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Do children with overweight respond faster to food-related words?

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ABSTRACT

Overweight in childhood is a risk factor in developing obesity as an adult, thus having severe consequences on the individuals' physical health and psychological well-being. Therefore, studying the cognitive and emotional processes that sustain overweight is essential not only at a theoretical level but also to develop effective interventions. In the present experiment, we examined whether children with overweight respond faster to food-related than non-food-related words in a word recognition task: lexical decision. The participants were 24 children diagnosed with exogenous overweight and 24 children with a healthy weight. The stimulus list included positively valenced food-related words and positively valenced non-food-related words matched in a number of psycholinguistic variables—we also included negatively valenced non-food words. While children with a healthy weight showed similar response times to positively valenced food-related and non-food-related words, children with overweight showed much faster response times to food-related words than to non-food-related words. Furthermore, both children with overweight and children with a healthy weight responded faster to positive than to negative words. These findings suggest a complex interplay of cognitive and emotional factors during word processing that can be used to implement more effective treatments for childhood overweight.

1. Introduction

Childhood overweight has become a severe threat to psychological well-being and public health in the past decades. While in 1975, the overweight prevalence in individuals aged between 5 and 19 years was 4%, it reached 18% in 2016 (World Health Organisation, 2020). Notably, being overweight as a child is associated with developing obesity in adulthood (see Lee, 2009; Simmonds, Llewellyn, Owen, & Woolacott, 2015). While there may be multiple factors underlying overweight, Sheeran, Gollwitzer, and Bargh (2013) showed that implicit emotional and cognitive processes have a significant effect on health behavior. Thus, understanding the core cognitive mechanisms underlying maladaptive food-intake behavior from childhood is a crucial element to implement effective long-term psychological interventions that may minimize the risks of overweight and obesity.

Overweight (BMI $\geq$ 25) can be understood as the result of addictive behavior, being food the overconsumed substance (Cope & Gould, 2017; Meule, 2015). Addictive behaviors are associated with attentional biases (i.e., tendency to focus on certain elements while ignoring others) to stimuli related to substances of abuse (see Field & Cox, 2008). A general framework that can explain these biases is the incentive-sensitization model (Robinson & Berridge, 1993). This model assumes that, after repeated exposure to the substance-related stimuli (e.g., food), an association via classical conditioning takes place, and a dopaminergic response occurs via the reward system in the brain. In consequence, the food acquires incentive properties in which dopaminergic pathways are involved (see Berridge & Robinson, 2016)—note that a number of studies have found changes in the dopaminergic activity in individuals with obesity (Baik, 2013; Wang et al., 2001; Wang, Volkow, Thanos, & Fowler, 2004). Thus, food would acquire motivational properties to individuals with overweight, and hence they would develop a bias toward food stimuli.

However, in a recent systematic review and meta-analysis, including various methodologies (e.g., dot-probe task, emotional Stroop task, eye-movement tasks, among others), Hagan, Alasmar, Exum, Chinn, and Forbush (2020) did not find evidence favoring the existence of biases

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toward food stimuli in individuals with overweight. (Note the vast majority of these studies were conducted with adults.) Hagan et al. (2020) suggested that this could have been due to the limitations of tasks (e.g., dot-probe tasks may not be reliable enough to study individual differences; see Chapman, Devue, & Grimshaw, 2019). They also stressed the need for further experimentation with other paradigms to attain a more in-depth understanding of whether individuals with overweight process more rapidly food stimuli.

