The influence of visual attention on choice between high versus low energy food items.

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Abstract

Food selection is primarily guided by the visual system. Multiple studies have investigated the link between visual attention and food choice and showed that chosen items are looked at longer. However, there is still uncertainty about the role of visual attention in healthy food choice. In this study it is examined whether manipulation of visual attention can be used to promote a healthy food choice. The study aimed (1) to investigate the influence of manipulation of visual attention, by increasing the exposure time, on food choice, (2) the difference in the effect of attention manipulation on choice between high energy [HE] and low energy [LE] food items and (3) the influence of manipulation of visual attention in HE and LE choices for dietary restraint individuals. Participants chose between two products; a HE item and LE item which were equally liked. To investigate the influence of manipulation of visual attention on HE and LE items the exposure time of one of the two items was manipulated (300ms versus 900ms). Participants selected the product they wanted. In general our findings showed that manipulating one item did not result in a choice preference for HE or LE items. However, the results show a small but non-significant effect that the manipulation might be more effective for LE items. LE items may be chosen more often when manipulated. This is also the case in the dietary restraint group. The effect is too small for implementation in public health aspects. The lack of an actual effect may be due to the amount of choice pairs. It is suggested that the influence of attention manipulation on food choice is minimal. The results provide important implications for the use of attention manipulation in food selection.

Introduction

Overweight and obesity are a global problem. Eating too much unhealthy products causes health and economic problems (Antipatis & Gill, 2001; James, 2004; McLellan, 2002; Swinburn et al., 2011). Overweight and obesity are caused by unhealthy food choices (Antipatis & Gill, 2001). Since people have a higher preference for energy-rich foods, people find it hard to make a healthy food choice (Drewnowski & Greenwood, 1983; Nijs, Muris, Euser, & Franken, 2010). Previous studies have found indications that choice preference is steered by visual attention (Krajbich, Armel, & Rangel, 2010; Armel, Beaumel, & Rangel, 2008; Shimojo, Simion, Shimojo, & Scheier, 2003; Krajbich & Rangel, 2011; Glaholt & Reingold, 2009; Glaholt, Wu, & Reingold, 2009; Bradley, Mogg, Falla, & Hamilton, 1998; Schotter, Berry, McKenzy, & Ryner, 2010). In this study it is investigated whether manipulation of visual attention can be used to influence the choice between high energy

[HE] and low energy [LE] food. In view of the link between attention manipulation and choice, it is examined whether we can use attention manipulation to simulate a LE food choice and thereby lead to healthier food choices.

Food choice

Food selection is primarily guided by the visual system (Laska, Freist, & Krause, 2007; Linne, Barkeling, Rossner, Rooth, 2002). Earlier studies have shown a link between visual attention and food choice (Armel et al., 2008; Krajbich et al., 2010; Krajbich & Rangel, 2011). For example, there is a link between attention for food and food intake. When attention to foods is increased it causes an increase in food intake (Werthmann, Field, Roefs, Nederkorn, & Jansen, 2014). People also prefer to attend to food items compared to non-food items (Castellanos et al., 2009). Furthermore, individuals who direct their attention more often towards unhealthy foods are more likely to eat more snack foods (Werthmann, et al., 2011). These studies support the idea that visual attention plays a role in food choice.

Visual attention

Visual attention is not only important in food choice, but plays a role in decision-making in general as well. Bundesen, Habekost, and Kyllingsbaek (2005) define attention as selectivity in perception. It is said that attention influences perception by directing overt visual attention to a specific stimulus (Orquin, & Mueller Loose, 2013. This means that the stimulus is projected onto the fovea so visual attention is directed at a specific item and causes increased visual processing of that item (Orquin, & Mueller Loose, 2013). Since visual attention enhances perception, fixating a stimulus should result in an enhanced perceptual representation, in comparison with non-fixated stimuli. Eye movements, fixations, fixation duration and first and last case are indicators of visual attention (Orquin, & Mueller Loose, 2013).

In short, visual attention controls perception. When a decision maker fixates at an item, the perception of this item and its characteristics (e.g. location, category, visual features) will be enhanced. Furthermore, it is likely that attention causes two down-stream effects; the decision will be limited by fixated items only and the influence of the information of item characteristics will enhance when looked at longer. This may also influence decision-making (Orquin, & Mueller Loose, 2013). This explains the link between visual attention and decision making.

