associative knowledge – Fruit		-0.0222		-0.0899
S.E.		0.0388		0.4099
Associative knowledge – Sweets		-0.0026		-0.1553
S.E.		0.047		0.5021
Factual knowledge		0.0155*		0.1636*
S.E.		0.0086		0.0858
Observations	1372	1372	1372	1372
log-likelihood	-467.59	-453.82	-514.44	-501.78
chi2	59.52***	89.91***	67.11***	78.97***
Serial correlation - ρ	-0.1017**	-0.1046**	-	-

Significance level is as follows: * = 0.10, ** = 0.05, *** = 0.01. S.E. refers to standard errors clustered at the level of the individual child. Note: the dependent variable is the probability of choosing the healthy option across repeated choices (7 per child). Associative knowledge refers to a dummy equal to 1 if the child drew fruit or sweets in the drawing task, 0 otherwise; while factual knowledge refers to the results of a knowledge test asking children to identify the healthy option (out of two) in 24 questions, with the final score going from 0 to 24.

valenced cues in a more controlled and policy-relevant way.

4.2.1. Food choices and Nudges

Children were asked to make 16 binary food choices. Each choice consisted of selecting between one healthy option – a vegetable (tomato, yellow pepper, salad, and savoy cabbage) – and one unhealthy food option – a sweet (gummies, chocolate chip cookies, ice cream, and chocolate cake) – with no opt-out alternative. We used a fully crossed, balanced forced-choice experimental design, where each food item appeared four times across the experiment and was displayed twice on the left and twice on the right side of the screen to control for positional bias. This design fully crossed the four healthy and four unhealthy items, resulting in all 16 possible healthy-unhealthy pairings being presented exactly once. The order of the 16 choice tasks was fixed across participants; while this leaves open the possibility of order effects, the fully crossed and balanced design ensures that any such effects would not systematically favor specific food categories.

As part of this choice task, participants were randomly assigned to one of three groups:

1. *Control*: Emoticons were not presented alongside the potential options from which respondents made a choice.

2. *Green emoticons*: The healthy option was displayed alongside a green emoticon with a smiling face, which was expected to nudge children towards the healthier option by signaling approval (see Figure 4 for illustration).

3. *Green-Red emoticons*: The healthy option was displayed alongside a green emoticon with a smiling face, while the unhealthy option had a red emoticon with a frowning face, which was expected to deter children from selecting the unhealthy option by signaling disapproval. We introduced the negative cue for two reasons. First, interpretive labeling research suggests that negative evaluative signals (e.g., warnings) can be especially influential because they draw attention and elicit a negative effect that increases health-related processing (Song et al., 2021). Second, including both positive and negative signals can outperform one-sided labeling, supporting the idea that adding a negative cue may increase discriminability and strengthen behavior change (Grummon et al., 2023).

4.3. Implicit attitudes

In Study 2, implicit attitudes were measured in the same way as in Study 1.

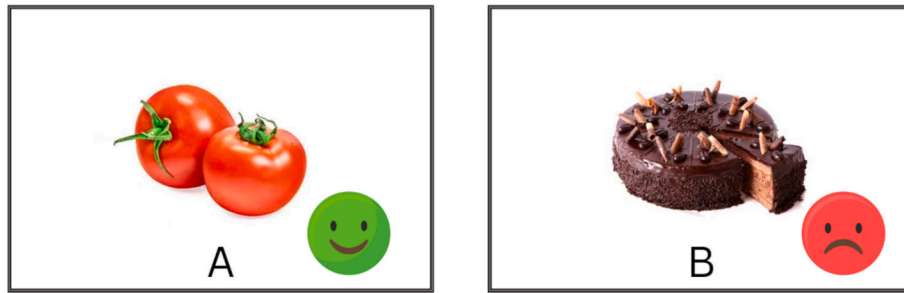


Figure 4. Green happy and red unhappy emoticons (Study 2)

4.4. Explicit attitudes

Explicit attitudes were measured differently than in Study 1. Whereas Study 1 relied on children's agreement with eight statements concerning vegetables, Study 2 used a forced-choice categorization task (Marty et al., 2017; Monnery-Patris et al., 2016) in which children evaluated pictures of healthy and unhealthy foods. In this task, children viewed four pictures of healthy foods and four pictures of unhealthy foods, and were asked to rate how much they liked the food by selecting one of four options that were presented alongside pictures of each food: (1) I really don't like this food (sad face); (2) I neither like nor dislike this food (uncertain face); (3) I really like this food (smiling face); or (4) I have never tried this food (mouthless face). The pictures used in this measure were the same healthy and unhealthy food pictures that appeared during the Child IAT.

