Attentional bias for food cues in advertising among overweight and hungry children: An explorative experimental study

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**ARTICLE INFO**

**Keywords:**
- Food cues
- Energy-dense snacks
- Childhood obesity
- Attentional bias
- Advertising

**ABSTRACT**

People with an increased motivation for rewarding substances show increased automatic selective attention towards cues that are related to that specific substance. The aim of this study was to explore if overweight and hungry children have an attentional bias for food cues in food advertising. A randomized between-subject design was used with 95 children who played an advergame that promoted either energy-dense snacks or non-food products. Overweight children had a higher gaze duration for the food cues compared to normal weight children. No effects were found of overweight on the attentional bias measurements for the non-food cues. Furthermore, hungrier children had a higher gaze duration, a higher number of fixations, and a faster latency of initial fixation on the food cues than less hungry children, while we found the opposite results for the non-food cues. The findings largely confirm our expectations, adding important knowledge about individual susceptibility to food advertisements. Overweight and hungrier children seem to be stronger affected by food advertising than normal weight and less hungry children. This study is the first that examined attentional bias in a food advertisement that is highly comparable to advertisements that are used by food companies, thereby increasing the external validity of the findings. The second strength is that the development of an attentional bias for food cues is developing at a young age and it was examined in a real-life situation.

1. Introduction

Childhood obesity remains a major public health priority worldwide (Silventoinen et al., 2004). A central factor in understanding the impact of the environment on the obesity epidemic will be to explore the influence of industry-developed food cues on the brain and behaviour (Brownell & Gold, 2014; Folkvord, 2019). In an “obesogenic” society that is characterized by an abundance of highly palatable food items and the presence of food-related cues, people are frequently exposed to attractive food and food-related cues (Wardle, Carnell, Haworth, & Plomin, 2008). Food advertisements are omnipresent and contrived to be attention-grabbing, activating people’s consumer behaviours. These food advertisements are mostly promoting energy-dense snacks, high in salt, sugar and fat, and have low nutritional value (WHO, 2009).

Motivational stimuli, like food advertisements, capture attention and trigger neurological reward systems, promoting craving and motivating behaviour toward the foods (Castellanos et al., 2009). Multiple studies have examined the effects of food marketing on eating behaviour of children and found that food advertising techniques are effective (Boyland et al., 2016; Folkvord, Anschütz, Boyland, Kelly, & Buijzen, 2016, Folkvord & van’t Riet, 2018). Considering that most food advertising promotes unhealthy, palatable, and rewarding food products, it is considered to be an important factor in the current obesity epidemic (Boyland et al., 2016; Folkvord, 2019; Folkvord et al., 2016; Harris, Bargh, & Brownell, 2009). Food commercials influence children’s preferences (Borzekowski & Robinson, 2001), requests for advertisements that are used by food companies, thereby increasing the external validity of the findings. The second strength is that the development of an attentional bias for food cues is developing at a young age and it was examined in a real-life situation.

Remarkably, there is very little research about attentional bias for food cues among children, in particular in real-life contexts, such as food advertising. A recent systematic review assessing the effect of food marketing on children’s attitudes, preferences and consumption showed...
that there is a lack of use of physiological methodologies in researching food marketing effects (Smith, Kelly, Yeatman, & Boyland, 2019). The development of attentional biases is a process of classical conditioning (Field & Cox, 2008), which starts at a very young age. For example, children who show elevated reward circuitry responsivity during food cue exposure also show increased attention for food cues and have a greater risk for future weight gain (Yokum, Ng, & Stice, 2012a; Yokum, Ng, & Stice, 2012b). Next, there are no studies reported that examined attentional bias for food cues in food advertisements, although food advertisements are specifically designed to capture attention and overweight and hungry children are more susceptible to food advertisements (Bruce et al., 2013; Forman, Halford, Summe, Macdougall, & Keller, 2009; Folkvord et al., 2015, 2016, 2019; Halford, Gillespie, Brown, Pontin, & Dovey, 2004).