Visual attention and choice

Several studies found the link between visual attention and decision making. These observational studies suggest that chosen items are looked at longer. It is indicated that the amount of fixations and fixation duration on the selected item is higher in simple choices (Krajbich et al., 2010; Krajbich & Rangel, 2011; Glaholt & Reingold, 2009; Bradley, et al., 1998; Schotter et al., 2010). For example, in a study of Pieters and Warlop (1999) participants made a choice between product brands that were presented on a screen. The results indicated that they chose brands where afterwards fixation duration was longer. This is also the case when participants chose between pairs of food items. The probability of choosing one food item should increase with the excess time for which is fixated (Krajbich et al., 2010). It is suggested that people tend to look longer at items that were eventually chosen. Because these studies were observational, causality cannot be inferred from their results.

To our knowledge, only two studies assess the causal effect of manipulation of visual attention and choice. Shimojo et al. (2003) showed that a longer-presented image of a face was preferred when an observer's attention was manipulated by showing one face longer than the other (300ms vs 900ms)[1]. Secondly, Armel et al. (2008) investigated whether manipulating visual attention, by showing one food item longer than the other food item, influences food choice (300ms vs. 900ms). The probability of choosing the manipulated item increased by 7.34%. However, this effect was marginally significant. These results showed that manipulation of visual attention influences choice. Participants were more likely to choose the item that they were exposed to for a longer duration. The findings suggest that manipulation of attention can steer decision making.

Decision making

One possible theory about the effect of visual attention on decision making is based on Krajbich et al. (2010). They describe a model to explain how choices are made. The model is based on Ratcliffs (1981; 1982; 1985; 1988) drift diffusion model [DDM] of binary response selection. Krajbich et al. (2010) illustrate that a choice depends on the relative decision value [RDV]. This value changes over time due to fixations; the item which is fixated on and the duration of the fixation. The longer someone fixates on a stimulus the higher the relative value becomes. If the relative decision value has reached a threshold, a choice between the items is made. The RDV changes according to $V_t = V_t{-}1 + d(r_{left} - \theta r_{right}) + \varepsilon_t$ when the

[1] This was the case when the face images were repeatedly presented for 6 and 12 repetitions.

participant looks at the left item and $V_t = V_t{-}1 + d(r_{right} - \theta r_{left}) + \varepsilon_t$ when the participant looks at the right item[2] (Krajbich et al., 2010; Krajbich, Lu, Camerer, & Rangel, 2012). The average rate of change in the RDV slope that is biased towards the stimulus where the fixation is attended to is displayed in Figure 1. The model predicts that there is a choice bias that depends on the total looking time at one item versus the other item. This is the case when items are equally liked. The probability of choosing one item above the other should increase with the excess time for which is fixated (Krajbich et al., 2010).