Unsurprisingly, this mixed evidence also applies to the few experiments with children or adolescents with overweight. While some experiments reported a bias toward food-related stimuli in children with overweight (see Koch, Matthias, & Pollatos, 2014, for evidence with a Stroop-like task using food-related images and Werthmann et al., 2015, for evidence with a pictorial visual probe paradigm using high-caloric food and neutral images), other experiments either found this bias only under some circumstances (dot-probe task: Rojo-Bofill et al., 2019 who used food and neutral images; visual search task: Brand, Masterson, Emond, Lansigan, & Gilbert-Diamond, 2020 using food and toy images; advergame task: Folkvord, Anschütz, & Buijzen, 2020 using high-dense snacks and non-food images) or completely failed to obtain it (imbedded word task: Soetens & Braet, 2007 employing high caloric food words and control words). This lack of consistency could be due to differences in the characteristic of the samples (e.g., the range of age of the children). Another possibility is that the manipulation (i.e., food-related vs. non-food-related stimuli) could have been too blatant (e.g., a high proportion of food-related stimuli). This scenario would leave room for the presence of participants' strategies, and this would result in inconsistent findings. As described below, in the present experiment we employed a subtler manipulation in which the proportion of food-related stimuli was low; furthermore, instead of using images (i.e., visually salient stimuli), we employed a set of word stimuli (e.g., chocolate vs. millionaire) in a word/nonword discrimination task. Of note, the statistical analyses in previous experiments examined the effects over participants, but not over items. As discussed by Baayen, Davidson, and Bates (2008), researchers should always include both participants and items in the inferential analyses (e.g., some of the effects [or lack of] could have been due to a small subset of items).

In the present experiment, we examined whether children with overweight would respond more rapidly to food-related words than to non-food-related words (i.e., enhanced attention toward food-related words). To that end, we used a standard visual word identification task that entails access to lexical-semantic information: the lexical decision task ("is the stimulus a word?"). We included a group of children with a healthy weight as a control. Importantly, unlike other tasks employed to assess biases toward food stimuli (e.g., dot-probe task), the lexical decision task does not require spatial shifts of attention (see Peach, Jovev, Foster, & Jackson, 2012). Furthermore, only a relatively small proportion of the stimuli in our experiment were food-related (10% of trials), thus minimizing the chances of participants using strategies in case they guessed the manipulation in the investigation. Although response times in the lexical decision task have traditionally been interpreted as a function of cognitive factors (e.g., spatial coding model, Davis, 2010), recent research has convincingly shown that emotional factors such as valence also play an important role. Kousta, Vinson, and Vigliocco (2009) found faster lexical decision responses to positively valenced words than to neutral words, which they attributed to the greater motivated attention of positive words (see Lang, Bradley, & Cuthbert, 1990). More recently, Kuperman, Estes, Brysbaert, and Warriner (2014) found a monotonic relationship between response times in lexical decision and valence: response times were faster for positive words and slower for negative words (see also Soares et al., 2019; for a similar finding in Portuguese).

The critical question in the present experiment was whether, because of the motivational properties of food stimuli in children with overweight, response times to food-related words (e.g., chocolate) would be faster than those to non-food-related words (e.g., millonario [millionaire]). To examine this hypothesis, we selected two groups of words, all of them with positive valence in Spanish norms for affective words (Redondo, Fraga, Padrón, & Comesaña, 2007): food-related words and non-food-related words. These two sets of words had been matched in a series of psycholinguistic factors (e.g., word-frequency, length, orthographic neighborhood). Therefore, one would not expect any differences in lexical decision times between food-related and non-food-related words in children with a healthy weight. Importantly, if children with overweight have developed a bias toward food-related stimuli (incentive-sensitization model: Robinson & Berridge, 1993; see also Field & Cox, 2008, for similar claims), they would respond faster to food-related than to non-food-related words. This outcome would reveal food-related words would have a special status (i.e., significant stimuli) in children with overweight. Keep in mind that fMRI experiments have shown that food-related words activate the reward system to a greater degree than non-food-related words (Carnell et al., 2017). Conversely, if children with overweight have not developed a bias toward the processing of food-related words, one would expect similar response times for food-related and non-food related words in both children with a healthy weight and children with overweight.

A novel element of the present research is that, besides examining the effects with Bayesian linear mixed-effects models, we also visualized the properties of the RT distributions using quantile-based exploratory data analyses (delta plots; see De Jong, Liang, & Lauber, 1994). Keep in mind that RT distributions provide useful information on the time course of an effect, provided it exists (see Gomez, 2012; Ratcliff, Gomez, & McKoon, 2004, for evidence in the lexical decision task). Finally, the stimulus list in the experiment contained not only positive words: while half of the words had positive valence, the other half had negative valence—none of the negative valence words were food-related. This manipulation allowed us to examine whether, for non-food-related words in children, response times were faster for positive than for negative words (see Kuperman et al., 2014, for evidence with skilled adult readers).