In this study eye movements during exposure to an advergame promoting energy-dense snacks or non-food products were measured, to assess duration of fixation, number of fixations, and the latency of initial fixations on food or non-food cues (for more information see Field & Cox, 2008; Mogg, Bradley, Field, & de Houwer, 2003). Advergames are online electronic games that are used to advertise a product or a brand, frequently used by food companies. Experimental studies have found that advergames that promote food increase subsequent food intake among children (Folkvord et al., 2013; Folkvord et al., 2014; Folkvord, Anschütz, Wiers, & Buijzen, 2015). Until now, no study has examined an attentional bias for food cues during exposure to food advertisements among children.

2. Theory

Attentional bias theory suggests that when people have an increased motivation to receive or avoid a rewarding substance, like palatable food, they show increased attention towards cues that are related to that substance (Field & Cox, 2008; Werthmann et al., 2011). Furthermore, attention biases and craving for the rewarding substance are assumed to be reciprocally related. Attention biases for food may elicit craving, and craving can in turn trigger attentional biases for food. This self-stimulating circle may cause a preoccupation with palatable food (Nijs, Franken, & Muris, 2010).

The incentive-sensitization model of obesity suggests that repeated pairings of reward from food intake and cues that predict future caloric intake result in increased attention to these food cues (Berridge, 2009). In line with this model, numerous studies have found that overweight individuals have more attention for food cues than normal weight individuals (Castellanos et al., 2009; Nijs, Muris, et al., 2010; Nijs, Muris, Euser & Franken, 2010; Werthmann et al., 2011). For example, overweight individuals directed their first gaze more often toward food pictures than healthy-weight individuals (Castellanos et al., 2009). Furthermore, obese individuals retained incentive salience for food cues despite feeding and decreased self-reported hunger levels, while normal weight individuals showed no attentional bias for food cues after eating and decreased hunger (Castellanos et al., 2009). In addition to overweight people, hungrier people also seem to have an automatic selective preference for food cues compared to less hungry people (Nijs, Franken, et al., 2010). This can be explained from an evolutionary perspective, because a selective detection of food seems to be one of the most adaptive characteristic of humans and animals. Different studies have found that the motivational state of hunger is associated with an attentional bias toward food-related cues (Castellanos et al., 2009; Mogg, Bradley, Hyare, & Lee, 1998; Nijs, Muris, et al., 2010; Veenstra & de Jong, 2010).

Based on the attentional bias theory and the incentive-sensitization model, it is hypothesized that overweight children have a greater attentional bias for the food cues compared to normal weight children (H1), while no differences are expected in attentional bias for the non-food cues (H2). Furthermore, it is hypothesized that hungry children have a greater attentional bias for the food cues compared to less hungry children (H3), while no differences are expected in attentional bias for the non-food cues (H4).

3. Materials and methods

3.1. Procedure

The committee for ethical concerns in the Behavioral Science Institute at the Radboud University approved the current study. After obtaining consent from the schools to participate, parents were sent a letter with detailed information regarding the study. Around 90% of the children participated. It was emphasized to the parents and the children on beforehand that the data would remain confidential and that children could cease participation at any moment.

Children were individually tested at their schools during regular school hours. The teacher assigned the children (in alphabetical order) to the experimenter and the experimenter brought each child to a separate (class)room containing a computer. The children started with an online questionnaire to assess sex, age, and pre-experimental hunger. Subsequently, the child was placed behind a separate computer to play one version of the advergames and the child’s eyes were calibrated and validated.

After calibration, the experimenter instructed the child to play the advergame. The experimenter read the instructions from the screen. The child would be playing a memory game for 5 min and should attempt to finish as many games as possible, which were unlimited. The experimenter left the room until the child finished playtime. When the playtime was finished, the child signaled the experimenter. Children had a 5 min break after playing the advergame, before we continued the rest of the experiment, where they could snack ad libitum from two bowls containing energy-dense snacks for 5 min. The children were not told about the break before the advergame. The effect of the advergames on the snack intake is described elsewhere (Folkvord et al., 2015).

