



Research report

The role of attentional bias in the effect of food advertising on actual food intake among children [☆]

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ABSTRACT

This study examined the potential moderating role of attentional bias (i.e., gaze duration, number of fixations, latency of initial fixation) in the effect of advergames promoting energy-dense snacks on children's snack intake. A randomized between-subject design was conducted with 92 children who played an advergame that promoted either energy-dense snacks or nonfood products. Eye movements and reaction times to food and nonfood cues were recorded to assess attentional bias during playtime using eye-tracking methods. Children could eat freely after playing the game. The results showed that playing an advergame containing food cues increased total intake. Furthermore, children with a higher gaze duration for the food cues ate more of the advertised snacks. In addition, children with a faster latency of initial fixation to the food cues ate more in total and ate more of the advertised snacks. The number of fixations on the food cues did not increase actual snack intake. Food advertisements are designed to grab attention, and this study shows that the extent to which a child's attention is directed to a food cue increases the effect of the advertisement.

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Introduction

A large body of research shows that young children are susceptible to food advertisements (Boyland, Harrold, Kirkham, & Halford, 2012; Folkvord, Anschutz, Buijzen, & Valkenburg, 2013; Folkvord, Anschutz, Nederkoorn, Westerik, & Buijzen, 2014; Halford, Gillespie, Brown, Pontin, & Dovey, 2004). Most of the food products promoted in advertisements are energy-dense, high in fat, sugar and/or salt (WHO, 2009). In particular, online digital games that are used to advertise a product or a brand, so called 'advergames', seem to influence food intake among children strongly (Folkvord et al., 2013, 2014; Harris, Speers, Schwartz, & Brownell, 2011; Nairn & Hang, 2012). These online games provide a more highly involving, interactive, and entertaining brand experience than conventional media (Nairn & Hang, 2012). As yet, very little is known about the determinants of individual susceptibility of children to persuasive food messages in the media on consumption behaviour.

Individual susceptibility to food advertisements among children can possibly be explained by the amount of attention that is paid to food-related cues during exposure to these advertisements. It is via cognitions (e.g., thinking or learning processes), emotional aspects, or external sensory cues (e.g., the sight or smell of food) that the environment influences our eating behaviour, influencing the so-called non-homeostatic system of food intake (Berthoud, 2006; Cornier, 2011). The incentive sensitization theory suggests that through classical conditioning substance-related stimuli elicit the expectancy of substance availability, which in turn causes both attentional bias for substance-related stimuli and subjective craving (Field & Cox, 2008). During the past two decades, a considerable body of evidence has accumulated to suggest that substance use and abuse are characterized by biases in the attentional processing of substance-related stimuli. Via classical conditioning, a cue that is substance related acquires incentive-motivational properties and, subsequently, "grabs attention, becomes attractive and 'wanted,' and thus guides behaviour to the incentive" (Robinson & Berridge, 1993, p. 261). Classical conditioning occurs at a very young age. Therefore, it is important to examine the role of attentional bias for food cues in eating behaviour among children. The automatic and cue-driven nature of this classical conditioning is well supported by literature on craving and substance use (Goldstein & Volkow, 2002; Mogg, Field, & Bradley, 2005; Palfai & Ostafin, 2003; Tiffany & Carter, 1998) and has recently been applied to eating behaviour. For example, a study by Veenstra and de Jong (2010) demonstrated that restrained eaters showed increased automatic

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approach tendencies towards food. [Havermans, Giesen, Houben, and Jansen \(2011\)](#) found that obese men had a pronounced approach tendency towards high caloric food, providing additional support for altered motivational functioning.

In a similar vein, [Castellanos et al. \(2009\)](#) found that obese individuals in a satiated state had longer gaze durations and preferred orientation towards food images, compared to normal weight individuals. The longer duration gazes and preferred attention towards food images is generally labelled as 'attentional bias' ([Field & Cox, 2008](#)). Attentional bias theory ([Field & Cox, 2008](#)) proposes that when people have an increased motivation to receive or avoid a rewarding substance (e.g., food or alcohol), they show increased attention towards environmental cues related to that specific substance.