In summary, the main research question of the present word recognition experiment was whether food-related words were processed more rapidly than non-food-related words in children with overweight (but not in children with a healthy weight). Furthermore, we also examined whether positive words were responded more quickly than negative words in young readers.

2. Methods

2.1. Participants

Forty-eight children took part in the experiment—this sample size was similar to that of previous on this issue with children (e.g., Rojo-Bofill et al., 2019). The age range was 8–13 years—we chose this age range for comparison with other previous studies (i.e., participants were old enough to understand and accomplish the task while avoiding the potential changes due to by adolescence). The 24 children with overweight had an BMI percentile equal or higher than 95 (37.5% of them had a BMI over 30) and the 24 healthy-weight children had a BMI percentile lower than 85 (Himes & Dietz, 1994). The children with overweight were recruited from the Pediatric Endocrinology Unit at La Fe University Hospital (Valencia, Spain), and the children with a healthy weight were recruited via a local primary school. We obtained parental informed consent for all participants before the experiment. The Research Ethics Committee of the La Fe Hospital (Spain) approved all the experimental procedures.

No participant exhibited major medical disorders or used medication that could influence their weight (e.g., diabetes, psychotropic medication, treatment with corticosteroids). Furthermore, no children had repeated any grade or presented any disorder that affected their reading and writing skills. To control the subclinical psychological symptoms in the two groups of children, every parent completed the Child Behavior

Checklist (CBCL; Achenbach, 1991). The CBCL gives information regarding problematic behavior of children aged 6–18 years. It consists of 113 items, evaluated through a Likert-scale, which form eight syndrome scales (Anxious/Depressed (13 items); Withdrawn/Depressed (8); Somatic Complains (5); Social Problems (11); Thought Problems (15); Attention Problems (10); Rule-Breaking Behavior (17); Aggressive Behavior (18)) and an Other Problems scale (17 items). Table 1 shows the demographic and clinical data—note that there were no significant differences between the two groups in age or sex.

2.2. Materials

We selected 45 words with positive valence and 45 words with a negative valence from the Spanish adaptation of the Affective Norms for English Word (ANEW) database (Redondo et al., 2007). The mean valence for the positive and negative words was 6.5 (6.48 for food-related words and 6.53 for non-food-related words) and 1.9, respectively, $p = .001$. The two sets of words were matched in arousal (4.9 [4.87 for food-related words and 4.95 for non-food-related words] vs. 4.8 for positive and negative words, $p = .55$). We also controlled for the influence of lexical/sublexical factors such as word-frequency (18.7 [18.5 for food-related words and 18.9 for non-food-related words] vs. 17.7 per million words for positive and negative words, respectively, $p = .80$, in the Spanish database B-Pal, Davis & Perea, 2005), the number of orthographic neighbors (2.2 [2.44 for food-related words and 2.04 for non-food-related words] vs. 1.8 for positive and negative words, $p = .59$), and the number of letters (6.8 [6.89 for food-related words and 6.59 for non-food-related words] vs. 7.2 for positive and negative words, respectively, $p = .23$). We also created 90 orthographically legal pseudowords with the same length and syllable structure as the word stimuli to act as foils in the lexical decision task (e.g., dercota, mofiroto). The complete list of items is available in the Appendix.

2.3. Procedure

The experimental session took place at noon. In the morning of the experiment, all participants had a breakfast consisting of a liquid and a solid piece of food. The lexical decision experiment was run individually on a Windows computer running DMDX (Forster & Forster, 2003). On each trial, a fixation point (+) was presented for 500 ms in the center of the computer screen. Then, the target word (always in lowercase, in black on a white background) was presented in the center of the computer screen until the participant responded or until 3000 ms had elapsed. The inter-trial interval was 1.5 s. Participants were told that there would have to decide whether the item on the screen was a word or not—they were instructed to press M ("word") or Z ("nonword") as quickly as possible while trying to be accurate in their responses. The task included a practice block of 16 stimuli (4 positive non-food words, four negative non-food words, and eight pseudowords) followed by three blocks of 60 stimuli each (6 positive food words, nine positive non-food words, 15 negative non-food words, and 30 pseudowords). The order of the items in the experimental blocks was randomized for each participant. The whole experiment lasted 14–18 min.