Subsequently, the child had a small break for 5 min. After the break, the experimenter and the child filled out the second part of the online questionnaire. The second part of the questionnaire consisted of questions that assessed brand recognition and attitude to the brand shown in the advergame. The experimenter read the questions and answers aloud, and the children gave their answers to the experimenter who filled the answers in the computer. When the questionnaire was finished, the experimenter measured height and weight of the children. The children were then accompanied back to their (class)rooms, and the experimenter invited the next child to participate. The experimenter requested that all children refrained from discussing the experiment with their classmates.

3.2. Experimental design and stimulus materials

This study was part of a larger study (Folkvord et al., 2015), which focused on the role of attentional bias in the effect of food advergames on snack intake among children. In the present study two factorial between-subject designs were used to test our hypotheses: a 2(type of advergame: energy-dense snacks vs. non-food products) × 2(weight status: overweight vs. normal weight) design and a 2(type of advergame: energy-dense snacks vs. non-food products) × 2(hunger status: hungry vs. satiated) design. Children were randomly assigned to one of two conditions, which involved playing (1) the energy-dense snacks advergame (i.e., promoting a popular candy brand and different gummy and jelly sweets from this popular candy brand); (2) the non-food advergame (i.e., promoting a popular toy brand and individual toys from this brand). Counterbalancing was conducted to start with a different condition every day. Furthermore, the order of conditions was also counterbalanced to avoid any order effects. The dependent variables were the measurements of attentional bias. While playing one of the advergames, children’s eye movements were recorded with a
corneal reflection eyetracker (Tobii T120 Eyetracker, Tobii Technology, Danderyd, Sweden). The Tobii eye-tracking system with a 17” TFT flat screen monitor on which the stimuli were presented was used. The eye-tracking system recorded gaze data of both eyes at 60 Hz with an average accuracy of 0.5° visual angle. We have used 60 Hz because this increases the track box, allowing minor movements by the children. We preferred not to use chin support (which is needed with 120 Hz) to make the experiment more realistic. Tobii studio was used as software. Before beginning the experiment, children’s gazes were calibrated with a nine-point calibration procedure, in which an expanding–contracting circle appeared in every position of a screen-wide 3 × 3 grid of calibration points on a white background. Children were asked to accurately fixate the circle. When seven or fewer points were calibrated successfully, the calibration was repeated for the missing calibration points; otherwise the experiment commenced. Areas that were specified as food cues or non-food cues during playtime were measured if both of the participant’s eyes overlapped with the display of the food or non-food cues. The memory game that the children played required their attention continuously, so every time the children directed their eyes towards one of the nongame related cues, it affected their game results in a negative way. Children were motivated to finish as many games as possible, thereby trying to influence their concentration to play the game. During playtime, every 16.667 ms the eyetracker measured where the eyes of the children were located.

The advergame was developed by a professional game designer. The two versions of the game were identical, except for the advertised brands and products that were shown on the side of the screen. The game involved a memory game with 16 cards with unbranded toys on the backside of the cards. The front sides of the cards were plain white. The brands (popular candy brand, Fig. 1; or popular toys brand, Fig. 2) appeared on the left and on the right side of the screen, at random on the upper or lower part of the screen, and the individual products (candy or toys) appeared on the opposite side (respectively lower or upper part) of the screen. The cues of the food and non-food brands and products were displayed continuously, for the total remaining of the advergame. Similar to advergames from food companies, two specific features to immerse the children into the game were integrated. First, a digital timer appeared on the top left of the screen, and a time bar appeared in the top center of the screen to exert time pressure on the children. Second, the game played an unpleasant sound when a child selected a false pair and a pleasant sound when a child selected a correct pair.

![Fig. 1. A visualization of the advergame promoting energy-dense snacks.](image)

3.3. Measures

**Attentional bias.** To measure the participants’ attention to food-related or non-food cues, three dependent variables were used: (1) the duration of fixations (i.e. gaze duration), (2) the number of fixations on the cues, and (3) the latency of initial fixations on the cues. A participant’s gaze duration was defined as the overall amount of time that the participant’s gaze was directed to the food or non-food cues. Number of fixations was determined by counting the total number of times the participant fixated on the food or non-food cues. Initial fixation was defined as the time of the first fixation of the cue after its appearance. The food or non-food cues remained visible at the screen at the same place throughout the game. To compute groups of high versus low attention to the food or non-food cues M split was conducted. **BMI.** BMI was measured as weight (kg)/height$^2$ (cm). Weight was measured to the nearest 0.1 kg while the children were wearing clothing but no shoes. Height was also measured according to standard procedures to the nearest 0.5 cm. Additionally, BMI was divided in two different groups by calculating whether the children were underweight or normal weight ($n = 79$), and overweight or obese ($n = 16$), using international cut-off scores (Cole, Bellizzi, Flegal, & Dietz, 2000). In this study 6 children were underweight, 73 children were normal weight, 15 children were overweight, and 1 child was obese.

