Using visual stimuli to promote healthy snack choices among children

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Abstract

Most interventions against obesity use information to persuade people to change their behavior, with moderate results. Because eating involves automatic routines, new approaches have emerged appealing to non-reflective cognitive processes. Through a randomized controlled trial, we evaluated the impact of visual stimuli (positive and negative) on children's snack-choices at school. Results showed that the negative stimulus had no effect, while the positive stimulus increased the probability among girls of choosing a healthy snack. We also found that children with excess weight had a larger baseline probability of choosing the healthy snack than those without. We conclude that happy emojis, used to nudge non-reflective processes, can steer children towards healthy choices.
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1 Introduction

Obesity and overweight have become a global epidemic, and the number of those affected continues to rise at an alarming rate, particularly among children. In 2016, 124 million children and adolescents aged $5-19$ years were estimated to be affected by obesity worldwide, and 213 million were overweight (NCD Risk Factor Collaborators, 2017). This same report documents that the evolution of BMI or excess weight in children and adolescents from 1976 to 2016 has followed a rising trend which has stabilized at high levels in high-income countries. Together with Greece, Italy and the UK, Spain is among the countries of Europe with the highest prevalence of child obesity and overweight, affecting 41.3% of the population between 6 and 9 years old (GBD 2015 SDG Collaborators, 2016).

The implications of obesity and overweight are serious. In addition to causing various physical disabilities, such as difficulties in walking and dressing (Alley and Chang, 2007; Walter et al., 2009), and psychological problems, such as low self-esteem and anxiety (Puder and Munsch, 2010), excess weight drastically increases the risk of developing a number of non-communicable diseases, including cardiovascular disease, cancer and diabetes (Lean, 2000). Co-morbidity, or the risk of developing more than one of these diseases, increases with body weight (Pulgarón, 2013) and children with excess body weight are more likely to become adults with excess weight. Moreover, childhood obesity is linked with higher morbidity and mortality later in life, independent of adult obesity (Patel and Volpp, 2015). Because of these risks and the fact that acquired health status in childhood has a major influence on patterns of adult life (Almond et al., 2018), preventing obesity and excess weight among children is a critical task.

Risk factors for childhood obesity include inadequate consumption of fruits, vegetables, and milk and excess consumption of sugary drinks. The evidence indicates that a balanced diet high in fruits and vegetables supports positive developmental and health outcomes in children and adults, and ought to be promoted together with increased levels of physical activity (Patel and Volpp, 2015). Yet the majority of the Spanish population, especially among children and young adults, is shifting from the traditional Mediterranean diet toward the consumption of processed foods and reduced intake of fruits and vegetables (FEN, 2018; Partearroyo et al., 2019). This dietary shift among younger populations is consistent with a worldwide trend (Imamura et al., 2015).

Interventions to improve the diets of children have taken different forms and approaches. Most have focused on using information to persuade people of the risks associated with unhealthy foods and the potential benefits of improved diet, and have disseminated this information through school-based educational programs or public health messages and campaigns. These approaches obtain mixed results when evaluated. While a number of studies identify a positive impact of educational programs on reducing consumption of junk food among children (for example, Sichieri et al. (2009) for sugar-sweetened beverages), others do not find any impact (for example, Toral and Slater (2012), for fruit and vegetables) or find that the impact is curbed in environments that allow the promotion of unhealthy beverages (Mora and Lopez-Valcarcel, 2018).

Recent evidence indicates that the impact of information may depend on how the educational message is framed (List and Samek, 2015; Carrieri and Wuebker, 2016). In the realm of public health, most preventative programs follow a fear-based approach that focuses on health risks (Randolph and Viswanath, 2004; Kelly and Barker, 2016). This approach assumes that if people are told about the negative consequences of eating too much or exercising too little, they will make a rational decision and change their behavior accordingly. But knowledge of health risks is usually not enough to change behavior (Sahota et al., 2001; Webb and Sheeran, 2006). Moreover, efforts to change dietary habits face additional challenges from highly profitable industries that actively promote unhealthy food (Kelly and Barker, 2016). The fear-based approach may be effective if the audience is knowledgeable (Wansink and Pope, 2015) or belongs to the health community, but it is not likely to be effective for other audiences (Witte et al., 2001), especially children (Thomas et al., 2014; Binder et al., 2020).

More recent approaches have focused on incentivizing healthy eating behaviors among children at school. Just and Price (2013) provided different types of incentives: quarter or a nickel, given as an immediate or postponed reward for consuming one serving of fruit or vegetables. Loewenstein et al. (2016) provided a special token as a reward for consuming at least one serving of fruits or vegetables. The tokens were worth $0.25 and could be spent at the school store, school carnival, or book fair. In another study, Belot et al. (2016) provided students with stickers and small gifts for choosing healthy lunch items for a period of four weeks. All of these studies found positive effects on the increase of vegetable and fruit consumption during the incentive period, but not all found that the effects persisted after the incentives were removed.