Table 1
Sociodemographic and clinical data for each Group. Standard Deviations are presented between brackets.

	Healthy–weight	Overweight	*p*
Girls (%)	46%	42%	0.771
Age (in years)	10.9 (1.4)	10.5 (1.1)	0.317
BMI	19.5 (2.1)	28.9 (3.5)	<.001
CBCL scores			
Anxious/Depressed	3.0 (1.8)	3.9 (4.4)	0.322
Withdrawn/Depressed	0.5 (0.8)	2.5 (2.2)	<.001
Somatic Complains	1.6 (1.2)	6.2 (4.0)	<.001
Social Problem	1.7 (1.1)	4.2 (3.0)	<.001
Thought Problems	1.6 (1.6)	2.1 (2.4)	0.405
Attention Problems	3.0 (2.3)	5.4 (4.6)	0.024
Rule-Breaking Behavior	1.3 (1.3)	3.0 (3.7)	0.030
Aggressive Behavior	4.1 (3.0)	7.3 (7.3)	0.052

2.4. Analysis plan

To minimize the influence of outliers, very fast RTs (shorter than 300 ms), as well as those RTs beyond 2.5 standard deviations from the participants' mean, were removed from correct RT analyses. We also excluded those words with more than 40% of errors.

We employed Bayesian linear mixed-effect models using the *brms* package (Bürkner, 2018) in R (R Development Core Team, 2020) with two fixed factors: WordType (positive valence food-related word, positive valence non-food-related word, negative valence non-food-related word) and Group (overweight, healthy-weight). The two levels of Group were zero-centered (−0.5, 0.5), and the reference level for the factor WordType was "positive non-food-related." This coding allowed us to examine the two questions of interest: 1) positive food-related words vs. positive non-food-related words in children with overweight vs. children with a healthy weight (i.e., the critical test); and 2) positive non-food words vs. negative (non-food) words. We chose the most complex model in terms of random factor structure of subjects' and items' intercepts and slopes (i.e., Dependent_Variable ~ typeword * group + (1 + typeword*group | subject) + (1 + group | item). We employed the ex-Gaussian distribution to model the RT data, whereas we used the Bernoulli distribution to model the accuracy data. For each dependent variable, we run the model with four chains, each with 10, 000 iterations and. In case there was a significant interaction, we conducted simple test effects with the *emmeans* package in R (Lenth, 2018).

The data from the CBCL questionnaire were used to conduct exploratory correlational analyses between the various CBCL scales and the participants' response time advantage for food-related words.

To complement the Bayesian linear mixed-effects models, we employed delta plots. These plots show the magnitude of the difference between two conditions as a function of time speed (see De Jong et al., 1994; Ridderinkhof, van den Wildenberg, Wijnen, & Burle, 2004, pp. 369–377). Specifically, we computed the difference in response times between non-food-related words and food-related words for the 0.1, 0.2, …, 0.9 quantiles in each participant (also called vincentiles; see Ratcliff, 1979) along the y-axis, whereas the x-axis characterizes the means per quantile.

3. Results

The percentage of incorrect responses to word trials was 7.2%. The percentage of outliers removed in the latency data (RTs < 300 ms [4 data points] and RTs beyond the ±2.5 SD criterion per participant) was less than 2% of correct trials. We also excluded the four words with more than 40% of error (a positive food-related word: crepe [a loan word from French, crêpe] and three negative valenced words: jaqueca, pesimismo, and viruela)—the pattern of data was essentially the same if we had included those items in the analyses. The mean correct RTs and the accuracy for words in each condition are shown in Table 2.