Responses in category (4) were treated as missing, because they could not fit any of the other 3 categories. These missing values were then imputed using multiple imputation by chained equations, assuming an ordinal response scale going from 1 to 3 (White et al., 2011); missing values were then imputed estimating an ordered logit model conditional on gender and age. In this study, we generated 10 imputed datasets. Following imputation, explicit attitudes were aggregated into an index, which equals the difference between the mean attitude toward healthy foods H (kale, pepper, salad, tomato) minus the mean attitude toward unhealthy foods U (cake, candy, cookies, ice cream), as

$$EA_i = \frac{1}{4} \sum_{j=1}^4 A_{ij}^H - \frac{1}{4} \sum_{j=1}^4 A_{ij}^U$$

where $A_{ij} \in \{1, 2, 3\}$ denotes the observed or imputed explicit attitude toward item j . This aggregation was implemented using a passive imputation rule, to obtain an index within each imputed dataset, therefore preserving internal consistency across imputations.

4.5. Estimation of treatment effects

As in Study 1, we estimate the impact of the nudges on children choices using the mixed-effects model with random intercept of equation (1). As before, the parameter δ captures treatment effects. In Study 2, the order in which choices were presented to children was randomized, eliminating concerns about systematic order effects and therefore removing the need for an autocorrelation correction, particularly as the order of choices is not recorded in the data. As a second step, similarly to study 1 we re-estimated equation (1) using a mixed-effects logistic regression model.

5. Results

Table 3 reports descriptive statistics for all core variables employed in the analyses.

6. Results of Study 1

6.1. Relations between implicit and explicit attitudes

Figure 5 details the relations between implicit and explicit attitudes. Both attitudes moved in the same direction: an increase in implicit attitudes was associated with an increase in explicit attitudes, an indication that these two metrics reflect the same underlying evaluations. However, as in Panzone et al. (2016), the correlation between these two sets of attitudes is weak in both age groups, suggesting that they refer to somewhat different constructs: for 6- and 7-year-olds, the Spearman correlations were 0.27 ($p=0.009$, $N=90$); and for 8- and 9-year-olds the correlation was 0.17 ($p=0.0566$, $N=130$).

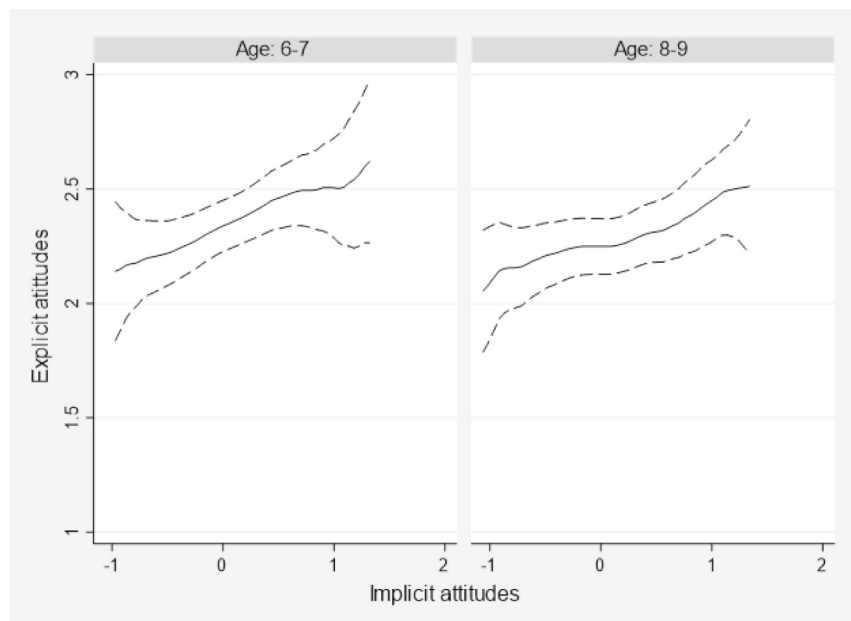
Using the implicit and explicit attitude scores reported above, we tested whether children who depicted specific food categories in the draw and write exercise differed in their attitudes.

6.2. Food knowledge

Fruit was the food item that was most commonly associated with health (Table 4): it was drawn significantly more frequently by children aged 8-9 than by those aged 6-7 [$\chi^2(1) = 23.6715$, $p < 0.001$]. Vegetables and animal products were also associated with health, and both were drawn significantly more frequently by older children [vegetables, $\chi^2(1) = 8.56$, $p < 0.01$; animal products, $\chi^2(1) = 5.97$, $p < 0.05$]. The two age groups drew or mentioned generic terms related to a healthy diet with similar frequency, such as "food," "healthy," "eat," "nutrition," and "energy." Very few children drew or wrote water, tea, soup, cereals, or non-food items such as sport, nature, social relationships (e.g., friends), or hygiene. However, children who depicted vegetables also recorded more positive health-related implicit attitudes [K-W $\chi^2 = 5.294$, $p = 0.021$], while healthier explicit attitudes were significantly associated with the depiction of animal products (K-W $\chi^2 = 6.142$, $p = 0.013$).