The possibility of combining educational messages with incentives has also been explored. For instance, List and Samek (2015) provided low-income students with a small prize as a reward for choosing the healthier of two snacks (dried fruit vs. a cookie) at after-school programs in urban and suburban neighborhoods of the Chicago area. In addition, students were given a short educational health message. The impact of this combination on the consumption of healthier snacks was larger in comparison to the impact of either the incentive or the educational message alone.

Most of the interventions mentioned above follow the standard route to behavioral change: use of information and incentives to change assessments of the costs and benefits of different options. All such interventions target cognitive processes of conscious reasoning and reflection. However, evidence indicates that relying on conscious and deliberative reflection to change behavior leaves a substantial proportion of behavioral variance unexplained (Webb and Sheeran, 2006; Dolan et al., 2012). The reason, it seems, is that the standard economic approach does not reach cognitive processes that are automatic, uncontrolled, effortless, associative, fast, unconscious, and affective (Kahneman, 2003; World Bank, 2015). Behavior is much less driven by processes of conscious reasoning than is commonly acknowledged, especially in the case of routine learned behaviors such as what and when to eat (Marteau et al., 2012; Kelly and Barker, 2016). It seems, then, that changing these highly routine behaviors requires interventions that go beyond deliberative and reflective decision-making by introducing small changes in the physical or social environment in which decisions are made.

In this paper, we present the results of a randomized controlled trial experiment that was designed to identify the impact of visual stimuli (positive and negative) on children's snack-choices in a highly controlled environment. By using visual stimuli we intended to target automatic associative processes, steering children towards a positive association with healthy snacks (fruit) and a negative association with unhealthy snacks (highly-processed and sugary food). Specifically, the visual stimuli were smiling emoji images surrounded by fruit, and angry/unhappy emoji surrounded by unhealthy snacks. The idea was that these emojis would function as a nudge that would subtly induce children to make more healthy choices. At the same time, we used the angry/unhappy emojis to test whether the most common fear-based method of delivering public health messages is effective with children.

Our analysis of the data shows that the effect of the visual stimulus varied depending on whether it was positive or negative. Specifically, we find that the positive visual stimulus was more effective as a nudge that steered children toward healthy choices. Moreover, the data reveal gender-heterogeneous effects. The positive visual stimulus increased the likelihood of a healthy snack choice among girls, but it did not have the same effect on boys. Furthermore, we find behavioral differences related to the weight status of children as measured by their Body Mass Index (BMI), such that children with excess weight and obesity were more likely to choose the healthy snack.

These results contribute not only to the area of visual stimuli within the field of behavioral economics, but also to the field of policy making, as the use of visual stimuli is less costly and easier to implement at a larger scale than many other interventions evaluated to date. Emoticons and emojis have been used before to help school-age children make better food choices in experimental settings, obtaining positive results (Privitera et al., 2014; Siegel et al., 2015). However, our study differs in three main respects: 1) our experiment did not mix emojis with written or verbal messages that appeal directly to reflective thought and may interact with the effect of emojis on food choices; 2) our experiment included analysis of the heterogeneous effect of emojis in relation to sex and weight status; 3) our experiment included control and treatment groups assigned by a random sample selection approach, as opposed to a random discontinuity approach (Siegel et al., 2015) or a random selection between treatments without a control group (Privitera et al., 2014).

The rest of the paper is structured as follows. Section 2 presents the conceptual framework and main research questions. Section 3 presents our methodology, explaining the experimental design and procedure together with data analysis and results. Section 4 discusses implications of results and concludes with suggestions for further research.

2 Conceptual framework and research questions

The design of our experiment is grounded in an important strand of behavioral economics and psychology that deals with "nudging". Thaler and Sunstein (2008) define the concept of nudge as any intervention designed to alter choice behavior in a predictable way while preserving individual freedom of choice. Nudges commonly take the form of small changes to the environment in which decisions are made, such as changing the way certain items are displayed in a store. Policies based on nudging can span a wide range. They include, for instance, setting default rules (e.g. automatic enrollment in a program), making healthy choices easier and more convenient (e.g. making healthy food more visible) and exploiting social norms (e.g. informing individuals that most people are already engaged in the desired behavior).

Nudging can target deliberative and reflective decision-making (Thaler and Sunstein, 2008) as well as the automatic processes that influence decision-making and are frequently the real drivers of health behavior (Marteau et al., 2012). Nudges can be directed toward these automatic processes either by altering environments to constrain behavior or by targeting automatic associative processes. Our intervention targeted automatic associative processes through the introduction of an affective prime which was expected to induce an emotional response (Kahneman, 2003), thereby "nudging" children toward a more healthy choice. Specifically, children had to choose between a cup of fresh fruit (healthy option) versus a cup with highly processed or sugary food (non-healthy option) in a school facility where they were exposed to a positive visual stimulus (smiling emoji), a negative visual stimulus (angry/sad emoji) or no visual stimulus (control group). To avoid potential bias, students and their families were told that the main purpose of the experiment was to collect data about height and weight. They were also told that they would receive a free snack to thank them for their participation in the experiment, but not that they could choose the snack.