The fits of the Bayesian linear mixed-effects models of both latency and accuracy data were excellent (Rhat = 1.00 in all cases). These models indicate an estimate for each parameter and their 95% credible intervals (95% CrI). For inferential purposes, an effect was interpreted as significant when its 95% CrI did not contain zero.

3.1. Latency data

Overall, children with overweight responded more slowly than children with a healthy weight, $b = 113.31$, $SE = 48.98$, 95% CrI [17.07, 210.84]. With respect to the first research question (positive food-related words vs. positive non-food-related words in overweight and children with a healthy weight), we found no overall differences in

Table 2
Mean correct response times (in ms) and percent error for positive valence food words, negative valence non-food words, and positive valence non-food words in children with a healthy-weight vs. children with overweight. The standard errors are presented between parentheses.

	Healthy–weight		Overweight	
	RT	% Errors	RT	% Errors
Positive valence food words	912 (15)	3.9 (1.0)	977 (18)	3.7 (0.9)
Positive valence non-food words	923 (13)	4.5 (0.8)	1087 (17)	5.6 (0.9)
Negative valence non-food words	1020 (12)	9.0 (0.9)	1170 (16)	11.4 (1.0)

response times to food-related vs. non-food-related words, $b = -8.84$, $SE = 23.68$, 95% CrI [-55.75, 37.99], but more important, we found a significant interaction between Group and Type of (positive) word ($b = -69.40$, $SE = 23.75$, 95% CrI [-116.43, -23.00]). This interaction revealed that children with overweight responded faster to food-related words than to non-food-related words ($b = 78.38$, 95% CrI [17.5, 140.8]). In contrast, children with a healthy weight showed similar response times to both food-related and non-food-related words ($b = 8.84$, 95% CrI [-38.6, 55.0]).

Concerning the second research question (positive [non-food] words vs. negative [non-food] words in overweight and children with a healthy weight), we found faster responses to positive valence (non-food) words vs. negative valence (non-food) words, $b = 77.91$, $SE = 20.54$, 95% CrI [37.85, 118.40]—the magnitude of this effect did not differ for children with overweight and children with a healthy weight (interaction effect: $b = -10.67$, $SE = 21.46$, 95% CrI [-52.50, 32.11]).

Accuracy data. The Bayesian models on the accuracy data only showed that participants were more accurate in their responses to positive valence (non-food) words than in the responses to negative valence (non-food) words, $b = -0.79$, $SE = 0.32$, 95% CrI [-1.42, -0.15].

Exploratory analyses. We conducted correlation analyses for the whole set of participants, between the difference in mean RTs between non-food-related and food-related words and the different scales of CBCL. There were no signs of an effect in any of the scales (all *r*s < 0.13, all $BF_{01} > 3.83$) (footnote1). Furthermore, as suggested by a Reviewer, we conducted a post hoc analysis to examine whether the food-related bias differed between boys and girls, but we did not find any signs of a differential food-related bias as a function of the sex of the participants ($p = .42$, $BF_{01} = 2.10$).

Exploratory RT distributional analyses. To visualize the advantage of food-related words over non-food-related words in children with overweight, but not in children with a healthy weight, we used the delta plot method. We generated two delta plots, one for children with overweight and another one for children with a healthy weight—as indicated in the Method section, the effect in the y-axis reflects the difference between the RTs in the 0.1, 0.2, …, and 0.9 quantiles in the non-food-related words and the food-related words.

As presented in the right panel of Fig. 1, the delta plot for children with overweight has an intercept well above zero and a positive slope. Therefore, the processing advantage of food-related words over non-food-related words in these children was very sizeable. Furthermore, this advantage was already present in the faster responses (i.e., the leading edge of the RT distribution), and it increased monotonically with time (except in the 0.9 quantile). Conversely, the delta plot corresponding to children with a healthy weight (left panel of Fig. 1) shows a qualitatively different picture. The intercept was only slightly above zero, and the function was approximately a flat line, except for a small increase in the 0.9 quantile (i.e., for children with a healthy weight, there were no RT distributional differences between non-food-related and foot-related words). Thus, this exploratory data analysis technique, using a robust quantile-based procedure, offers converging evidence to the results of the Bayesian linear mixed-effects models presented above.