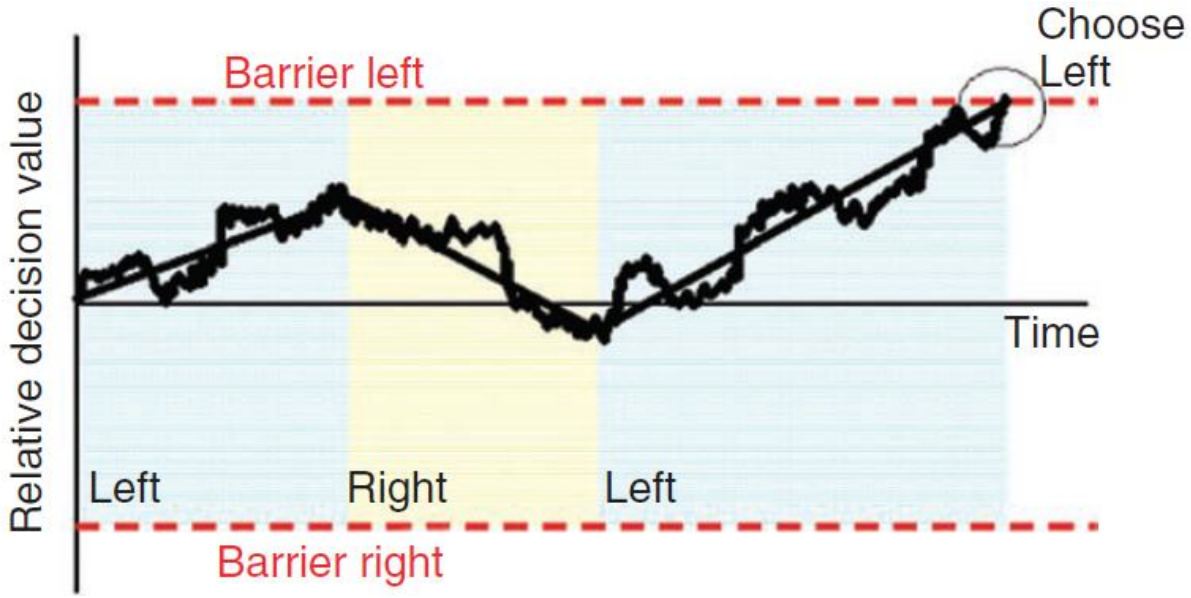

Figure 1. Illustration of the relative decision value. A relative decision value (RDV) evolves over time with a slope that is biased toward the item that is being fixated. The slope dictates the average rate of change of the RDV. When the RDV hits the barrier a choice is made for the corresponding item. The shaded vertical regions represent the item being fixated. Reprinted from "Visual fixations and the computation and comparison of value in simple choice" by I. Krajbich, et al., 2010, *Nature Neuroscience, 13*(10), p. 1293. Copyright by 2011 by Nature America.

Since the RDV is influenced by looking time, it is of great interest to test whether changes in looking time influence decision making in food choice. This leads to the main question in this study. It is examined what the effect is of manipulation of visual attention on food choices between HE and LE foods. Visual attention can be manipulated by exposure time of images (see also Shimojo et al., 2003; Armel et al., 2008). It is expected that the longer exposed item is more likely to be chosen (see also Shimojo et al., 2003; Armel et al., 2008). This is in agreement with the *mere exposure theory* which states that looking at a stimulus increases preference for that item (Kunst-Wilson & Zajonc, 1980; Moreland & Zajonc, 1977, 1982; Zajonc, 1968; Birch, Shimojo, & Held, 1985; Frantz, 1964). First of all, the exposure time is

[2] Where V_t is the value of the RDV at time t, r_{left} and r_{right} are the values of the two options, d is a constant that the speed of integration (in ms^{-1}), θ is between 0 and 1 and reflects the bias toward the fixation option and ε_t is white Gaussian noise with variance σ^2. For further explanation see Krajbich et al., 2010.

longer for one item in comparison to the other item. Thereby participants are able to look longer at one item. This can result in a higher rate of fixations and increased fixation durations, which are indicators of visual attention (Armel et al., 2008; Hoffman & Subramaniam, 1995; Orquin & Loose, 2013; Schotter et al., 2010; Shimojo et al., 2003). For this item visual attention will be increased. Given that the probability of choosing one item above the other should increase with the excess time for which is fixated and thereby reaches the corresponding RDV barrier it is expected that participants will be more likely to choose the longer exposed item (Orquin, & Mueller Loose, 2013).

In previous studies Armel et al. (2008) and Krajbich et al. (2010) investigated the relation between visual attention and food choice. They only describe the influence of liking or tastiness on the RDV. For example, Armel et al. (2008) states that a decision, and the corresponding RDV, will be influenced by liking rating. However, there are other factors that may influence the relative decision value in food choice. Many individuals have a goal to limit their energy intake (Rideout & Barr, 2009; Fayet, Petocz, & Samman, 2012; de Ridder, Adriaanse, Evers, & Verhoeven, 2014). Calorie content is an important motivation for food choice, especially for dieting individual who are searching for a healthy alternatives in food consumption (Furst, Connors, Bisogni, Sobal, & Falk, 1996; Carrillo, Varela, Salvador, & Fiszman, 2011; Hare, Malmaud, & Rangel, 2011). Thus, for them a foods' energy content might also be included in the calculation of the RDV (Furst et al., 1996; Hare et al., 2011; Carrillo et al., 2011). No earlier study has taken into account the energy content of foods (e.g. Armel, 2008; Krajbich et al., 2010; Krajbich & Rangel, 2011). Moreover, all earlier studies using attention manipulation used HE food products only. HE products are preferred over LE foods and therefore a decision between HE and LE foods might be different. Furthermore, it is still unknown if the effect of the attention manipulation is different for HE or LE products. Therefore we also investigate whether the effect of the attention manipulation differs between HE and LE food items. When the RDV is taken into account both liking and energy content will determine this value (Armel et al., 2008; Krajbich et al., 2010). Since in our study the liking rating is equal between the stimuli, it is hypothesized that manipulation of visual attention will mainly affect the item with a greater healthiness value, the LE item. When the liking rating is equal between the HE and LE foods, energy content will mainly affect the RDV and will therefore influence the decision on LE food items. It is interesting to focus on HE versus LE choices, because in a HE versus HE choice attention manipulation can only promote a HE choice (see Armel et al., 2008; Krajbich et al., 2010). Attention manipulation cannot be used to stimulate a healthy food choice. HE versus LE choices might be of great