In this study a randomized between-subject design is used with an advergaming promoting either energy-dense snacks or nonfood products, to examine the moderating role of attentional bias in the effect of food advertising on actual food intake among children. Based upon earlier findings, we have multiple reasons to expect this moderating effect. First, studies have shown that some children are more susceptible to food advertisements than others, for example impulsive ([Folkvord et al., 2014](#)) and overweight children ([Forman, Halford, Summe, MacDougall, & Keller, 2009](#); [Halford et al., 2004](#)). Second, studies have found that attention to food cues generate greater activation in brain areas among children that are associated with food reward processing ([Yokum, Ng, & Stice, 2012](#)), food motivation and general appetitive cues ([Holsen et al., 2005](#)), and with future weight gain and weight maintenance ([Murdaugh, Cox, Cook, & Weller, 2012](#)). Third, according to the incentive sensitization theory ([Robinson & Berridge, 1993](#)), salient sensory attributes are transformed into incentives by repeated exposure, causing craving and subsequent actual eating behaviour of energy-dense food. This would imply that an attentional bias for food cues during a food advertisement could lead to more craving and, subsequently, to higher caloric intake. Until now, no study has examined whether an attentional bias for food cues during a food advertisement explains subsequent eating behaviour. The aim of this study is to examine the moderating role of attentional bias in the effect of food advertising on actual food intake among children.

By analogy of other studies ([Castellanos et al., 2009](#); [Nijs, Muris, Euser, & Franken, 2010](#)), we use an eye-tracker to measure attentional bias by assessing gaze duration, number of fixations, and latency of the initial fixation, on commercial food or nonfood cues. In general, we expect that children who play the advergaming promoting energy-dense snacks will eat more afterwards than children who play an advergaming promoting nonfood products (H1). More specifically, we expect that children with a longer gaze duration (H2a), a higher number of fixations (H2b), and a faster latency of the initial fixation (H2c) to the food cues will eat more of the energy-dense snacks after playing the advergaming.

Procedure

The committee for ethical concerns of the Faculty of Social Sciences at the Radboud University Nijmegen approved the current study. After obtaining written consent from the schools to participate, we sent the parents of the children a letter with detailed information regarding the study, and we asked them to inform us if they did not want their child to participate in the experiment or if their child was allergic to one of the test foods. Children who were allergic to the test food did not participate in the experiment. Around 90% of the children were allowed to participate. We emphasized to the parents and the children beforehand that all of the data that we collected would remain confidential and that children could cease participation at any moment.

We tested the children individually at their schools during regular school hours. The experimenter collected one child at a time from

the classroom; the teacher assigned the children (in alphabetical order) to the experimenter. The experimenter brought each child to a separate classroom or office containing a computer. The children started with an online questionnaire for approximately 3 minutes to assess sex, age, class, and pre-experimental hunger. We masked the question about hunger with questions about their perceived levels of energy, fatigue, and arousal. Subsequently, the child was placed behind a separate computer to play a version of the advergaming and participant's eyes were calibrated and validated. After calibration was successfully conducted, the experimenter assigned one of the advergaming to the child. Then the experimenter read the instructions from the screen, which stated that the child would be playing a memory game for 5 minutes and should attempt to finish as many games as possible, the number of games being unlimited. Children played on average seven memory games during these 5 minutes. The experimenter left the room until the child finished playtime. When the playtime was finished, the child signalled the experimenter. The child was placed at a different table and the experimenter placed the bowls with food and a glass of water at the table. The experimenter explained to the child that (s)he was having a break for 5 minutes and could eat and drink something during the break, *ad libitum*. These methods have been used in previous studies ([Folkvord et al., 2013, 2014](#)).

After the break, the experimenter and the child filled out the second part of the online questionnaire. The second part of the questionnaire assessed liking of the test food, brand and product recognition, attitude to the advergaming, frequency of playing similar advergaming at home, and attitude to the candy brand. At the end of the session, we asked the children to indicate the goal of the research, but no child gave the correct answer. The experimenter read the questions and answers aloud, and the children gave their answers to the experimenter who wrote the answers in the questionnaire on the computer. When the questionnaire was finished, the experimenter measured the height and weight of the children to assess body mass index. The children were then accompanied back to their classrooms, and the experimenter invited the next child to participate. The experimenter requested that all children refrained from discussing the experiment with their classmates. After each session, the experimenter weighed the bowls to calculate caloric intake. The experimenter refilled and weighed the bowls before the next child entered the room to make sure that the children did not notice whether and how much the previous child had eaten.

Material and methods

Experimental design and stimulus materials

We used a factorial between-subjects design: 2 (type of advergaming: energy-dense snacks vs. nonfood products) × 2 (attentional bias: high vs. low), with caloric intake as the dependent variable. To manipulate type of advergaming we randomly assigned children to one of two conditions, playing either (1) the energy-dense snacks advergaming (i.e., promoting a popular candy brand and different gummy and jelly sweets from this popular candy brand; see [Fig. 1](#)); or (2) the nonfood advergaming (i.e., promoting a popular Dutch toy brand and individual toys from this brand; see [Fig. 2](#)). Thus, children played either the advergaming promoting energy-dense snacks or the advergaming promoting nonfood products.