In terms of the unhealthy prompt, sweets were the most frequent food-related association, followed by fast food, soft drinks, and generic unhealthy terms ("eating unhealthy," "food that I cannot eat," "eating too much," "something tasty"). Among these associations, only soft drinks were more frequently mentioned by older children than younger children. Unhealthy non-food items, such as sedentary leisure activities (e.g., watching TV, playing computer games), idleness (i.e., lack of exercise) or poor hygiene, were mentioned very infrequently.

Overall, these findings indicate that children possess associative knowledge about which foods are considered healthy and unhealthy. This knowledge appears to develop between ages 7 and 8. Interestingly, while an older age was associated with a greater ability to associate healthy foods such as fruit and vegetables with overall health, the ability to associate a range of unhealthy food options with negative health outcomes did not differ significantly between the two age groups. Children's *factual food knowledge*, measured by the categorization task, was generally high across all year groups. A modest drop in knowledge scores was observed between 6-7-year-olds, with mean scores ranging between 20.5 out of a possible 24 and 21.4 for 8-9-year-olds, a non-



Note: Dashed lines refer to 95% confidence intervals. The local polynomial regression has degree 0.

Figure 5. Local polynomial regression of implicit and explicit attitudes in children, by age (Study 1) Note: Dashed lines refer to 95% confidence intervals. The local polynomial regression has degree 0.

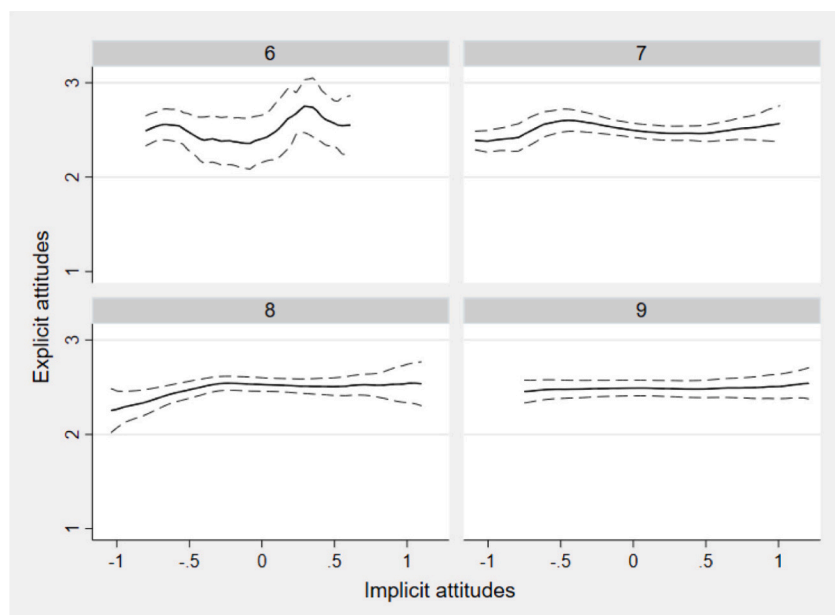
significant difference when applying a Bonferroni correction ($p=0.7$).

6.3. Impact of nudges on food choice

To understand the role of nudges in choices of the healthy option (apple) in our sample, we employed a multi-level linear model with random intercept, regressing the choice (apple = 1, 0 otherwise) over the presence of a specific label or emoticon, attitudes, and demographics. Table 5 presents both a multi-level linear multi-level model

that corrects for the potential autocorrelation of children's choices (that is, attenuating potential sequence effects), as well as a multi-level logit. Both models cluster residuals at the individual level, reducing problems of heteroskedasticity and autocorrelation.

Table 5 indicates that labelling apples as “Tasty” or “Healthy” (supporting H1a and H1b) but not “Popular” (H1c), as well as the presence of emoticons (H2), had a positive and significant impact on the probability of choosing an apple. Overall, these results indicate that specific labels and emoticons can play useful roles in shaping children's



Note: Dashed lines refer to 95% confidence intervals. The local polynomial regression has degree 0. Lines are estimated using only individuals with complete sets of implicit and explicit attitudes ($N=246$ in study 2).

Figure 6. Local polynomial regression of implicit and explicit attitudes in children, by age (Study 2) Note: Dashed lines refer to 95% confidence intervals. The local polynomial regression has degree 0. Lines are estimated using only individuals with complete sets of implicit and explicit attitudes ($N=246$ in study 2).

choices.

Considering determinants other than nudges, explicit attitudes were strong predictors of behavior, while the predictive power of implicit attitudes was noisier, particularly in the logit estimation. The results are qualitatively comparable in both the linear and logit models. The linear model also detected limited serial autocorrelation, with the estimated $\rho = -0.10$ ($p < 0.05$). No knowledge variable was significant at $p < 0.05$.