**Hunger.** Hunger was measured by presenting the children with a visual analogue scale (VAS; 14 cm) to measure the extent to which they felt hungry before the experiment began. VAS are widely used and are reliable and valid rating scales for measuring subjective experiences related to food intake (King & Hill, 2004; Van Laerhoven, Van der Zaan-Loonen, & Derks, 2004). The anchors were “not hungry at all” and “very hungry”. M split-method was used to divide the children in high ($n = 61$) vs. low ($n = 54$) hunger levels. The cut-off score was a hunger level of 3.2 cm ($\pm$ 3.7 cm).

3.4. Analyses strategy

Randomization checks using a one-way analysis of variance was conducted for sex, age, hunger, brand recognition, candy brand attitude, gaze duration, number of fixations, latency, and BMI. In Table 1, means and standard deviations are presented for all variables separately for each condition.

Data was tested for normality and homogeneity of variance (Levene’s test). Distribution of the data was normal and the Levene’s test showed no significant differences in homogeneity of variance. To test our hypotheses, three separate multivariate analyses of covariance were conducted, with age and sex as covariates. The first multivariate analysis was conducted with BMI, hunger, and type of advergame as independent variables, and the attentional bias measurements (gaze duration, number of fixations, and latency of initial fixation) as dependent variables, see Table 2. The second multivariate analysis was conducted with an interaction between BMI and type of advergame, and the attentional bias measurements as dependent variable, see Table 3. The third multivariate analysis was conducted with an interaction between hunger levels and type of advergame, and the attentional bias measurements as dependent variables, see Table 4. Bonferroni corrections were used to correct for multiple comparisons. The hypotheses were tested with one-tailed analyses, the adjusted p-value that was considered significant was 0.05. We calculated effect sizes for Cohen’s $d$ and Cohen’s $f^2$.

4. Results

4.1. Descriptives

The total sample consisted of 116 children (grades 2, 3, and 4) from 3 primary schools in the Netherlands, 44% of the participants were boys. 15 children were excluded from the analyses because calibration
The percentage of overweight children in the current study was higher than the percentage of overweight children in the Netherlands (13.3%). It is assumed that schools with a higher percentage of overweight children were more likely to participate in our study because the board was more interested in possible factors that could explain obesity among children. No differences were found between the experimental conditions for sex, age, hunger, candy brand attitude, gaze duration, number of fixations, latency, and BMI. More children ($P < 0.05$) recognized the advertised candy brand in the advergame compared to the toys brand. Correlations were calculated between BMI and hunger and no significant association between BMI and hunger ($r = −0.093$) was found. Sex and age were included in the models as covariates because other studies have shown that these variables are associated with attentional bias for food cues\(^5\).}

### 4.2. Main analyses

The results (see Table 2) from the first multivariate analysis of covariance yielded a significant effect for BMI on gaze duration ($P < 0.001$, Cohen’s $d = 0.70$). Overweight children had a higher gaze duration for the commercial cues (food as well as non-food) in the advergames ($M = 8807.3$ ms, $SD = 5087.5$ ms) than normal weight children ($M = 5689.0$ ms, $SD = 3642.6$ ms). In agreement with H1, the post hoc analysis showed that overweight children who played the energy-dense advergame ($M = 9652.1$ ms, $SD = 6602.2$ ms) had a higher gaze duration for food cues ($P < 0.05$, Cohen’s $d = 0.72$) than normal weight children who played the energy-dense advergame ($M = 5802.3$ ms, $SD = 3642.1$ ms), see also Fig. 3. Overweight children who played the non-food advergame did not have a higher gaze duration to the non-food cues ($P > 0.05$) than normal weight children, thereby supporting H2. Furthermore, no main effect of BMI was found on number of fixations and latency of initial fixation ($P > 0.05$), which contradicts H1 and supports H2. No effect for hunger was found. Finally, no effect of sex and age on the attentional bias measurements ($P > 0.05$) was found.