Attentional bias was operationalized as eye movements while playing one of the advergaming, recorded with a corneal reflection eye tracker (Tobii T120 Eye Tracker, Tobii Technology, Danderyd, Sweden). The Tobii eye-tracking system was integrated to a 17" TFT flat screen monitor on which the stimuli were presented. The apparatus recorded gaze data of both eyes at 60 Hz with an average accuracy of 0.5° visual angle. The gaze of each child was cali-

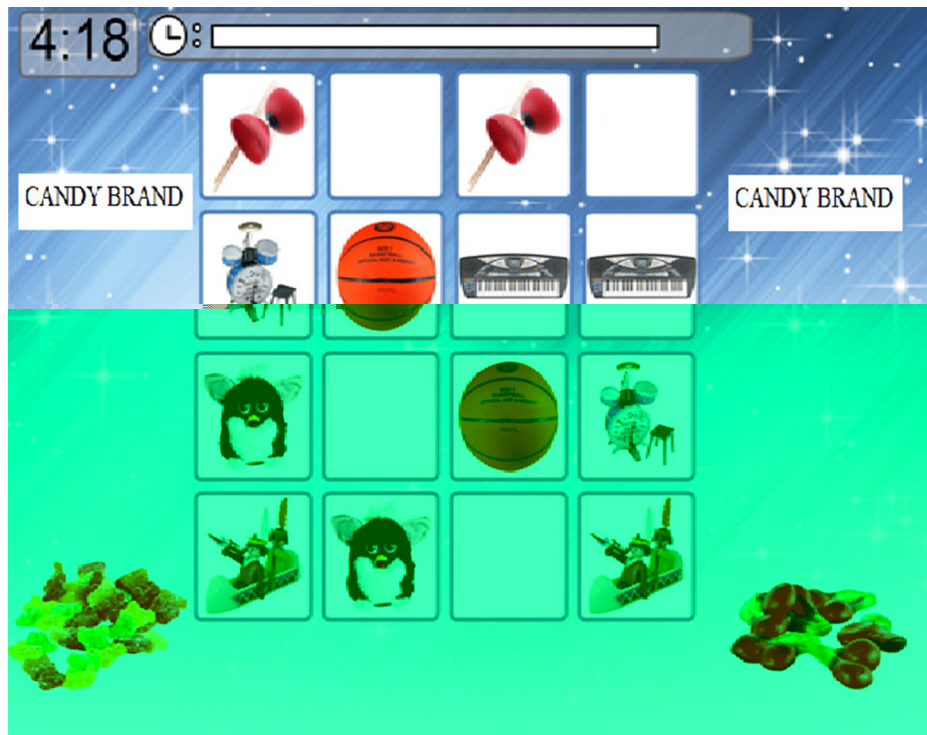


Fig. 1. A print screen of the advergame promoting energy-dense snacks.

brated prior to testing. We used 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. The children were asked to accurately fixate the circle. If seven or fewer points were calibrated successfully, the calibration was repeated for the missing calibration points; otherwise the experiment commenced. The area that we specified as food cues or nonfood cues during playtime was restricted if both of the pa-

rticipant’s eyes overlapped with the display of the food or nonfood cues. The memory game that the children had to play required their attention continuously, so every time the children directed their eyes towards one of the nongame related cues, it affected their game results. The 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.



Fig. 2. A print screen of the advergame promoting nonfood products.

To assess caloric intake after playing the game, children were presented with two bowls of energy-dense snacks: (1) jelly candy (cola bottles) and (2) milk chocolate candy shells. The jelly candy cola bottles were identical to one of the food products shown in the advergame promoting energy-dense snacks. Children were told that they could eat freely from the bowls.

A professional game designer developed the advergames. All games 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 toys on the backside of the cards. The advertised brands (popular candy brand or popular toys brand) were placed on the left and the right side of the screen, at random on the upper or lower part of the screen, and the individual advertised products (candy or toys) were placed on the opposite side (respectively lower or upper part) of the screen. The advertised brand and products were not part of the game. We decided to place the advertisement of the brand and the products not in the content of the game, because this would make it very difficult to assess differences in attention for the advertisement related cues in the games. If we integrated the brand and products in the content of the game, every child would have their eyes fixated on the advertisement cues for almost 5–full minutes and there would be no variation. Therefore, we placed the advertisement of the brands (candy brand or toy brand) and products (candy or toys) on both sides of the screen and used toys on the memory cards. Similar to regular advergames, we integrated two specific features to immerse the children into the game. First, a digital timer appeared on the top-left of the screen, and a time bar appeared in the top-centre 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.