7. Results of study 2

7.1. Relations between implicit and explicit attitudes

Figure 6 displays the relationship between children's implicit and explicit attitudes toward healthy food, including only children with non-imputed explicit attitudes. The visual patterns suggest that more favorable implicit attitudes toward healthy food are associated with more favorable explicit attitudes toward healthy food, indicating that both measures may reflect similar underlying evaluations. As in Study 1, the correlation is statistically significant but moderate overall (Spearman's $\rho = 0.33$, $p < 0.01$, $N = 246$). Notably, the alignment between implicit and explicit attitudes is strongest among younger children (particularly age 6) and becomes weaker or nearly absent by age 9.

7.2. Impact of nudges on food choice

Study 2 employed a multi-level regression with random intercept to determine the impact of attitudes and nudges on food choices (Table 6). For each of the 16 choices made by the 419 children, the dependent variable equals 1 if the child chose the healthy option from the pair of items, and 0 if the child preferred the unhealthy option instead. This binary response was then regressed over attitudes, age, biological sex, and the experimental condition. As before, we use both a linear and a logit specification; for the logit regression, because Stata does not allow

estimating the model after imputation, we estimate two models with attitudes: one with implicit attitudes only, and one with all attitudes, but limited to those 246 children requiring no imputation of explicit attitudes. The model clusters the standard errors at the level of the individual child, correcting for the potential presence of serial autocorrelation, therefore mitigating the impact of potential sequential effects.

Results in Table 6 indicate that emoticons increased the likelihood of making a healthy choice, with green emoticons increasing the probability of such a choice by 11% and green-red emoticons increasing the probability by 15% (Table 6). These results align with the results of Study 1, and support H3a and H3b, albeit the respective effects fell to 5% and 8% when attitudes were added to the regression. Notably, the effect of healthy attitudes only is not significantly different from zero when we included all attitudes in the logit regression, therefore restricting the analysis to those children who had a complete set of explicit attitudes; the strong significant effect in the linear model suggests this change in significance and effect size is linked to the smaller sample (therefore a loss in power) rather than the logit specification. Implicit and explicit attitudes were strongly and positively associated with the likelihood of making a healthy choice. Boys were more likely to prefer the unhealthy options, while age did not significantly influence choice.

8. Discussion

This paper provides evidence that simple, developmentally appropriate nudges—emoticons and labels—can influence children's healthy food choices. Across two experiments with children between 6 and 9 years of age, we found that both specific visual and textual cues increased the probability of selecting a healthy snack. Labels emphasizing *health* or *taste* were effective, while the *popular* label did not significantly influence children's food choices. However, the popular label was displayed in red text, a color often associated with negative or

Table 6

Multilevel regression models (random intercept only) predicting choice of the healthy option (vegetable) – Study 2

Model	Linear model		Logit		
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	0.6403***	0.6562***	1.2350**	1.4888***	1.1333**
S.E.	0.0647	0.0466	0.5228	0.4571	0.4830
No emoticon	Baseline	Baseline	Baseline	Baseline	Baseline
Green emoticon	0.1097***	0.0532*	0.9629***	0.8309***	0.4461
S.E.	0.0381	0.0292	0.3056	0.2637	0.3096
Green-red emoticons	0.1502***	0.0805***	1.2142***	0.9486***	0.7935***
S.E.	0.0368	0.0264	0.3078	0.2620	0.2628
Implicit attitudes	-	0.1405***	-	2.3492***	0.5889**
S.E.	-	0.0272	-	0.2612	0.2858
Explicit attitudes	-	0.2242***	-	-	2.1046***
S.E.	-	0.0154	-	-	0.1831
Age: 6	Baseline	Baseline	Baseline	Baseline	Baseline
Age: 7	0.0536	0.0422	0.5683	0.4387	0.7337
S.E.	0.0649	0.0494	0.5374	0.4649	0.5388
Age: 8	-0.0340	-0.0442	-0.3322	-0.5239	-0.0290
S.E.	0.0644	0.0496	0.5365	0.4600	0.5042
Age: 9	-0.0128	-0.0148	-0.1623	-0.2255	0.2032
S.E.	0.0658	0.0493	0.5413	0.4687	0.5058
Male	-0.1071***	-0.0697***	-0.9784***	-1.3510***	-0.8062***
S.E.	0.0304	0.0250	0.2519	0.2303	0.2609
No. observations	6704	6704	6704	6704	3,936
No. children	419	419	419	419	246
No. choices	16	16	16	16	16
Wald χ^2	39.01***	-	38.69***	126.92***	202.27***
Log pseudolikelihood	-2984.92	-	-2950.89	-2912.68	-1543.56
Imputations	-	10	-	-	10
Model F test	-	66.05***	-	-	-

Significance level is indicated as follows: * = 0.10, ** = 0.05, *** = 0.01. S.E. refers to standard errors clustered at the level of individual children. Note: the dependent variable is the probability of choosing the healthy option across repeated choices (16 per child). Explicit attitudes include imputed values for all those instances where the child indicated "I have never tried this food" in the elicitation process. Note that imputations and autocorrelation correction are not possible for a multi-level logit regression in Stata.

warning cues in childhood contexts (Akyol et al., 2018; Genschow et al., 2012; Mehta & Zhu, 2009; Pravossoudovitch et al., 2014), which may have undermined its intended social-norm signal.