interest to promote healthy food choices. When attention manipulation seems to be effective in HE versus LE choices and a choice preference for LE foods can be stimulated this method can be implemented in real-life settings. This may improve public health.

The current study implements several characteristics of the study of Armel et al. (2008). However they excluded individuals high in dietary restraint. For them, food choices between high and low energy stimuli involve a trade-off between tastiness and how much the food is in line with their goal of losing weight (Fishback et al., 2003). A food choice between HE and LE may be different, because of the trade-off between the feeling of enjoyment when eating immediately in contrast to future benefits of eating healthy (Fishbach, Friedman, & Kruglanski, 2003). Especially people high in dietary restraint should make conscious choices between these two aspects. Therefore, also individuals high in dietary restraint are taken into account. Since energy content of food is particularly relevant for dieting individuals, we also investigate whether the effect of manipulating attention on HE and LE foods differs between individuals high in dietary restraint and no weight-concerned participants. It is expected that the RDV in no-dietary restraint participants is mainly based on liking. The RDV in dietary restraint individuals is both affected by liking and energy content. However when the liking rating is equal for both items, like in our study, the RDV will primarily be influenced by calorie content. Therefore it is hypothesized that the effect of attention manipulation on LE foods will be stronger for dietary restraint individuals.

Method

Participants

The total study comprised 136 participants of which 102 individuals completed the choice task and met the criteria of the study (28 men, 74 women; age range 18-74; mean age 28.6 years; mean Body Mass Index [BMI] 22,1) (Table 1). To answer our last question the total sample was divided in 47 participants high in dietary restraint and 55 no-dietary restraint participants (13 men, 34 women; age range 18-74; mean age 29.0 years; mean BMI 23.14) (see also Table 1). Participants were recruited with posters, flyers, research websites and social media. Participation in the experiment was promoted by giving the participants feedback about their eating behavior and impulsive characteristics. Furthermore, participants had a chance on winning a gift voucher. The actual aim of the study was not mentioned. The cover story was that respondents were needed for a study on eating behavior.

Procedure

The online experiment contained two different parts and two questionnaires. The used software in this experiment is LimeSurvey[3]. The URL link for the online experiment was accessible for 6 weeks.

First, participants filled out demographic questions, e.g., age, gender, weight, length, and level of education. There were also some questions about eating behavior (e.g., vegetarian, vegan, weight-loss/dieting, and food allergy). Furthermore, participants reported when they had eaten their last meal, how hungry they were at that moment and how much they would have liked to eat something at that moment (9-point Likert scale ranging from 1: not hungry at all or very much and 9: very hungry or not at all). Then, participants completed two tasks. First, they completed a questionnaire with questions about 40 different food items. A food image was presented on the screen. The questions with this image were "At this moment, how tasty do you think this product is?", "How healthy do you think this product is?" and "How many calories do you think this product contains?". Each question was rated on a scale of 1 to 9 (not tasty – tasty, not healthy – healthy, and few calories – many calories). Participants also rated each item in terms of how it made them feel while viewing it. The rating also included 10 non-food images (office supplies). Participants made an indication of their feeling of pleasantness and the state of arousal while viewing the image (self-assessment manikin) (Lang, Bradley, & Cuthbert, 1997; Lang, Bradley, & Cuthbert, 2005). Results from these ratings are not reported here. The liking rating of the food items was used for the next task, the choice task (described in more detail below).