Measures

Caloric intake

To measure caloric intake after playing the advergame, we allowed the children to eat *ad libitum*. We weighed the amount of snack food that a child ate before each child entered the room and weighed again after eating. We used a professional balance scale to estimate to the nearest 0.1 g. Gram intake of each item was recorded and, using nutritional information of products, was converted to kcal intake of each item and overall kcal intake for use as dependent variables.

Attentional bias

To measure the participants' attention to food-related or nonfood 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. We only measured participants' attentional bias for either the food related or the nonfood related cues, dependent on the condition the participant was assigned to. A participant's gaze duration was defined as the overall amount of time that the participant's gaze was directed to the food or nonfood cues. A participant's number of fixations was determined by counting the total number of times the participant fixated on the food or nonfood cues. A participant's initial fixation was defined as the time of the first fixation of the cue after its appearance. The food or nonfood 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 we used a mean split procedure.

Hunger

We controlled for individual differences in hunger 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.

Table 1

Variables measured, by type of advergame.^a

	Energy-dense snack advergame (n = 50) ^a	Nonfood advergame (n = 42) [#]
Sex (boy)	44%	48%
Hunger on VAS (cm)	3.0 ± 3.5	2.9 ± 4.2
Age (years)	8.5 ± 1.1	8.3 ± 1.1
Liking of the jelly candy	10.6 ± 4.1	11.8 ± 2.9
Liking of the milk chocolate candy shells	11.4 ± 3.4	11.6 ± 3.5
BMI	17.1 ± 2.5	17.1 ± 2.3

^a n = 92.

* p < 0.01.

p < 0.05.

We assessed hunger before the children played the game and ate. VASs are widely used reliable and valid rating scales for measuring subjective experiences related to food intake (King & Hill, 2008; van Laerhoven, van der Zaag-Loonen, & Derkx, 2004). The anchors were “not hungry at all” and “very hungry.” We masked the question about hunger levels by also assessing energy, fatigue, and arousal.

Analysis strategy

Randomization checks using a one-factor ANOVA were conducted for sex, hunger, age, liking of the jelly candy, liking of the milk chocolate candy shells, BMI, gaze duration, number of fixations, and latency of initial fixation. In Table 1 we present the means and standard deviations for the control variables separately for each condition and in Table 2 we present the means and standard deviations for the attentional bias measurements and dependent variables separately for each condition. The Pearson's correlations between the variables in the model are shown in Table 3.

Our hypotheses were tested with two multivariate analyses of covariance. The first analysis tested the main effects of type of advergame, controlled for sex, hunger, and age; with dependent variables total intake, jelly candy intake, and milk chocolate candy shells intake. The second analysis tested the interaction effects between type of advergame and the attentional bias measurements (gaze duration, number of fixations, and latency of the initial fixation), controlled for sex, hunger and age, with dependent variables total intake, jelly candy intake, and milk chocolate candy shells intake. Post hoc analyses were conducted to examine the differences between type of advergames. Because we had to correct for multiple comparisons we used Bonferroni correction. We tested our hypotheses one-tailed because our expectations were specified in one direction. The adjusted p value that was considered significant was 0.05. We calculated effect sizes Cohen's *d* and Cohen's f^2 . Cohen's *d* was calculated to compare two conditions,

Table 2

Variables measured, by type of advergame.^{a,b}

	Energy-dense snack advergame (n = 50)	Nonfood advergame (n = 42)
Gaze duration (ms)	383.7 ± 262.5	428.9 ± 351.0
Number fixations (ms)	56.2 ± 36.8	65.7 ± 36.2
Latency (ms)	728.5 ± 1475.0	674.0 ± 1096.5
Jelly candy intake (kcal)	74.3 ± 59.3	57.3 ± 43.1
Milk chocolate candy shells intake (kcal) ^c	103.8 ± 83.6	75.6 ± 77.3
Total intake (kcal) ^c	178.0 ± 99.5	132.9 ± 87.0

^a n = 92.

^b p < 0.01.

^c p < 0.05.