Emoticons proved particularly powerful, with green and green-red designs increasing the likelihood of a healthy choice by 11–15%. These results resonate with research on color psychology, which highlights green as a symbol of health and “go” signals (Schuldt, 2013) and red as a cue for avoidance or warning (Pravossoudovitch et al., 2014). The combination of these cues creates a contrastive framing effect, reinforcing the healthy item as the desirable choice and the unhealthy item as less desirable. Given that color-coded nutrition labels also influence adults, the findings suggest that simple color-affect cues affect young children as well, rather than as evidence of a child-specific effect (Song et al., 2021). Developmental work nevertheless suggests that children may be especially responsive to visually salient food cues: compared with adults, children show stronger neural responses to unhealthy (vs. healthy) food images in reward/motivation regions (van Meer et al., 2016a) and are less likely to disengage attention from unhealthy food cues (Junghans et al., 2015).

8.1. Discussion of study 1

Study 1 demonstrates that simple nudges—both textual and visual—can significantly shape children’s food choices, even after accounting for their existing knowledge and attitudes. It extends to children a key lesson from adults (Global Food Research Program, 2025), that nutritional labels are effective tools to nudge consumers towards healthier food and drink choices. Specifically, when children were repeatedly asked to choose between an apple and a chocolate pudding, the labels “healthy” and “tasty” increased the likelihood of selecting the apple, as did emoticons representing a smiley face, a heart, or a muscle. In contrast, the label “popular” did not increase selection of the healthier option in our sample. Among the affective cues, visual symbols proved particularly influential: in the linear model, the smiley emoticon increased the probability of choosing the apple by 16.8% ($p < 0.01$), followed by the muscle emoticon at 14.3% ($p < 0.01$), and the heart emoticon at 11.7% ($p < 0.01$). Both “healthy” and “tasty” labels also had significant effects—raising the probability by 14.8% and 12.8% respectively (both $p < 0.01$) in nudging elementary school-aged children toward healthier food decisions. The latter finding is consistent with notions that affective primes may demonstrate stronger effects on food choices than purely cognitive ones (Walsh & Kiviniemi, 2014).

In contrast, the “popular” label did not affect choice. This null effect is interesting because popularity cues (e.g., “best seller” badges) are common marketing devices that provide social proof (Ghiassaleh et al., 2020), and child-directed food marketing predominantly promotes less healthy products (Smith et al., 2019). However, several features of our operationalization may have limited the cue’s diagnostic value for 6–9-year-olds. First, “popular” is underspecified (“popular among whom?”), whereas descriptive norm messages that make the referent explicit may increase selection of healthy options (Sharps & Robinson, 2016). Second, the label was rendered in red, which may be interpreted as a stop/warning signal and could have diluted any normative meaning. Third, popularity may be food-category contingent: peer and sibling influence on eating is often associated with increased consumption of energy-dense, low-nutrition foods (Ragelienė & Grønhoj, 2020), suggesting that popularity cues may be more persuasive when attached to indulgent snacks than to fruit/vegetables. Finally, sensitivity to normative influence changes with development (Hang et al., 2020; Steinberg & Monahan, 2007). As we did not measure children’s interpretation of “popular” and did not cross popularity with food type or age, we cannot draw any general conclusions about norm-based nudges.

Explicit attitudes significantly predicted children’s likelihood of choosing an apple across all age groups ($p < 0.01$), whereas implicit attitudes were only significant at the 5% level in the linear model and not in the logit model. This evidence is consistent with König et al.

(2016), who found that in a binary food choice task with university students (confectionery vs. fruit) explicit attitudes had greater predictive power than implicit attitudes. Neither associative nor factual food knowledge predicted children’s likelihood of choosing an apple. Again, this is consistent with evidence for adults that non-conscious processes and environmental cues can be more important in decision-making than food knowledge (Gillison et al., 2021). Given the limited explanatory power of knowledge variables in predicting food choice, they were not included in the design of Study 2.