4. Discussion

The main aim of this research was to examine whether children with overweight would show a bias toward food-related words. This bias was operationalized in terms of faster responding to food-related than to carefully matched non-food-related words (e.g., chocolate faster than millionaire) in a word recognition task (lexical decision). The key finding was that, while response times were considerably faster to food-related words than to non-food-related words in children with overweight, children with a healthy weight responded similarly to the two types of words (see Fig. 1). Another relevant finding was that, for both groups of children, response times were faster to positive than to negative words—this extends recent research with adults (Kuperman et al., 2014) to young readers. As we discuss below, our findings have implications from theoretical, methodological, and applied perspectives.

To the best of our knowledge, this is the first experiment that has studied the biases toward food stimuli in children with overweight employing a task that requires lexical access (see Peach et al., 2012, for earlier use of lexical decision to compare threat-related vs. neutral words). Thus, our experiment adds converging evidence of a bias toward food stimuli in children with overweight ([2]). Soetens and Braet (2007) did not find interferences in the attentional processing of food words in overweight adolescents, although this could be related to methodological differences—in their experiment, participants had to find words in a letter grid. In line with our results, an attentional preference toward food related to non-food images has been described as characteristic of children with overweight has been often obtained in the literature across various experimental tasks (Brand et al., 2020; Folkvord et al., 2020; Koch et al., 2014; Rojo-Bofill et al., 2019). Werthmann et al. (2015) found a bias toward food stimuli in both children with overweight and in children with a healthy weight, but this could have been due to differences in salience of their food stimuli: they used exclusively hypercaloric food images (see Spielvogel, Matthes, Naderer, & Karsay, 2018).

At a theoretical level, the processing advantage of food-related words over non-food-related words in children with overweight is entirely consistent with the incentive-sensitization model (Robinson & Berridge, 1993). This model assumes that, because of the repeated association of the substance intake with a reward, substance-related stimuli become salient, thus acquiring incentive motivational properties. Hence, food-related words would be particularly salient for children with overweight. As a result, these words are processed faster than non-food-related words in a word recognition task (i.e., food-words would lead to greater motivational attention in the framework proposed by Lang et al., 1990). In contrast, food-related words would not have these motivational properties for children with a healthy weight, and hence these stimuli would be processed similarly as

[1] Bayes Factors (BF_{01}) offer a measure of the likelihood of the null hypothesis (Model 0) when compared to the alternative hypothesis (Model 1) for a given set of data. Typically, a BF_{01} value above three is interpreted as providing evidence in favor of the null hypothesis (see Jeffreys, 1961).

[2] One might argue that the advantage of food-related words in children with overweight was due to these words being more familiar to them. To examine this hypothesis, a new group of 19 healthy-weight and 20 children with overweight rated the familiarity of the experimental words on a 1–5 Likert-type scale. Familiarity ratings were asymptotical for all food-related concepts (i.e., 5.0), thus discarding an explanation of our findings in terms of uncontrolled subjective familiarity.