Table 3
Pearson's correlations between the mode variables.^a

	Sex	Hunger	Age	BMI	Experience with playing advergames	Liking jelly candy	Liking milk chocolate candy shells	Gaze duration	Number of fixations	Latency	Jelly candy intake	Milk chocolate candy shells intake
Sex (boy = 1, girl = 0)	-0.13											
Hunger on VAS (cm)	-0.21 ^c	0.19										
Age (Years)	0.06	-0.05	0.06									
BMI	-0.01	0.10	0.17	0.04								
Experience with playing advergames	-0.01	0.16	-0.16	-0.12	-0.15							
Liking jelly candy	0.15	0.17	-0.03	0.07	-0.18	0.50 ^b						
Liking milk chocolate candy shells	-0.08	-0.04	-0.08	0.26 ^c	0.03	-0.06						
Gaze duration (ms)	-0.08	-0.05	0.13	0.39 ^b	0.12	0.01	0.64 ^b					
Number of fixations (ms)	0.07	-0.06	-0.03	0.03	-0.22	-0.16	-0.21 ^c		-0.30 ^b			
Latency (ms)	-0.14	0.00	0.03	-0.11	0.15	0.10	0.04		0.13	0.00		
Jelly candy intake	-0.24 ^c	0.17	-0.07	0.11	0.01	0.13	0.26 ^c		0.05	-0.13	-0.02	
Milk chocolate candy shells intake	-0.28 ^b	0.14	-0.08	0.04	0.09	0.17	0.20		-0.03	-0.11	0.84 ^b	0.53 ^b

^a n = 92.

^b p < 0.01.

^c p < 0.05.

Cohen's f^2 effect sizes were calculated to assess the effect sizes over the interactions.

Results

Descriptives

The total sample consisted of 116 children (grades 2, 3, and 4) from three primary schools in The Netherlands, 44% of the participants were boys. We excluded 15 children from the analyses because calibration was not successfully conducted, five children because they had not finished the session completely, and four children because they had outlying scores on total intake ($M + 2 \times SD$). The final sample consisted of 92 children. The mean ($\pm SD$) age of the children in grade 2 ($N = 43$) was 7.6 ± 0.54 years, in grade 3 ($N = 22$) was 8.6 ± 0.73 years, and in grade 4 ($N = 27$) was 9.6 ± 0.56 years. In our sample, 6.3% of the children were underweight, 75% were normal weight, 16.7% were overweight, and 2.1% were obese (weight status classifications calculated following Cole, Bellizzi, Flegal, & Dietz, 2000). The percentage of children in our study that were overweight and obese was higher (18.8%) than the current percentage of overweight and obese children in The Netherlands (13.3%). We assume that schools with a higher percentage of children with obesity were more likely to participate in our study because the board was more interested in possible factors explaining energy-dense snack intake among children. We found no significant differences between the experimental conditions for sex, hunger, age, liking of the jelly candy, liking of the milk chocolate candy shells, BMI, duration of fixation, number of fixations, and latency, see Tables 1 and 2.¹

Thus, randomization seemed to be successful. We found that sex was significantly related to milk chocolate candy shells intake and total intake, see Table 3. The attentional bias measurements were correlated with each other. Furthermore, we found that gaze duration was significantly related to milk chocolate candy shells intake. Experience with playing advergames was negatively correlated with latency of initial fixation ($p < 0.05$). The association means that the more frequently children played games on the internet, the faster they fixated on the brand or product. We found no significant correlations for the other variables. Furthermore, correlations between number of games that the children played and the attentional bias measurements were not significant ($p > 0.05$). Correlations between number of games that the children played and the snack intake measurements were also not significant ($p > 0.05$). We decided to add sex, hunger, and age into our models as covariates because sex significantly correlated with the dependent variables, and because other studies have shown that hunger and age also influence caloric intake (Folkvord et al., 2013). BMI was not included in our models as a

¹ Separate analyses were conducted to examine the effect of the attentional bias measurement for the brand and for the products. Furthermore, additional analyses were conducted to examine the effect of the attentional bias measurement on recognizing the brands after playing the game. We found no significant differences between brands versus products for gaze duration ($p > 0.05$) or number of fixations ($p > 0.05$). Furthermore, we found no significant differences for the attentional bias measurements for the candy brand versus the toy brand, and between the candy products and the toy products ($p > 0.05$). So children had approximately equal attention for the brands as for the products in both conditions. We found no effect of the attentional bias measurements for the brand ($p > 0.05$) or product ($p > 0.05$) on the snack intake separately. Next, we found a positive and significant correlation between gaze duration and recognizing the candy brand ($r = 0.316, p < 0.05$) and between the number of fixations and recognizing the candy brand ($r = 0.347, p < 0.05$). This means that if children had a longer gaze duration and a higher number of fixations they also recognized the candy brand afterwards more often. For the attentional bias measurements in the nonfood advergaming we found no significant differences between the attentional bias measurements on recognizing the brand ($p > 0.05$).