The idea to test the influence of pictures of happy and angry faces on children's snack choice came from evidence showing that visual information can have a strong influence on the formation of children's food preferences (Kraak and Story, 2015).

Although the idea that fruit snacks are healthier than those with added sugar is well established in modern societies, there is room to create new positive associations that reinforce this preconception, encouraging the choice of fruit-based snacks. By linking happy emojis to healthy, fruit-based snacks and angry emojis to unhealthy snacks, we hoped to test whether it is possible to reinforce or create positive and negative associations with these foods so as to influence healthy choice. However, because the preconceptions of each individual were not known, the emojis may have reinforced or altered different preexisting associations. For instance, in Spain it is still common to provide junk food at birthday parties, creating a positive association between junk food and special celebrations. The same intervention in another country or culture might interact with a different set of preexisting associations.

Within this framework, our goal was to address the following questions:

Research question 1: Do visual stimuli encourage the choice of healthy snacks? Do negative and positive stimuli have different effects on children's choices?

The use of emojis as visual stimuli to promote healthy choices has been scarce, but shows promising results (Privitera et al., 2014). In Privitera et al. (2014), happy-sad emojis are explicitly linked to healthy and unhealthy food options through verbal explanation. In contrast, we introduced the emojis in a subtler way, without explanation, which may affect the children through processes outside conscious reflection. Based on the conceptual framework introduced above, it seemed reasonable to expect a positive impact from the implementation of visual stimuli and, as a result, an increase in the selection of fruit (healthy snack). It was not clear, however, whether the negative message would have a similar impact. As indicated by Marteau et al. (2012), humans are generally predisposed to approach positive stimuli and avoid negative stimuli. Other studies also show that positive frame messages are more effective for changing preventative-type behaviors (Carrieri and Wuebker, 2016). Because eating well is a preventative behavior, it seems that positive frame messages could be more effective in encouraging the choice of healthy options (Wansink and Pope, 2015). However, when applied to children, evidence is mixed. Some studies have found that fear-based messages can backfire when used with children (Thomas et al., 2014; Binder et al., 2020), while other studies found that both positive-framed and fear-based messages had a beneficial effect on children's snack choices (Bannon and Schwartz, 2006). We did not know, however, whether the same effects would be observed when using a visual stimulus instead of a message. Based on the literature, our initial expectation was that both positive and negative visual stimuli would lead to a higher probability of choosing the healthy snack, with a bigger impact from the positive stimuli.

Research question 2: Are there gender differences in the effects of visual stimuli on behavior?

A number of studies have reported gender differences in health behaviors, including especially food preferences (Wardle et al., 2004; Lassen et al., 2016; Mollborn et al., 2020). For instance, women seem to be more likely to avoid high-fat foods and to prefer more fruit and fiber than men (Wardle et al., 2004). Studies have highlighted the relevance of social as well as biological factors in explaining such differences (Mollborn et al., 2020). Although gender differences tend to increase during adulthood, there is also evidence of different food choices and eating patterns among boys and girls (Sweeting, 2008; Larson et al., 2009). In particular, it seems that girls' food choices are more influenced by healthiness while boys' food choices are more influenced by taste (Larson et al., 2009; Weible, 2013). However, there is also evidence indicating that social pressure and weight stigma differentially affect boys and girls. For instance, Haines et al. (2006) finds that teasing about weight increases the likelihood of dieting among girls and binge eating among boys.

In light of these tendencies, it is possible that interventions designed to motivate children to choose healthy food can interact with preconceptions and beliefs in different ways according to gender. For instance, Weible (2013) found that girls were more responsive to a nudge that consisted of teachers consuming milk in front of their students. Similarly, other studies found that girls are more likely than boys to respond in the expected direction to nutritional educational programs (Mora and Lopez-Valcarcel, 2018; Brown and Summerbell, 2009; Stice et al., 2006). Although none of these studies evaluated the impact of visual stimuli, there is evidence that women react more strongly when exposed to visual stimuli. After exposing individuals to 160 pictures with different emotional contents and measuring how their brains processed the images, Lithari et al. (2010) identified gender differences in processing visual stimuli with emotional content, with women being more reactive than men. Based on this evidence we expected that girls would be more receptive to nudging with emojis -simple emotional stimuli- than boys.

Research question 3: Are students with excess weight more likely to choose the healthy snack under the influence of visual stimuli?