8.2. Discussion of study 2

Study 2 reinforces and extends the findings from Study 1. The green emoticon alone and the green-red combination significantly increased the likelihood of selecting a healthy food option. When attitudes were included in the model, however, these effects were more modest, indicating that emoticons may work partly by amplifying the impact of existing attitudes. The latter dovetails with theories that emoticons function by amplifying pre-existing attitudes rather than independently steering interpretation (Aldunate et al., 2024). Critically, while attitudes matter in shaping children’s decisions, simple visual cues like emoticons can further enhance healthy food selection. These nudges appear effective in the short term, even without changing attitudes, extending to children their potential as low-cost tools in behaviorally informed interventions (Fennessy et al., 2024).

Results revealed that both green and green-red emoticon combinations significantly increased the likelihood of selecting the healthy option (vegetable) compared to no emoticon, with the green-red combination exerting the strongest effect. This pattern aligns with existing research suggesting that color symbolism strongly shapes health-related perceptions (van Herpen et al., 2012). Specifically, green is widely associated with healthiness, as evidenced by Schuldt (2013) who demonstrated that products bearing green nutrition labels were perceived as healthier, even when objective nutritional content was identical. Conversely, red is often interpreted as conveying danger and is commonly used on front-of-pack labels to denote unhealthiness (Pravossoudovitch et al., 2014). By integrating both green and red emoticons, our design may have amplified contrastive signaling (Wan et al., 2022), reinforcing the vegetable as a “go” or “good” choice and the alternative as a “stop” or “bad” one. We again found a moderate positive correlation between implicit and explicit attitudes.

8.3. Theoretical implications

These results advance research on nudging and children’s decision-making in three ways. First, they demonstrate the applicability of associative priming theory (McNamara, 1992) to children’s decisions. Specifically, we present evidence that pictorial nudges, effective in adult populations, also extend to younger children when adapted into simple, intuitive cues. However, the effectiveness of word-based labels varies. Consistent with goal activation theory (Nguyen, 2007), a “healthy” label helps children select the “better-for-you” option at the moment of choice. Similarly, a “tasty” label also increases the likelihood of children selecting a healthy option – a finding consistent with goal conflict theory (Belei et al., 2012). The latter suggests that a “tasty” label may reduce the tension between two goals (healthy and enjoyable), making a particular choice more appealing. In contrast, the “popular” label did not significantly influence children’s food choices. However, as this label was displayed in red text, a color often associated with negative or warning cues in childhood contexts (Genschow et al., 2012), we avoid drawing wider conclusions regarding the effectiveness of social norm-based nudges amongst children (Filipovic et al., 2025).

Second, the analysis of implicit and explicit attitudes confirms that the two types of attitudes may already reflect separate mental systems in this age range (Cvencek et al., 2020; Greenwald et al., 2009). This theorizing is further reinforced by a finding that the alignment between

implicit and explicit attitudes was strong among younger children, and was nearly absent by age 9. Interventions for children may therefore be most effective when they combine explicit point-of-choice nudges with efforts that shape children's automatic responses toward healthy foods (e.g., increasing positive affect or reducing the implicit "healthy = not tasty" inference). In other words, consistent with dual process models (Sheeran et al., 2013), targeting both types of attitudes may be more effective rather than focusing on either type of attitude alone, especially as children grow older. Explicit attitudes consistently predicted healthy food choices. This suggests that when children consciously endorse positive views about healthy foods, they are more likely to act on them.

Finally, the results extend the literature on affective priming theory (Stoianov et al., 2025), highlighting the ability of emoticons to influence elementary school aged children's choices. This is consistent with evidence that visual components, especially characters and colors arouse emotional reactions, particularly amongst pre-adolescent children, driving preferences (Lagomarsino & Suggs, 2018). Emoticons may be particularly effective, given the general appeal and familiarity of cartoons and emojis for such children (Gallo et al., 2017b; Lagomarsino & Suggs, 2018).

8.4. Policy and practical recommendations

Studying children is critical because early experiences can shape long-term attitudes and behaviors, and children are particularly susceptible to persuasive marketing cues (Cvencek et al., 2011; John et al., 2024). Interventions that change the choice environment therefore have practical value, especially in settings where children regularly make independent selections. Consistent with evidence that exposure to healthier options can improve children's diets and related outcomes (Belot et al., 2016), and that food choices are shaped by environmental and social factors (Echelbarger & Maimaran, 2024), our findings indicate that simple, developmentally appropriate nudges can be used to support healthier decisions at the point of choice from an early age.

Across both studies, emoticons increased selection of the healthy option, although effects were smaller once knowledge and attitudes were accounted for. This pattern suggests that nudges provide an incremental shift that operates alongside children's underlying evaluations, and should be implemented as complements to approaches that strengthen healthy-eating knowledge and attitudes rather than substitutes for them. In practice, low-cost nudges could be integrated into school cafeterias, snack displays, and public health materials to make healthier options easier to notice and choose (School Food Trust, 2011).