In the second multivariate analysis of covariance (see Table 3) no significant interaction between BMI and type of advergame on gaze duration ($P > 0.05$), between BMI and number of fixations ($P > 0.05$), and between BMI and latency of initial fixation ($P > 0.05$) was found. The difference in attentional bias between overweight

### Table 1

Variables measured, by condition.\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>Energy-dense snack (n = 52)</th>
<th>Nonfood (n = 43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (boy = 1, girl = 0)</td>
<td>44%</td>
<td>47%</td>
</tr>
<tr>
<td>Age (y)</td>
<td>8.5 ± 1.1</td>
<td>8.4 ± 1.1</td>
</tr>
<tr>
<td>Hunger on VAS(^2) (cm)</td>
<td>2.9 ± 3.5</td>
<td>3.4 ± 4.5</td>
</tr>
<tr>
<td>Brand recognition</td>
<td>77%</td>
<td>46%</td>
</tr>
<tr>
<td>Candy brand attitude</td>
<td>11.0 ± 1.9</td>
<td>10.5 ± 1.7</td>
</tr>
<tr>
<td>Gaze duration (ms)</td>
<td>6394.6 ± 4374.3</td>
<td>5996.1 ± 3693.5</td>
</tr>
<tr>
<td>Number fixations</td>
<td>57 ± 37.6</td>
<td>64.3 ± 36.1</td>
</tr>
<tr>
<td>Latency (ms)</td>
<td>11734.3 ± 24183.9</td>
<td>11016.7 ± 18111.0</td>
</tr>
<tr>
<td>BMI</td>
<td>17.1 ± 2.5</td>
<td>16.9 ± 2.1</td>
</tr>
</tbody>
</table>

\(^1\) n = 95.

\(^2\) VAS, visual analog scale.

### Table 2

Results from the first multivariate analysis of covariance, with attentional bias measures as dependent variables.\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>Gaze duration (ms)</th>
<th>Number of fixations</th>
<th>Latency (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (boy = 1, girl = 0)</td>
<td>F (1, 89) = 0.002</td>
<td>F (1, 89) = 0.083</td>
<td>F (1, 89) = 0.499</td>
</tr>
<tr>
<td>Age (y)</td>
<td>F (1, 89) = 0.156</td>
<td>F (1, 89) = 1.879</td>
<td>F (1, 89) = 0.073</td>
</tr>
<tr>
<td>Hunger on VAS(^3) (cm)</td>
<td>F (1, 89) = 0.026</td>
<td>F (1, 89) = 1.717</td>
<td>F (1, 89) = 0.004</td>
</tr>
<tr>
<td>BMI</td>
<td>F (1, 89) = 8.352(^2)</td>
<td>F (1, 89) = 2.795</td>
<td>F (1, 89) = 0.083</td>
</tr>
<tr>
<td>Advergames</td>
<td>F (1, 89) = 0.402</td>
<td>F (1, 89) = 0.316</td>
<td>F (1, 89) = 0.042</td>
</tr>
<tr>
<td>Explained variance</td>
<td>8.9</td>
<td>7.6</td>
<td>9</td>
</tr>
</tbody>
</table>

\(^1\) n = 95.

\(^2\) P < 0.01.

\(^3\) VAS, visual analog scale.
children and normal weight children in the advergame promoting energy-dense snacks was not significantly different than the difference in attentional bias between overweight children and normal weight children in the advergame promoting non-food products.

In the third multivariate analysis of covariance (see Table 4) a significant interaction between hunger and type of advergame on gaze duration ($P < 0.05$, Cohen’s $f^2 = 0.18$), number of fixations ($P < 0.05$, Cohen’s $f^2 = 0.19$) and latency of initial fixation ($P < 0.05$, Cohen’s $f^2 = 0.15$) was found.