Children with excess weight or obesity are also influenced by educational and cultural factors. As a result, they experience pervasive weight bias, defined as negative stereotypes and prejudice regarding their weight (Cramer and Steinwert, 1998). These preconceptions may have an influence on their decision-making when choosing a healthy versus non-healthy snack. A common stereotype of individuals with excess weight is that they prefer high-fat or sugary foods. However, evidence of an association between adiposity and preference for high-fat or sugary foods is inconclusive in adults and there is limited research in children (van Meer et al., 2016). The few studies that analyze this association for children find mixed results. Hill (2009) investigated whether child adiposity was associated with a higher preference for fatty or sugary foods and a lower preference for fruit and vegetables but did not find any association. However, Lanfer et al. (2011) found a positive association between excess weight and preference for fatty and sweet foods in European children across several countries with varying food cultures. Consensus is clearer on the larger susceptibility of individuals with excess weight and obesity to food cues and the motivation to eat. Thus, evidence shows that children with excess weight and obesity direct their attention to food-related stimuli to a greater extent than children without excess weight or obesity, especially when hungry (Nederkoorn et al., 2012).

Evidence also indicates that there is a heterogeneous response to different interventions corresponding to weight status. For instance, television advertisement of junk food for children has a larger effect on the food choices and intake of children with excess weight (Halford et al., 2008; Russell et al., 2019). But it is also true that the response of children to TV advertisements can be influenced by multiple individual factors such as parental feeding practices, cognitive control, or personality traits (Norman et al., 2018; Schlam et al., 2013; Boyland and Halford, 2013). Other studies have shown that individuals with excess weight can be more sensitive to negative messages. For instance, Puhl et al. (2013) empirically assessed a media campaign to prevent obesity among adults and children and found that individuals (adults) with excess weight viewed the messages as more stigmatizing.

With these findings in mind, we hypothesized that children with excess weight and obesity in our sample would react more strongly than children without excess weight to visual stimuli (which may act as a food cue), although the direction of their response was unclear.

3 Methods, data analysis and results

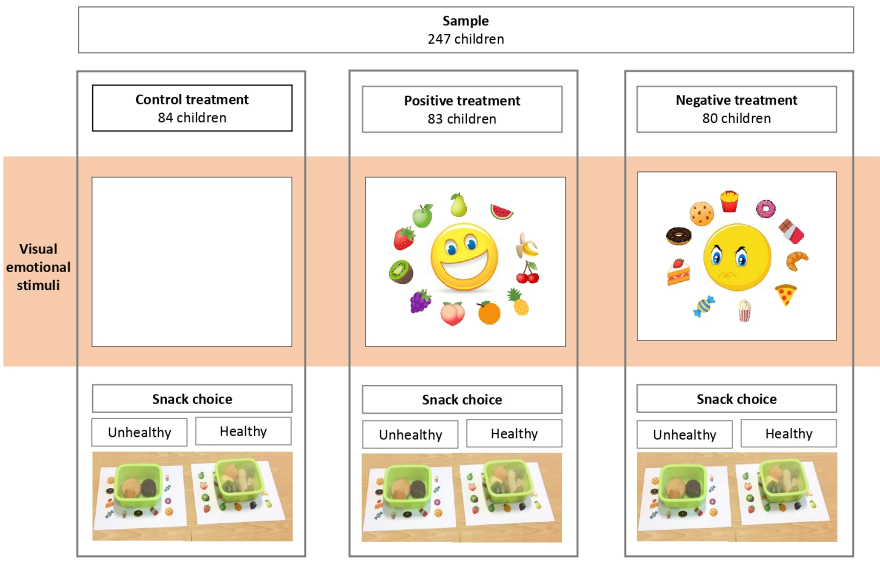
The experiment was carried out in October-November 2018, which corresponds to the midterm of the first semester and was conducted in seven schools in the city of Pamplona (Spain). Our target population was 294 students, of which 257 received permission to participate. Ten students were excluded from the analysis because of food intolerances, resulting in a final sample of 247. The students were in the fourth grade of elementary school (8-9 years old). Parental permit was obtained in written form before the experiment.

3.1 Experimental design

The procedure of the experiment was as follows. Around the time of mid-morning pre-lunch snack, the students entered a school facility one by one and were randomly assigned to one of three treatment groups (control, positive stimuli and negative stimuli). The students were randomly assigned to the different treatments: 84 students participated in the control treatment, 83 in the positive treatment and 80 in the negative treatment. Each child was welcomed by one of the experimenters who then measured the child's height and weight. In order to minimize experimenter demand effects (Zizzo, 2010), the same experimenter welcomed all the students and always used the same wording. Depending on the treatment group, during this measurement the child was (i) not exposed special visual stimuli (control), (ii) exposed to posters with a happy emoji surrounded by fruits (positive treatment), or (iii) exposed to posters with a sad emoji surrounded by highly processed and sugary foods (negative treatment). The poster size was A3 (297×420 mm) and was placed in view of the place where students were weighed and measured, not further than 1.5 meters (see Figure 1). Subsequently, the child was directed to a table where the snacks were covered with a box that displayed the same visual stimulus as the poster (or no stimulus, for the control group). Once in front of the box, the experimenter lifted it and asked them to choose between the two snacks. The procedure of measuring and weighing the children before the choice of snack was a strategy to ensure that they would be exposed to the visual stimulus for a longer time. Otherwise, the children would have had only a brief exposure to the visual stimuli on the box that covered the two snacks.