Our results contribute to ongoing discussions about front-of-pack and interpretive labelling. Evidence emphasizes that clarity and visual salience matter for consumers, and that color-coded, interpretive formats can facilitate healthier decisions (Global Food Research Program, 2025). For child-directed environments, this implies that policy should address not only what information is provided but how it is presented. A practical implication is to encourage simplified, visually salient labelling for healthier options while limiting the use of attention-capturing design features—such as characters, badges, and color signals—on foods high in fat, sugar, and salt.

Importantly, this is not an ethical critique of nudging: nudges preserve choice by changing the choice architecture rather than restricting options. However, the effectiveness of these cues highlights a related regulatory issue: the same design mechanisms can be used in commercial marketing to steer children toward less healthy products without deliberate awareness. This strengthens the case for comprehensive restrictions on child-directed marketing that encompass not only content but also format, design, and placement, consistent with WHO (2023) recommendations. At the same time, our findings support a constructive direction for policy and practice: public health actors can repurpose engaging, developmentally appropriate visual cues to increase the visibility and attractiveness of healthier foods.

Finally, this study underscores the value of child-centered research

designs. As noted by Moore et al. (2017), many previous studies rely on caregiver, especially parental, reports, limiting ecological validity. By engaging children directly, we provide clearer insights into the role of knowledge, attitudes, and nudges in their food choices. Such an approach is essential for crafting effective public policy aimed at children (Andrews et al., 2022).

8.5. Limitations and recommendations for future research

Several limitations should be noted. First, the task sequence may have introduced carryover effects: completing attitude/knowledge measures (including the IAT) before the choice task could have primed children to think about food healthfulness or categories in ways that influenced subsequent choices. Second, choices were hypothetical rather than consequential; however, the results demonstrate that the stated preferences of children are susceptible to nudges, providing an essential first step for testing cue mechanisms towards actual choices. Third, the food-choice tasks involved repeated decisions with limited stimulus variety, which may not fully capture the range of real-world food decisions and may introduce habituation or learning across trials. Fourth, we did not directly assess potential mechanisms such as perceived tastiness, endorsement of health norms, or children's comprehension of specific labels (e.g., "popular"), which limits our ability to interpret why particular cues were effective or ineffective. Fifth, Study 2 included returning participants from Study 1, and prior exposure to a similar task may have increased familiarity or awareness of the study's purpose, potentially affecting effect sizes. Sixth, comparisons across studies are constrained because the healthy option differed (apple in Study 1 versus tomato in Study 2), introducing a sweet versus savory contrast that could influence baseline preference and task difficulty. As baseline liking was not measured, taste-related differences cannot be separated from nudge effects when interpreting cross-study differences. Finally, the sample (urban Croatian children) was relatively homogeneous in terms of socio-economic and demographic characteristics, which may limit generalizability. As a minor measurement note, images used in the knowledge categorization task were not formally equated on low-level visual properties; this may add noise to that measure but does not affect the experimental comparisons, which held choice stimuli constant within each study.

Future research should test whether these effects generalize to a broader range of nudging formats and decision contexts. First, studies can extend the visual approach by comparing additional cue designs (e.g., animated, character-based, or personalized emoticons) and by systematically varying icon features (valence, intensity, and visual complexity) to identify which design elements are most effective for 6–9-year-olds. Second, these findings could be extended to real and incentivized choices, including consumption, lunchbox selection, or purchase behavior in school and retail settings, to assess whether the observed preference shifts translate into behavioral change. Future work should build directly on the boundary conditions suggested here: the null effect of the popularity badge warrants testing more explicit descriptive-norm messages (e.g., "most children chose this"), varying the referent group (classmates vs. children in general), and examining whether popularity cues operate differently when attached to hedonic/unhealthy foods versus healthier options. Third, the effect of the green–red condition suggests future research should disentangle color from valence by orthogonally manipulating color context and icon meaning, and by extending the cue set to include an intermediate "moderation/amber" signal aligned with real-world front-of-pack schemes. Fourth, future studies should measure candidate mechanisms more directly (e.g., expected tastiness, perceived healthiness, comprehension of each cue, and endorsement of health norms), and test whether these variables mediate nudge effects. Such an approach should be complemented by including category-specific implicit measures and direct tastiness ratings, to evaluate whether taste inferences help explain implicit responses. Fifth, future evidence would benefit from more

naturalistic choice environments: broader food assortments, realistic packaging, and field studies that embed cues in school and retail settings. Finally, longitudinal designs are warranted to assess whether short-run changes in choice translate into durable changes in habits, and to examine how implicit and explicit attitudes co-develop over time in interaction with everyday cues such as packaging, peer influence, and digital prompts.