Although the post hoc analyses showed no significant differences between the individual cells ($P < 0.05$), it is important to show the results of these analyses, see also Fig. 4. Results show that hungry children who played the energy-dense advergame ($M = 7826.5$ ms, $SD = 5314.3$ ms) had a higher gaze duration to the food cues than less hungry children ($M = 5699.1$ ms, $SD = 3726.7$ ms), while hungry children who played the non-food advergame ($M = 4743.2$ ms, $SD = 2843.4$ ms) had a lower gaze duration to the non-food cues than less hungry children ($M = 6815.4$ ms, $SD = 3997.3$ ms), see also Fig. 4.

Furthermore, hungry children who played the energy-dense advergame had a higher number of fixations ($M = 60.3$, $SD = 28.9$) to the food cues than less hungry children ($M = 55.4$, $SD = 41.5$), while hungry children who played the non-food game had a lower number of fixations ($M = 46.2$, $SD = 24.5$) to the non-food cues than less hungry children ($M = 69.8$, $SD = 33.2$), see Fig. 5. Finally, hungry children who played the energy-dense advergame ($M = 6326.5$ ms, $SD = 21773.9$ ms) had a faster initial fixation to the food cues than less hungry children ($M = 14360.9$ ms, $SD = 25148.7$ ms), while hungry children who played the non-food advergame ($M = 15317.8$ ms, $SD = 24185.2$ ms) who played the non-food advergame had a slower initial fixation to the non-food cues than less hungry children ($M = 8204.5$ ms, $SD = 12485.9$ ms). No effects were found for sex and age ($P > 0.05$) Fig. 6.

5. Discussion

Based on attentional bias theory (Field & Cox, 2008) and the incentive-sensitization model (Berridge, 2009), it was expected to find that overweight and hungry children had a greater attentional bias for the food cues compared to normal weight and less hungry children, while it was expected no differences in attentional bias for the non-food cues. The results showed that overweight children had a higher gaze duration for the food cues than normal weight children. No effect was found of overweight for number of fixations or latency of initial fixations for the food cues. These results partly support H1, because no effect was found of BMI on all attentional bias measures. No effect was found of overweight for gaze duration, number of fixations or latency of initial fixation for the non-food cues, thereby supporting H2. The interaction between BMI and type of advergame was not significant. Furthermore, no main effect of hunger was found on the attentional bias measurements. However, significant interactions between hunger

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**Table 3**

Results from the second multivariate analysis of covariance, with attentional bias measures as dependent variables.1

<table>
<thead>
<tr>
<th></th>
<th>Gaze duration (ms)</th>
<th>Number of fixations</th>
<th>Latency (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (boy = 1, girl = 0)</td>
<td>$F (1, 88) = 0.111$</td>
<td>$F (1, 88) = 0.138$</td>
<td>$F (1, 88) = 0.511$</td>
</tr>
<tr>
<td>Age (y)</td>
<td>$F (1, 88) = 0.132$</td>
<td>$F (1, 88) = 1.749$</td>
<td>$F (1, 88) = 0.068$</td>
</tr>
<tr>
<td>Hunger on VAS4 (cm)</td>
<td>$F (1, 88) = 0.005$</td>
<td>$F (1, 88) = 1.338$</td>
<td>$F (1, 88) = 0.008$</td>
</tr>
<tr>
<td>BMI</td>
<td>$F (1, 88) = 8.185^2$</td>
<td>$F (1, 88) = 2.890^3$</td>
<td>$F (1, 88) = 0.079$</td>
</tr>
<tr>
<td>Advergames</td>
<td>$F (1, 88) = 0.801$</td>
<td>$F (1, 88) = 1.174$</td>
<td>$F (1, 88) = 0.031$</td>
</tr>
<tr>
<td>BMI*Advergames</td>
<td>$F (1, 88) = 0.405$</td>
<td>$F (1, 88) = 1.004$</td>
<td>$F (1, 88) = 0.031$</td>
</tr>
<tr>
<td>Explained variance (%)</td>
<td>8.7</td>
<td>9.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1 $n = 95$.
2 $p < 0.01$.
3 $p < 0.05$.
4 VAS, visual analog scale.