The two snack options consisted of (i) a snack box containing different types of fruit (healthy snack), and (ii) a snack box containing different highly processed and sugary foods (unhealthy snack). Both snacks were designed by a nutritionist so that their caloric intake was appropriate to the age of the participating children. Specifically, the healthy snack contained fresh pieces of banana, kiwi, apple, grapes and mandarin. The unhealthy snack contained pieces of vanilla cake, chocolate cake and chocolate cookie. Both snacks had approximately 180 kcal, considered to be adequate for this type of mid-morning snack before lunch (Goran et al., 2017).

Figure 1: Experimental design



After students had chosen the snack, the experimenter asked for previous day pre-lunch snack contents. Once they left the room, they were directed to a different school area to avoid contact with other students who were waiting to participate.

During the performance of the experiment, neither teachers nor parents were present in the room, which reduced the potential social desirability bias.

3.2 Descriptive statistics

Table 1 presents the sample summary statistics. 45% of the participants were girls and 55% were boys. 32% of children in the sample had excess weight or obesity, which is close to the overall European level but below the Spanish level. Weight status is defined in accordance with World Health Organization (WHO), following the cut-offs of Body Mass Index for 9 year-old children according to sex (see Table A1 in the Appendix with the ranges on which we based our weight classification). Table 1 also presents information on the previous day snack choice, which is differentiated into three main types of snacks: sandwich (55%), fruit (38%) and highly processed or sugary food (15%). Since some participants brought a snack that contained more than one element, a child could be in two categories.

In addition, Table 1 includes a balance test to check statistically the comparability of the treatments. Column 2 displays the coefficient and robust standard deviation on positive treatment, column 3 displays the coefficient and robust standard deviation on negative treatment. The analysis shows that treatment groups were balanced in the observable characteristics of sex, BMI and reported snack on the previous day.

Table 2 provides data about two-proportion z-tests to determine whether the difference between the proportions of children choosing a healthy snack in two certain groups is statistically significant. For the pooled sample (column (1)), there are no

Table 1: Summary statistics and balance test.

	Average (%)	Coefficient (SE) Positive	Negative	Equality of means (p-value)	Observations
Girls	45	-0.07	0.04	0.41	247
		(0.08)	(0.08)		
Overweight-Obesity	32	0.04	0.04	0.82	247
		(0.07)	(0.07)		
Fruit Previous	38	0.03	0.05	0.77	247
		(0.07)	(0.08)		
Sugar Previous	15	0.04	0.01	0.78	247
		(0.05)	(0.05)		
Sandwich Previous	55	-0.02	-0.03	0.91	247
		(0.08)	(0.08)		

statistically significant differences in the proportion of children choosing a healthy snack in the different treatments. However, the proportion of girls choosing a healthy snack is significantly greater than the proportion of boys. In addition, the proportion of children with excess weight choosing a healthy snack is significantly higher that the proportion of children without excess weight.

If we split the sample by sex (columns (2)-(3), Table 2), we observe that the proportion of girls choosing a healthy snack is significantly higher in the positive treatment than in the control treatment, a result that is not found for boys in the sample. Any other comparison between treatments is not statistically significant. We observe that the proportion of boys with excess weight choosing a healthy snack is significantly higher than that of boys without excess weight. There are no significant differences between girls with and without excess weight.

Centering the analysis in the subgroups with different weight status (columns (4)-

Table 2: Healthy snack choice (percentages) and two-proportion z-tests

		(1) Pooled	(2) Girls	(3) Boys	(4) Non-overweight	(5) Overweight
Control		45	44	47	41	56
Positive		52	64	44	45	64
Negative		42	50	35	41	44
Girls		52	-	-	50	55
Boys		42	-	-	37	54
Non-overweight		42	50	37	-	-
Overweight		55	55	55	-	-
Control vs. Positive	Diff	-7	-20	3	-4	-8
	p	0.198	0.045	0.397	0.304	0.269
Control vs. Negative	Diff	3	-6	12	0	12
	p	0.362	0.284	0.138	0.465	0.202
Positive vs. Negative	Diff	10	14	9	4	20
	p	0.117	0.121	0.193	0.340	0.075
Girls vs. Boys	Diff	10	-	-	13	1
	p	0.067	-	-	0.040	0.482
Non-overweight	Diff	-13	-5	-18	-	-
vs. Overweight	p	0.033	0.298	0.024	-	-

(5), Table 2), we observe that the proportion of girls without excess weight that choose a healthy snack is significantly greater than that of boys. This difference is not statistically significant for children with excess weight or obesity.