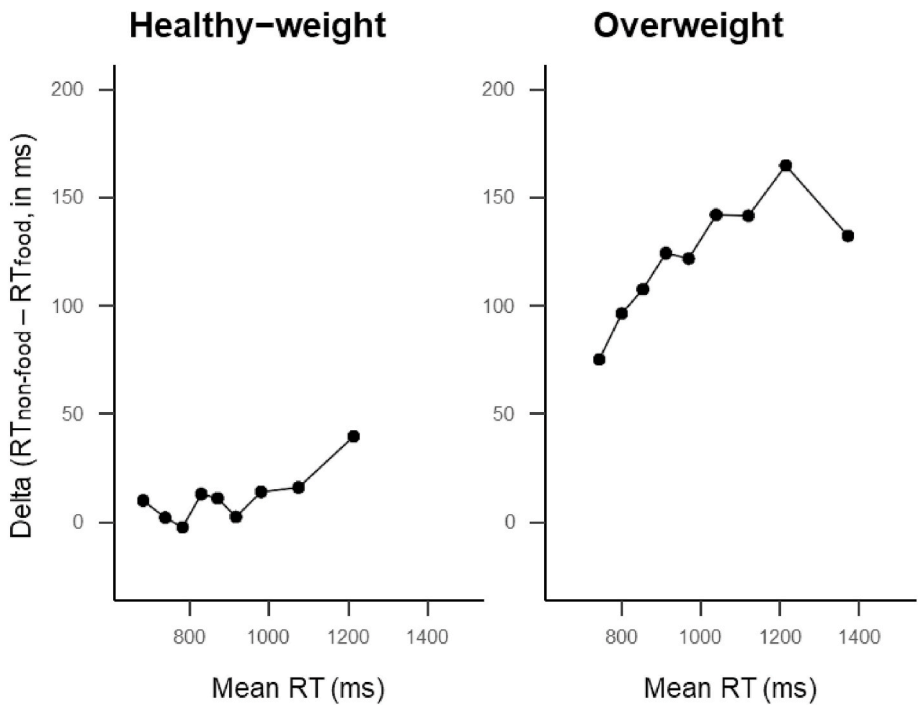

Fig. 1. Delta-plots: Processing advantage (delta, in ms) of food-related words over non-food-related words as a function of response time for children with a healthy weight (left panel) and children with overweight (right panel). The dots represent the .1, .2, …, 0.9 averaged quantiles.

non-food-related words. Thus, the present findings offer new avenues to examine in further detail the interplay between cognitive and emotional factors (e.g., using techniques from cognitive neuroscience) and how individual differences modulate this process (i.e., overweight, but not healthy-weight children, showed a processing advantage for food-related words).

At a methodological level, we have shown that the use of a standard word identification task (lexical decision) offers a novel and subtle approach to study attentional biases to food-related words in children with overweight. This adds to the recent interest regarding the examination of the interplay between cognition and emotion during word recognition and reading (e.g., Kousta et al., 2009; Kuperman et al., 2014; Scott, O'Donnell, & Sereno, 2012). Another innovative aspect of the present experiment is that we generalized our findings not only across participants but also across items—keep in mind that a significant effect in the by-subjects analysis may be due to a small subset of items. Furthermore, we focused not only on central tendency measures but also on exploratory data analyses on the RT distributions (via robust quantile-based methods: delta plots), as they offer fuller information than the mean RTs alone (e.g., whether response speed modulates the effect; see Ratcliff et al., 2004). In our case, the delta plots showed that the processing advantage for food-related words in children with overweight was sizeable even in the fastest responses. This advantage increased as a function of response speed (see right panel of Fig. 1)—this pattern suggests that the effect is mediated by decisional processes (see Gomez, 2012, for discussion).

We acknowledge that our experiment has several limitations. First, to examine the generality of the effects across age, it would have been desirable to run the experiment not only with children but also with adolescents and young adults. However, this was beyond the scope of our investigation, which focused on a children's population. Second, we employed a cross-sectional design (i.e., children with overweight vs. children with a typical weight), as is usual in the literature rather than a longitudinal design. A large-scale longitudinal design across several years in young children could help establish a causal relationship between food bias and being overweight—however, this would be beyond the goals of the present research. Third, response times are very informative, but other experimental techniques would add valuable information on the time course of the effects (e.g., electrophysiological methods, see Massol, Midgley, Holcomb, & Grainger, 2011; eye movement techniques, see Angele, Tram, & Rayner, 2013). Fourth, the influence of the abnormal processing of food cues in eating behaviors must be further characterized in the future. Finally, other domains, such as emotional processing could be affected in childhood overweight—this issue should be addressed in future research.