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**Table 4**

Results from the third multivariate analysis of covariance, with attentional bias measures as dependent variables.1

<table>
<thead>
<tr>
<th></th>
<th>Gaze duration (ms)</th>
<th>Number of fixations</th>
<th>Latency (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (boy = 1, girl = 0)</td>
<td>$F (1, 88) = 0.001$</td>
<td>$F (1, 88) = 0.998$</td>
<td>$F (1, 88) = 0.540$</td>
</tr>
<tr>
<td>Age (y)</td>
<td>$F (1, 88) = 0.049$</td>
<td>$F (1, 88) = 2.387$</td>
<td>$F (1, 88) = 0.179$</td>
</tr>
<tr>
<td>Hunger on VAS4 (cm)</td>
<td>$F (1, 88) = 0.002$</td>
<td>$F (1, 88) = 2.057$</td>
<td>$F (1, 88) = 0.001$</td>
</tr>
<tr>
<td>BMI</td>
<td>$F (1, 88) = 6.642^2$</td>
<td>$F (1, 88) = 1.907$</td>
<td>$F (1, 88) = 0.319$</td>
</tr>
<tr>
<td>Advergames</td>
<td>$F (1, 88) = 1.370$</td>
<td>$F (1, 88) = 0.003$</td>
<td>$F (1, 88) = 0.071$</td>
</tr>
<tr>
<td>Hunger*Advergames</td>
<td>$F (1, 88) = 4.204^4$</td>
<td>$F (1, 88) = 3.337^5$</td>
<td>$F (1, 88) = 3.019^6$</td>
</tr>
<tr>
<td>Explained variance (%)</td>
<td>13.1</td>
<td>11.0</td>
<td>4.2</td>
</tr>
</tbody>
</table>

1 $n = 95$.
2 $p < 0.01$.
3 $p < 0.05$.
4 VAS, visual analog scale.
levels and type of advergame for gaze duration, number of fixation and latency of initial fixation were found. Hungrier children who played the energy-dense advergame had a higher gaze duration, a higher number of fixations and a faster initial fixation to the food cues than less hungry children, while opposite results were found for the hungry children in the non-food advergame. The findings from the interaction analyses support H3 and refute H4. Previous studies have shown that advergames promoting unhealthy foods have an effect on pester power (Dixon, Scully, & Parkinson, 2006), food choice (Dias & Agante, 2011), food liking, nutritional knowledge (Esmailpour, Heidarzadeh, Mansourian, & Khousaviash, 2018), and actual eating behavior (see for an overview on the effects of advergames Folkvord & van't Riet, 2018). Considering that a great number of studies have shown that advertising knowledge does not result in increased counterarguments against advertising effects (An, Jin, & Park, 2014; Brucks, Armstrong, & Goldberg, 1988; Folkvord et al., 2016, 2017; Rozendaal, Lapiere, Van Reijmersdal, & Buijzen, 2011).

The incentive-sensitization model proposes that obesity is associated with anomalous responsitivity of reward circuitry to food. In line with this theory, hypersensitivity to motivational stimuli with high incentive salience (i.e., food cues in the advergame) produce a bias in attentional processing toward food-related cues, triggering the release of dopamine and driving attention towards food-related cues and consumption (Yokum et al., 2012a). Overweight is a trait that is strongly linked to attentional biases for food cues (Field & Cox, 2008). This makes it more difficult for overweight children to lose weight, or maintain a healthy eating pattern, than for normal weight children.

Furthermore, attentional bias theory states that if people have an increased motivation to receive or avoid a rewarding substance, they will show automatically increased attention towards cues that are linked to that substance. The current results show that hungrier children have this increased motivation. Hunger is a state which is strongly related to attention for food cues. From an evolutionary perspective this is very adaptive, because a selective detection of energy-dense foods seems a very effective survival characteristic of humans and animals (Brownell & Gold, 2014). But in an "obesogenic" society, where energy-dense food is omnipresent and designed to attract attention, this can have deteriorating effects, because hungrier children are more susceptible to the overwhelming amount of food-related cues and may therefore choose more often to eat energy-dense snack (Folkvord et al., 2014). This leads to unhealthy eating patterns and, subsequently, to overweight.