Table 4
Results from two multivariate analyses of covariance, with snack intake as dependent variables.^a

	Total intake (kcal)	Jelly candy intake (kcal)	Milk chocolate candy shells intake (kcal)	Total intake (kcal)	Jelly candy intake (kcal)	Milk chocolate candy shells intake (kcal)
Sex (boy = 1, girl = 0)	$F(1,87) = 8.368^b$	$F(1,87) = 2.020$	$F(1,87) = 5.592^b$	$F(1,81) = 9.251^b$	$F(1,81) = 2.639$	$F(1,81) = 5.926^c$
Age (years)	$F(1,87) = 2.930$	$F(1,87) = 0.425$	$F(1,87) = 2.332$	$F(1,81) = 3.470$	$F(1,81) = 0.564$	$F(1,81) = 2.720$
Hunger on VAS ^d (cm)	$F(1,87) = 1.743$	$F(1,87) = 0.008$	$F(1,87) = 2.495$	$F(1,81) = 1.272$	$F(1,81) = 0.338$	$F(1,81) = 2.794$
Advergaming	$F(1,87) = 5.572^b$	$F(1,87) = 2.310$	$F(1,87) = 2.843^c$	$F(1,81) = 0.094$	$F(1,81) = 0.570$	$F(1,81) = 0.446$
Gaze duration				$F(1,81) = 0.504$	$F(1,81) = 0.148$	$F(1,81) = 0.318$
Number of fixations				$F(1,81) = 0.026$	$F(1,81) = 0.616$	$F(1,81) = 2.225$
Latency				$F(1,81) = 0.300$	$F(1,81) = 0.252$	$F(1,81) = 0.091$
Advergaming × Gaze duration				$F(1,81) = 0.105$	$F(1,81) = 6.710^b$	$F(1,81) = 1.719$
Advergaming × Number of fixations				$F(1,81) = 0.043$	$F(1,81) = 0.925$	$F(1,81) = 0.150$
Advergaming × Latency				$F(1,81) = 3.685^c$	$F(1,81) = 3.160^c$	$F(1,81) = 1.097$
Explained variance (%)	13.0	6.0	8.5	12.0	6.8	7.1

^a $n = 92$.

^b $P < 0.01$.

^c $P < 0.05$.

^d VAS, visual analogue scale.

covariate because we found no significant correlations between BMI and the dependent variables.

Main analyses

Results from the first multivariate analysis showed that the effect of type of advergaming on total intake was significant ($p < 0.05$, Cohen's $d = 0.48$), shown in Table 4. Children who played the advergaming promoting energy-dense snacks ($M = 178.0$ kcal, $SD = 99.5$ kcal) ate significantly more than children who played the advergaming promoting nonfood products ($M = 132.9$ kcal, $SD = 87.0$ kcal). The results showed that the effect of type of advergaming on jelly candy intake was not significant ($p > 0.05$). Furthermore, the results showed that the effect of type of advergaming on milk chocolate candy shells was significant ($p < 0.05$, Cohen's $d = 0.35$). Children who played the advergaming promoting energy-dense snacks ($M = 103.8$ kcal, $SD = 83.6$ kcal) ate significantly more of the milk chocolate candy shells than children who played the advergaming promoting nonfood products ($M = 75.6$ kcal, $SD = 77.3$ kcal). These results confirmed H1. Finally, boys ate more than girls, ($p < 0.05$, Cohen's $d = 0.59$).

Results from the second multivariate analysis showed that the interaction effects between type of advergaming and gaze duration ($p > 0.05$) and between type of advergaming and number of fixations ($p > 0.05$) on total intake were not significant, see Table 3. However, the interaction between type of advergaming and latency of initial fixations on total intake was significant ($p < 0.05$, Cohen's $f^2 = 0.06$). Post hoc tests revealed that among children with a fast latency of initial fixations, the difference of total intake between children who played the energy-dense advergaming ($M = 189.2$ kcal, $SD = 94.9$ kcal) and children who played the nonfood advergaming ($M = 131.2$ kcal, $SD = 79.6$ kcal) was significant ($p < 0.05$, Cohen's $d = 0.66$), thereby supporting H2c. Among children with a slow latency of initial fixations, the difference of total intake between children who played the energy-dense advergaming ($M = 133.4$ kcal, $SD = 110.1$ kcal) and children who played the nonfood advergaming ($M = 137.9$ kcal, $SD = 109.4$ kcal) was not significant ($p > 0.05$).