All in all, we have demonstrated that children with overweight processed more rapidly food-related words than non-food-related words in a word recognition task—this difference was absent in children with a healthy weight. Our findings are in line with theories that defend the importance of addictive processes in overweight and obesity (see Cope & Gould, 2017; Meule, 2015). From this perspective, considering the role of the reward system in food overconsumption may be useful in the diagnostic and therapeutic approach of overweight in children. Among others, at an applied level, the special status of food-related words (and probably other food stimuli) for children with overweight can be used to implement remediation strategies. One such possibility is to design an attentional training program in which children with overweight would focus on non-food stimuli. Attentional Modification Programs have been widely studied in adults (see for example, Bazzaz, Fadardi, & Parkinson, 2017; Kemps, Tiggeman, Orr, & Grear, 2014; Smith, Treffiletti, Bailey, & Moustafa, 2020) but not in children. A study with one session of an Attentional Modification Program has shown to reduce eating in absence of hunger in children with overweight and obesity (Boutelle, Kuckertz, Carlson, & Amir, 2014). However, further studies with longer protocols are needed to confirm the clinical utility of Attentional Modification Programs in childhood overweight.

To conclude, our study showed, by means of a novel and subtle lexical decision task, that food-related words are more salient than non-food-related words in children with overweight. In addition, differently to children with a healthy weight, those with overweight showed faster responses to food-related relative to non-food-related-words. This adds converging evidence to the importance of attentional processing of food stimuli in childhood overweight with important theoretical and clinical implications. Future studies with longitudinal designs or including the analysis of emotional stimuli will help to continue characterizing the role of attentional biases in overweight and obesity.

Declaration of competing interest

No conflicts declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2021.105134.

AppendixList of words and pseudowords in the experiment

Positive valence, food-related words: chocolate, comer, pizza, magdalena, pasta, mermelada, pescado, mantequilla, leche, tarta, caramelo, pastel, crepe, comida, ensalada, hamburguesa, miel, azúcar.

Positive valence, non-food-related words: milagro, tranquilo, inocente, mariposa, diamante, arco-iris, tenis, lujo, moneda, humilde, protegido, ángel, liga, joya, salvador, favor, descanso, millonario, casita, muñeca, gatito, juguete, famoso, poderoso, ventaja, novia, boda.

Negative valence (non-food-related) words: cementerio, vencido, funeral, jaqueca, soledad, rancio, vertedero, tumba, débil, infeliz, depresión, enfermo, sarampión, triste, perdedor, ciego, deforme, ampolla, fiebre, deprimido, basura, carroña, frustrado, podrido, parálisis, ignorancia, cárcel, penoso, inútil, fracaso, roña, infierno, desanimado, aburrido, cansado, sucio, lástima, piojo, soso, prisión, pesimismo, estiércol, pena, descomposición, viruela.

Pseudowords: promigate, conir, petza, mosmaleca, custa, morcicada, mespido, montibiella, ferre, balta, camaseña, mestel, frebe, cocado, esmadado, hosmurbuesa, biel, acomar, pilitro, prenquelo, omigente, pacebosa, suesante, dercota, senus, fuvo, socedo, huselse, promibida, argil, leba, joad, sarfídor, fajer, descisco, pichocaria, hapadad, suhesa, bomicia, nuviote, nacoco, mofiroto, fentima, govio, loga, cemisgeria, emnada, nuceras, nazuesa, soredov, rartio, boltidero, sumpa, vejil, ingeled, rerrimión, envargo, sanirbión, chuste, pasmedor, caibo, defespe, anvobla, fautre, reflisida, tacuro, callopo, pamiada, moflado, pananisud, iudoriscia, carnol, mecoco, isunel, clacico, sova, infionso, calecimado, emufrida, cálmido, sunia, vastaza, bunra, rono, trinaón, memidisto, estuianol, meda, hempatal, ticiola.

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Ethical statement

The Research Ethics Committee of the La Fe Hospital (Spain) approved all the experimental procedures (Reference 2016_0169_PP_GARCIA). We obtained parental informed consent for all participants before the experiment.

We indicated the appropriate information in the Method section of the manuscript.

We do not have any conflict of interest, and the funders (Carlos III Health Institute and the Spanish Ministry of Science, Innovation, and Universities) played no role in the design/analyses/interpretation of the experiment.

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