3.3 Estimation strategy

To study the joint effect of all these factors on food choice, let us define a dichotomous variable, $Z_i \in \{0, 1\}$. $Z_i = 1$ if agent i chooses a healthy snack while $Z_i = 0$ if agent i does not choose a healthy snack. Using a probit regression model, we estimate

$$P(Z = 1|\mathbf{x}) = \theta(\alpha_0 + \beta_1 TPos + \beta_2 TNeg + X'B), \tag{1}$$

where $TPos$ is an indicator that takes value 1 if the person was assigned to the positive treatment, $TNeg$ takes value 1 if the person was assigned to the negative treatment, and X is a vector of individual characteristics that include sex (1 for girls), weight status (1 for children with excess weight/obesity), and type of previous day snack. For the last characteristic, we include a dummy that equals 1 when the previous day snack included any type of fruit, and a dummy that equals 1 if the previous day snack included a highly processed or sugary food snack, and we leave sandwich as control. We also control for school effects.

The marginal effects of being assigned to positive treatment, $TPos$, and negative treatment, $TNeg$, on the likelihood of a healthy food choice will allow us to obtain results that respond to Research question 1. If the marginal effects are positive (negative) and statistically significant, then visual stimuli increase (decrease) the likelihood of a healthy snack choice among children.

In order to investigate heterogeneous effects of visual stimuli by sex (Research question 2), we proceed by estimating Equation (1) separately for the sub-sample of boys and girls. Obtaining the marginal effects for each group allows us to identify the effect of visual stimuli on food-quality choice that otherwise, without group separation, would be confounded. However, by estimating Equation (1) separately for boys and girls, we cannot identify whether the difference between the responses of the two groups is statistically significant. Accordingly, we complement our approach by estimating an extended version of Equation (1), in which our treatments interact with sex. The statistical significance of the interaction term indicates whether the difference in the marginal effects obtained for boys and girls is statistically significant.

We follow a similar strategy to investigate heterogeneous effects of visual stimuli in relation to weight-status (Research question 3). First, we estimate Equation (1) for the sub-sample of children without excess weight/obesity and for the sub-sample of children with excess weight/obesity. Then, we examine the statistical significance of the difference in marginal effects in a subsequent estimation of an extended version of Equation (1), in which our treatments interact with children's weight status. If the interaction factor is statistically significant, we have heterogeneous effects of visual stimuli on food choice according to weight status.

3.4 Results

Table 3 shows the estimates of the likelihood of a healthy snack choice using probit regression analysis. Column (1) presents our results for the pooled sample, column (2) for girls, column (3) for boys, column (5) for children without excess weight, and column (6) for children with excess weight/obesity. Columns (4) and (7) display the differences between columns (2) and (3), and columns (5) and (6), respectively. For the pooled sample, the positive and negative visual stimuli show opposite marginal effects on the probability of choosing a healthy snack. The marginal effect of the positive visual stimulus is positive while that of the negative visual stimulus is negative, but neither effect is statistically significant. Before reaching any conclusion, however, it is worth considering the heterogeneous response of girls *vs* boys and of children without excess weight *vs* children with excess weight/obesity.

Restricting the analysis to the choice made by girls, column (2) in Table 3 shows that the positive visual stimulus has a positive and statistically significant impact on the probability of choosing a healthy snack. In particular, under the positive stimulus the probability that girls choose the healthy snack increases by 26 percentage points. Figure 2 illustrates this impact by showing the predicted probabilities for the healthy snack choice in the subgroup of girls with and without positive visual stimulus. In the absence of the positive visual stimulus, 44% of girls would choose the healthy snack, while, with the positive stimulus, this percentage would increase to 70%. This outcome should be treated with caution, however, as when we control for multiple hypothesis testing (List et al., 2019) the adjusted p-value is 0.16. Estimates for the impact of negative stimulus are not statistically significant. The picture is different when we restrict the analysis to the snack decisions of boys, as seen in column (3) in Table 3. Neither positive nor negative visual stimulus has a statistically significant effect on the snack choice. Column (4) shows that the difference in behavior between the group of girls and boys is statistically significant. Therefore, although the impact on snack choice of emotional visual stimuli seems limited in the general sample, further analysis indicates that positive stimuli are effective in improving girls' choices.

Regarding children's weight status, we explore the effect of visual stimuli on the probability of choosing a healthy snack among children with excess weight/obesity (Research question 3). We find that visual stimuli, negative or positive, do not seem to affect snack choices in this group (column (6)). In addition, we do not find any significant difference between children with and without excess weight/obesity when exposed to the different visual stimuli (column (7)). However, we do find that the likelihood of choosing healthy snack is greater for boys with excess weight/obesity than for boys without (column (3)).