Furthermore, we found a significant interaction effect between type of advergaming and gaze duration on jelly candy intake ($p < 0.05$, Cohen's $f^2 = 0.08$). Post hoc tests revealed that among children with a high gaze duration, the difference of jelly candy intake between children who played the energy-dense advergaming ($M = 87.7$ kcal, $SD = 69.6$ kcal) and children who played the nonfood advergaming ($M = 37.4$ kcal, $SD = 27.2$ kcal) was significant ($p < 0.05$, Cohen's $d = 0.96$), thereby supporting H2a. Among children with a low gaze duration, the difference of jelly candy intake between children who played the energy-dense advergaming ($M = 65.3$ kcal, $SD = 50.5$ kcal)

and children who played the nonfood advergaming ($M = 70.8$ kcal, $SD = 47.0$ kcal) was not significant ($p > 0.05$). We found no interaction effect between type of advergaming and number of fixations on jelly candy intake ($p > 0.05$).

Furthermore, we found that the interaction between type of advergaming and latency of initial fixations on jelly candy intake was significant ($p < 0.05$, Cohen's $f^2 = 0.15$). Post hoc tests revealed that among children with a fast latency of initial fixations the difference of jelly candy intake between children who played the energy-dense advergaming ($M = 78.9$ kcal, $SD = 63.2$ kcal) and children who played the nonfood advergaming ($M = 52.4$ kcal, $SD = 32.7$ kcal) was significant ($p < 0.05$, Cohen's $d = 0.52$), thereby supporting H2c. Among children with a slow latency of initial fixations, the difference of jelly candy intake between children who played the energy-dense advergaming ($M = 55.8$ kcal, $SD = 36.2$ kcal) and children who played the nonfood advergaming ($M = 77.1$ kcal, $SD = 64.3$ kcal) was not significant ($p > 0.05$).

Finally, we found no interaction effects between type of advergaming and the attentional bias measurements on milk chocolate candy shells intake ($p > 0.05$). Overall, the results for the interaction effects partly confirm H2a and H2c, and refute H2b.

Conclusions

Although many studies have shown that food advertisements induce food intake (Boyland & Halford, 2013; Folkvord et al., 2013, 2014), an unresolved issue is the extent to which attentional bias for food cues reflects on the susceptibility to food advertisements. This study was the first to examine the moderating role of attentional bias in the effect of food advertisements on food intake among children. Building on earlier research, the incentive sensitization theory (Robinson & Berridge, 2001), and the attentional bias theory (Field & Cox, 2008), we expected that children would eat more after playing the energy-dense advergaming than children playing the nonfood advergaming (H1). Furthermore, we expected a stronger effect of the food advergaming on food intake between children with an attentional bias for food cues (H2a, H2b, H2c).

The results showed that the children who played the advergaming promoting energy-dense snacks ate more in total and of the milk chocolate candy shells than the children who played the nonfood advergaming, which supports H1 and earlier findings (Folkvord et al., 2013). To measure visual attention towards either food or nonfood cues in this study, we examined gaze duration, number of fixations, and latency of initial fixation. We found an interaction effect for type of advergaming and latency of initial fixation on total intake. Furthermore, we found an interaction effect for type of advergaming

and gaze duration on jelly candy intake, and for type of advergaming and latency of initial fixation on jelly candy intake. We found no interaction effects for type of advergaming and the attentional bias measurements on milk chocolate candy shells intake. These results partly support H2a and H2c, and refute H2b.

The incentive sensitization theory states that cues elicit the expectancy of substance availability. The amount of attention to the food cues in the food advertisement seems to affect the craving for the advertised food. Food advertisements are designed to grab attention, and the extent to which the gaze of a child is directed to this food advertisement influences the susceptibility to the food advertisement. Functional magnetic resonance imaging studies have shown that orientation to food cues activate brain responses in neural regions associated with food reward processing rather than simple attention processing (Yokum et al., 2012). If children who allocate more attention to food cues are more likely to overeat, then the behavioural response to this attentional bias will be difficult to manage in an environment with attractive food cues omnipresent. This could imply that these children are more susceptible to become overweight or have problems with maintaining a healthy diet.