9. Conclusions

Healthy cues can encourage healthier choices among children. Specifically, this research shows that simple, developmentally appropriate nudges can increase children's selection of healthier options. Across two experiments with 6–9-year-olds, “healthy” and “tasty” labels and emoticon-based cues shifted choices toward a healthier snack, with visual cues producing the most consistent effects and the combined green–red signal performing particularly strongly. The findings indicate that nudges can deliver an incremental shift at the point of decision, but the magnitude of this shift depends on children's underlying attitudes. Practically, this implies that low-cost visual cues can complement, rather than replace, broader efforts to support healthier preferences and habits.

From a policy perspective, this research suggests a need for controls on marketing practices, since children are influenced by labelling elements commonly used commercially. The effectiveness of simple emoticons and labels underscores how powerful visual and verbal design elements can be in shaping children's food decisions. This has direct relevance for child-directed packaging and marketing: if small, non-informational cues can reliably steer choices toward healthier items, analogous commercial cues may also steer choices toward less healthy products. Our findings therefore support calls for comprehensive restrictions on the marketing of foods high in fats, sugars, and salt to children, including attention not only to marketing content but also to format, placement, and design features (WHO, 2023).

Ethical approval and informed consent statements

The study was approved by the Ethics Committee of the Faculty of Economics and Business, University of Zagreb (approval no. 643-01/22-01/015; date: 25 October 2022). All procedures were conducted in accordance with the ethical standards of the Committee and the 1964 Helsinki Declaration and its later amendments. Informed consent for participation in the study was obtained at three levels: first from the schools, then from the children's caregivers (normally parents), and finally from the children themselves. Consent was requested separately for Study1 and Study 2.

Appendix A. Appendix

A.1. Appendix 1:

Illustrative “draw and write” exercise drawings

CRediT authorship contribution statement

Ruzica Brecic: Writing – review & editing, Writing – original draft, Visualization, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Matthew Gorton:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis. **David Skala:** Writing – review & editing, Writing – original draft, Software, Investigation, Data curation. **Dario Cvencek:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis. **Luca Panzone:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Methodology, Formal analysis.

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Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

No generative AI or AI-assisted technologies were used in the preparation of this manuscript.

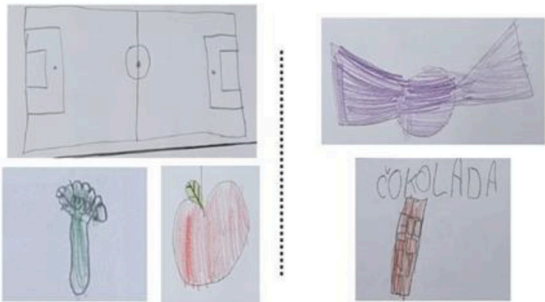
Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

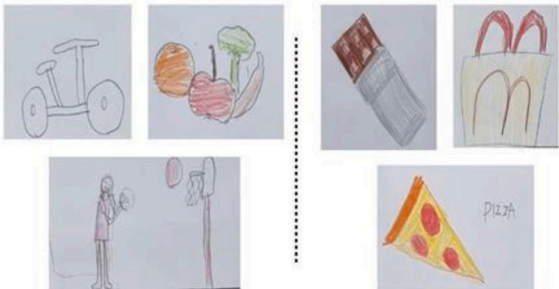
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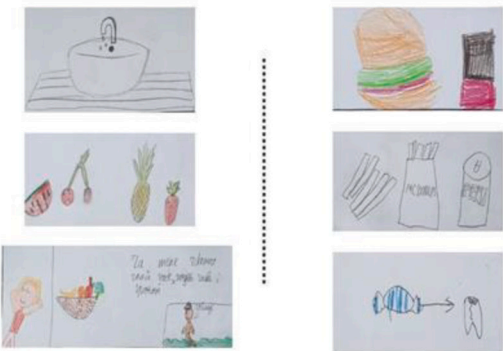
Six-year-olds drew what the word healthy/unhealthy means to them



Seven-year-olds drew what the word healthy/unhealthy means to them



Eight-year-olds drew what the word healthy/unhealthy means to them



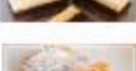
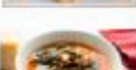
Nine-year-olds drew what the word healthy/unhealthy means to them



A.2. Appendix 2:

Categorization task (Tick whether the food in the picture is "Healthy" or "Unhealthy." If you are not sure, then tick the box next to "I don't know")

Kvačicom označi da li je hrana sa slika "Zdrava" ili "Nezdrava"
Ako nisi siguran/na, tada označi kućicu pored koje piše "Ne znam"

	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM
	☐	☐	☐		☐	☐	☐
	ZDRAVO	NEZDRAVO	NE ZNAM		ZDRAVO	NEZDRAVO	NE ZNAM

Note. Images are shown as presented to children (uniform thumbnail size). Pictures were sourced from free image libraries and used for identification in the knowledge measure.

Data availability

Anonymized data are available from the authors on request.

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