It is also worth mentioning that the probability of choosing a healthy snack is significantly affected by the previous day snack choice. Those boys whose previous-day snack was fruit have a higher probability of choosing the healthy snack than those whose previous day snack contained a sandwich or highly processed or sugary food. We find the opposite effect in the case of girls.

Table 3: Impact of visual stimuli on food-quality choice. Probit regression, Marginal Effects

	(1) Pooled	(2) Girls	(3) Boys	(4) (2)-(3)	(5) Non-Overweight	(6) Overweight	(7) (5)-(6)
T Positive	0.068	0.257**	-0.047	0.210*	0.068	0.026	0.042
	[0.074]	[0.113]	[0.093]		[0.091]	[0.142]	
T Negative	-0.030	0.129	-0.117	0.012	0.021	-0.098	-0.077
	[0.076]	[0.107]	[0.097]		[0.093]	[0.138]	
Girls	0.083				0.124	0.034	
	[0.063]				[0.077]	[0.115]	
Obesity	0.097	0.007	0.146*				
	[0.066]	[0.096]	[0.085]				
Fruit snack	0.059	-0.207**	0.235***		0.104	-0.075	
	[0.068]	[0.097]	[0.078]		[0.083]	[0.121]	
Sugary snack	-0.058	0.002	-0.065		-0.103	-0.012	
	[0.089]	[0.174]	[0.105]		[0.112]	[0.157]	
Sample Size	247	112	135	247	167	74	247

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in brackets.

Note: The dependent variable in all columns is the choice of high quality food (fruit based option). Column (1) estimates Equation (1) for the pooled sample, column (2) for the sub-sample of girls, column (3) for the sub-sample of males, column (5) for the sub-sample of children without excess weight, and column (6) for the sub-sample of children with excess weight/obesity. In column (6) we miss six observations. This is because one of the schools had only six students with excess weight/obesity, and consequently this school was removed from this sub-sample. Column (4) reports the difference between the marginal impact of visual stimuli for the sub-sample of girls and boys, and the $p - value$ corresponding to the interaction factor between visual stimuli and sex. Column (7) reports the difference between the marginal impact of visual stimuli for the sub-sample of children without and children with excess weight/obesity, and the *p-value* corresponds to the interaction factor between visual stimuli and weight status. All regressions include school indicators.

4 Discussion and conclusions

In this study we investigated the impact of visual stimuli (emojis) on children's snack choice at school by setting up an experiment in which children had to choose between a healthy, fruit-based snack and an unhealthy, sugary snack.

Results from this study suggest that positive visual stimuli do help to change health behaviors, while negative or fear-based visual stimuli do not. The few studies that have used emojis to influence children's food choices have shown their potential to change behaviors by combining them with educational messages (Privitera et al., 2014; Siegel et al., 2015). However, they did not address the effect of emojis alone, or investigate the different impact of positive and negative stimuli. Our experiment focused exclusively on emojis and found that a positive emoji can modify girls' behavior, increasing the probability of a healthy snack choice. The same outcome was not obtained for boys, and this difference is statistically significant. Our finding of a positive impact of emojis on snack choices is aligned with the findings of Privitera et al. (2014) and Siegel et al. (2015). Privitera et al. (2014) found that emojis influence healthy food choices among children 3-11 more effectively than labels that provide information about taste, social norms, and branding. Siegel et al. (2015) found that emojis at school cafeterias increased consumption of white milk and vegetables and decreased consumption of chocolate milk. Neither study differentiated their results based on gender. The fact that girls and boys responded differently to visual stimuli in our study is aligned with literature on obesity that indicates that boys do not respond as well to nutritional interventions (Mora and Lopez-Valcarcel, 2018; Weible, 2013; Brown and Summerbell, 2009), and with other studies that show that women are more responsive to emotional stimuli (Lithari et al., 2010). However, it is possible that girls are more reactive to the specific type of positive emoji that we used (a smiling face) and that boys might have found another type of positive emoji more appealing. To confirm and refine the results of our experiment it would be helpful in the future to explore the effects of different kinds of emojis on health behaviors of boys and girls.

Contrary to our expectations, the angry emoji surrounded by junk food did not have significant impact on the children's snack choices. This is a relevant result because many preventive public health messages follow a fear-based approach (Randolph and Viswanath, 2004; Kelly and Barker, 2016). Previous literature has found that negative-frame messages related to nutrition make children more reluctant to change their behavior (Thomas et al., 2014; Binder et al., 2020).

Regarding the group of children with excess weight or obesity, our data suggest the existence of behavioral differences between boys with and without excess weight or obesity. Our results indicate that boys with excess weight have a significantly larger baseline probability of choosing the healthy snack (fruit) than boys without excess weight. Previous empirical evidence is not clear on whether children with excess weight are more prone to choose high-fat or high-calorie foods than children without excess weight in the absence of any external intervention (Hill, 2009; Lanfer et al., 2011). Since our experiment was performed in a highly controlled environment, a plausible explanation for our result is that boys with excess weight are biased towards healthy choices when their decisions are being observed in such a controlled setting. Whether their decision-making would be different in an uncontrolled environment is a question that remains open for future research.