Attentional bias theory (Field & Cox, 2008) proposes that people with an increased motivation to receive or avoid a rewarding substance show increased attention towards environmental cues related to that specific substance. Attentional bias and craving have a mutual excitatory relationship, such that increases in one lead to increases in the other, which is likely to result in substance self-administration. In this study, increased attention, measured by gaze duration and latency of initial fixation, influenced the individual susceptibility to food advertisements. Where other studies have found that obese individuals are more responsive by salient external food-related stimuli than normal-weight individuals (Halford et al., 2004, 2008), the present study showed that this increased attention leads to more snack intake of the advertised food among children in a largely normal-weight sample.

Weierich, Treat, and Hollingworth (2008) showed that gaze duration, number of fixations and latency of initial fixation related to different psychological constructs. Gaze duration and number of fixation are related to attention maintenance and latency of initial fixation to vigilance. Both gaze duration as latency of initial fixation affected snack intake in this study, indicating that both attention maintenance and vigilance are psychological constructs that could explain the effect of food advertisements on children's snack intake. Children who more rapidly found the food cues and who had overt attention for the food cues ate more of the advertised energy-dense snacks afterwards than children who were slower and had less overt attention for the food cues.

A possible explanation why we found an interaction effect of type of advergaming and gaze duration, and not for number of fixations, could be that gaze duration activates greater neurological responses to the advertised food than the number of fixations. Bruce et al. (2012) found that exposure to food logos generated greater activation in regions among children that have been associated with future weight gain and difficulty with weight maintenance in response to food cues (e.g., middle frontal gyrus, middle temporal gyrus, insula; Murdaugh et al., 2012). Gaze duration is operationalized as the number of fixations multiplied by the length of the fixations (i.e., total fixation time), suggesting that the activation of the brain areas that are related to food intake are affected for a longer period.

The first strength of this study is that it is the first to examine the effect of attentional bias for food cues on actual snack intake. Many studies have shown that people with overweight compared to normal weight show an automatic approach tendency towards food and food cues (Havermans et al., 2011; Nijs et al., 2010; Veenstra & de Jong, 2010), but none of the studies have examined whether

this attentional bias also influenced subsequent snack intake. Second, the external validity of this research is high, because the advergaming that we used is identical to advergaming that are used by real food companies that have advergaming on their websites. Some advergaming contain product and brand integrated as part of the actual game, and might therefore even have a stronger effect than the games that we have used. Third, our study focused on children. The development of an attentional bias to food cues can develop during childhood, yet only a few studies have examined the effects of an attentional bias for food cues among children. Insights in individual susceptibility to food advertisement are necessary to inform public policy makers about the consequences of food advertisements.

One limitation of this study is that the memory game consists of pictures of toys and the commercial related cues in the nonfood advergaming display toys, while in the energy-dense advergaming advertisements display foods. The food cues may have had more attention-grabbing power because they were not in the same category as the memory cards. We did not find significant differences in attention between the two games, but this could possibly have influenced children's attention to the food cues. Next, we did not examine the frequency of the food consumption of the food that was in the advergaming or provided during the *ad libitum* test. Future research should take this into account. Other factors that could also influence attentional bias for food cues (e.g., impulsivity, BMI, previous consumption of the advertised food) should be studied more thoroughly in future studies to unravel attentional bias for food cues to a greater extent.

Many studies have found a strong association between addictive behaviour and attentional bias towards cues that are related to the addiction, making it important to examine the development of addiction (and related weight increase) to food among children. Without the necessary inhibitory processes to aid in decision-making, overweight children are susceptible to making poor health behaviour choices and these differences may be pronounced when evaluating appetitive cues (Somerville & Casey, 2010). Since food related advertisements are omnipresent and integrated in children's (media) environment, it is important to educate children about the influences of food marketing and how to become more defensible against these influences. More specifically, children's advertising literacy should be stimulated, to decrease their susceptibility to food advertisements. Furthermore, studies have shown that training adolescents to self-regulate their attention away from food cues is successful in reducing subsequent caloric intake (de Ridder, de Vet, Stok, Adriaanse, & de Wit, 2013; Kroese, Adriaanse, Evers, & de Ridder, 2011). Hopefully we are able to teach children to direct their attention and become less responsive to food advertisements. Another practical implication of this study is that policy makers should make clear and make decisive steps towards protecting children from unhealthy food marketing, by restricting or prohibiting food advertising to children. This might have a larger public health impact than individual approaches such as attention retraining to combat the impact of food marketing on children.

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