The results from this study add important knowledge to the existing literature about the effects of food marketing. The results can be used as an explanation for the findings that overweight and hungrier children are more susceptible to the impact of food advertisements (Forman et al., 2009; Halford et al., 2004). Assessing the influence of industry-developed food cues is considered a central factor of understanding the environment and its relationship with the obesity rates nowadays (Brownell & Gold, 2014). While people are evolutionary equipped for times of scarcity, we are constantly surrounded by plenty images and videos of high caloric and tasty snacks, especially in food advertisements on television and internet. A possible explanation why an effect of BMI was found on gaze duration to the food cues, and not for number of fixations and latency of the initial fixation to the food cues, might be that overweight children have a higher attention maintenance bias than normal weight children (Weierich, Treat, & Hollingworth, 2008). After the food cues have triggered the attention of children, overweight children cannot take their eyes off the food related cues, compared to normal weight children. It might be that overweight children have not (yet) developed strategies to direct their attention towards something else, instead of the attractive food cues. Furthermore, empirical evidence for attentional bias for food in overweight children, adolescents and adults is contradictory (Dürrschmid, Joechl, & Danner, 2013; Field et al., 2016; Folkvord et al., 2015; Liu, Roefs, Werthmann, & Nederkoorn, 2019). This may partly be explained by the use of different methods and type of advergame.
methodological approaches to measure attentional bias, and the impact of different factors such as hunger levels, energy–density of visual food cues and level of restrained eating (Doolan, Breslin, Hanna, Murphy, & Gallagher, 2014). Based on these findings, it might be too early to consider attention to food cues as an important factor related to overweight and obesity (Doolan et al., 2014; Field et al., 2016). However, both theoretical understandings and a great amount of empirical evidence highlight the importance of using the most appropriate methodology to use when assessing attentional bias and eating behavior or weight status. New computing methods have been developed that showed that the variability of attentional bias for food stimuli significantly predict the variance in BMI, showing that large variability of attentional bias for food cues exists in obese children (Liu et al., 2019).

The first strength of this study is that it examines attentional bias in a food advertisement that is highly comparable to advertisements that are used by food companies, thereby increasing the external validity of the findings. The second strength is that the development of an attentional bias for food cues is developing at a young age and it was examined in a real-life situation. One limitation of this study is the relatively small group of overweight children, thereby possibly creating false-positive results (Simmons, Nelson, & Simonsohn, 2011). However, this study is the first to test whether overweight children have more attention for food cues in a food advertisement. In addition, previous explorative studies have also used small numbers (Bannon & Schwartz, 2006). Therefore, it is interesting to use these results for further research with larger groups of overweight children. Another limitation is that we did not assess medium and long-term effects of advertising. Future research should examine how repeated exposure to food cues in advertising affects attentional bias to food cues among different groups of children (Folkvord, 2019; Folkvord et al., 2016). Next, the interaction effect between hunger and type of advergame is partly driven by the increased attention for non-food-related cues by less hungry children.

6. Conclusion

Different scholars suggest that attention bias and craving for a substance are reciprocally related (Field & Cox, 2008; Nijs, Franken, et al., 2010), but it is not exactly clear how this mechanism works with regard to palatable food (Field et al., 2016; Folkvord et al., 2016). It is important to examine the susceptibility to food and food-related cues among children in real-life contexts, such as food marketing, and unravel whether overweight children have developed an attentional bias for food cues, or that the children have become overweight due to the attentional bias for food cues. Furthermore, the question remains whether repeated pairings of reward from energy-dense food intake and cues that predict future snack intake create a stronger attentional bias among children, making it therefore harder to resist these palatable snacks. These are important questions that should be studied in future research.

Disclosure statement

No potential conflict of interest was reported by the authors.

Acknowledgements

The Behavioural Science Institute, Radboud University Nijmegen, the Netherlands, funded the research.

Contributions

Folkvord designed the research, provided essential materials for the research, Folkvord analyzed the data and performed statistical analyses. Folkvord, Anschütz and Buijzen wrote the paper. Folkvord, Anschütz and Buijzen have primary responsibility for final content.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2019.103792.

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