Finally, our data also indicate that boys who brought fruit the previous day had a higher baseline probability of choosing the healthy snack in the experiment. However, this effect was the opposite for girls. Notice that this information is based on self-report data, which might be altered by recall bias. In addition, we only have information on the snacks that children brought to school the previous day and this information is not enough to determine eating habits. Previous studies suggest that regular healthy eating habits make children more prone to choose fruits and vegetables as snacks (Reinaerts et al., 2007). A more comprehensive account of children's eating habits, including the snack that they regularly bring to school, could offer more insight into the conditions that affect snack choice under the influence of visual stimuli.

These results provide new insights into the design of policies and nutrition interventions at schools and suggest that certain target groups (e.g. boys, children with excess weight) may require more specific interventions. Other personal characteristics should also be taken into account, such as, for instance, socioeconomic status. According to a recent study (Varnum and Kitayama, 2017), lower socioeconomic status is linked to a greater reactivity to threat, so exploring the impact of visual stimuli on children from different socio-economic backgrounds could be of interest for future research.

We suggest that the utilization of visual stimuli not only has the potential to change behaviors but also may have additional advantages over more sophisticated interventions. Their delivery via a simple change of the environment does not usually require complex systems or direct contact with people, thus allowing increased efficiency and decreased costs as compared with individually delivered interventions. They also have the potential to reduce health inequalities as they do not rely on the communication and comprehension of complex information (Marteau et al., 2012). The visual stimuli used in our study present an additional advantage: they involve a message that is very easy to understand. After the analysis of data, the participant children in the experiment expressed to us that they had picked up on the positive association between the fruit and happiness as well as the negative association between the junk food and unhappiness. The simplicity of the visual stimuli should allow them to be used with even younger children.

Of course, the use of visual stimuli to influence food choice is nothing new: marketing specialists have used emotional and inspirational advertising to promote junk food for decades. As a result, most children are frequently exposed to labels and images that draw attention to unhealthy food products and make them appear attractive and desirable (Smith et al., 2019). It is interesting to note that the promotion of healthier food products has tended to emphasize health benefits and to be oriented toward parents, while junk food advertisements target youth and evoke themes of fun and adventure (Dixon et al., 2007). If positive emojis are in fact underutilized for the promotion of healthy food choices among children, this can be addressed: emojis on posters, labels and placements could be used to draw attention toward healthier foods in school cafeterias, in restaurants, and even in supermarkets. This strategy would involve opportunities for transfer of knowledge from marketing and advertising to the health sector. In addition, with this strategy governments might obtain a better response from the food industry than in the past, when nutritional labels were required to signal salty or sugary products (Kanter et al., 2018).

This study has some limitations. First, this field experiment was carried out in a particular context within a highly controlled environment: the school where children are educated in healthy habits and in a setting that guarantees no external distractions. It is not clear how children's choices would be affected when exposed to the same stimuli in other contexts with more options (presenting the possibility of decision fatigue), or in contexts where children are also exposed to other competing stimuli that promote unhealthy foods (as in supermarkets or candy shops). Future research should investigate whether visual stimuli intended to promote healthy choices can counterbalance the effect of the strong marketing and promotion of unhealthy foods to which children are exposed. When addressing other contexts such as supermarkets or school cafeterias, other relevant variables will come into play, such as prices of healthy and unhealthy snacks. Second, our experiment focused on a one-time choice and we only measured the immediate reaction to the stimuli. It would be interesting to explore whether visual stimuli may have the potential to achieve sustained healthy behaviors in the short run and even in the long run. Third, children were weighed before choosing the snack so they could be exposed to the visual stimuli for a longer time but the fact of being weighed before choosing the snack might have biased their choice. However, because we followed the same procedure with the control and two treatment groups, this potential bias was minimized.

This study shows that interventions based on visual stimuli can steer children toward healthy snack choices. The fact that our intervention relied exclusively on visual stimuli leads us to believe that its influence on children's choice of snack was less conscious than that of interventions based on educational messages with more explicit information. Evidence that food choices and eating behaviors involve less reflective engagement has led to other interventions that target automatic processes, such as locating healthy food in more convenient places in the school cafeteria (Hanks et al., 2012) or placing more healthy foods in vending machines (French et al., 2010), both of which show an impact on healthy food choice.

To address the growing problem of obesity and excess weight among children, it seems likely that the best approach will combine different strategies and interventions, amongst which nudging automatic processes could have a prominent role.

Appendix

Table A1: World Health Organization (WHO) cut-off Body Mass Index and participants' classification.

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