After the choice task the participant filled out a questionnaire on impulsivity; the Dutch version of the Barratt Impulsiveness Scale [BIS-11] (Lijffijt & Barratt, 2005) and the *dietary restrained* and *extern eating* scale of the Dutch Eating Behavior Questionnaire [DebQ] (De Nederlandse Vragenlijst voor Eetgedrag, Van Strien, Frijters, Bergers, & Defares, 1986; Van Strien, 2005). Both items contained 10 questions. This resulted in 20 questions, for example: "if you have something tasty to eat, do you eat it immediately?" or "if you gain weight, do you eat less than you do usually?". From the DebQ only the *restrained eating* items were used. Therefore, other results will not be reported here.

[3] LimeSurvey Project Team. Carsten Schmitz (2015). LimeSurvey: An Open Source survey tool. LimeSurvey Project Hamburg, Germany. URL http://www.limesurvey.org

Choice task

In this task participants made binary choices between two food items that were shown on a computer screen. Each trial contained a HE and LE product. Participants were instructed to choose the food item that they wanted to eat at that specific moment. The liking ratings of the food images were used to create a unique set of choice pairs for each subject. This set of choice pairs was presented in the choice task. Each choice pair consisted of a HE and LE food product. Since studies have the assumption that choice bias can only be generated by items of similar liking values, choice pairs were matched on equal liking ratings which were collected in the first part of the experiment. Only images with a liking rating of 5 or higher were used for matching, to accomplish that no disliked food items were used in the choice task. By using equal liking scores each subject created several food pairs between which they had to make a choice. Since 40 food items are presented in the first task, a maximum of 20 choice pairs can be created in the choice task.

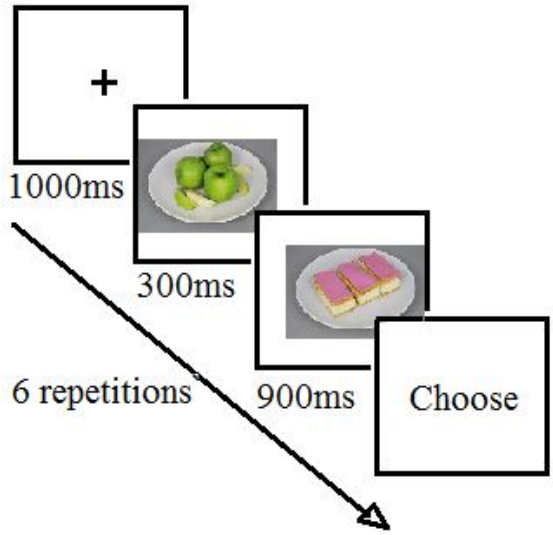

Figure 2. An example of a trial in the food choice task. A fixation cross is presented on the screen. Then two food items (HE versus LE) alternated on the screen, one at a time. One image was presented for 300ms, the other image was presented for 900ms. This was repeated for six alternations. Afterwards the subject chose one of the two food items. This procedure was repeated with other food items.

During the choice task participants made binary choices between high and low energy product images (Figure 2). The trial started with a fixation point in the center of the screen for 1s**.** The images of the two food items alternated on the screen, such that at each moment only one of the foods was displayed. One item appeared on the right of the screen, the other item appeared on the left of the screen. The food items in each pair were subsequently shown alternatively on the screen, for 300 and 900 ms, with six repetitions. Because of the six alternations of 300

and 900 ms, the food items were presented for 7200ms. The manipulation of visual attention was just as often on the left and right side of the screen and as often on the HE or LE stimulus. In half of the trials, the longer manipulation of visual attention was on the HE foods; in the other half of the trials, the manipulation was on the LE foods. Subsequently, the word "choose" appeared on the screen. The participants made a choice by pressing either the left or right key on the keyboard. In this task the duration of fixations was manipulated by the exposure time of the images. This design allowed us to investigate the effect of attention manipulation on choice between HE and LE food items.

Stimuli

For this experiment the F4H image collection was used (Charbonnier, van Meer, van der Laan, Viergever, Smeets, 2016). This database consists of food and non-food images (such as crisps, donuts, carrots, breadsticks, tape, pencils and paperclips. The food images that were used in this experiment were selected as a LE food (<150 kilocalories) or a high energy food (>151). This cut off criterion employed in earlier studies (Rothemund et al., 2007; van der Laan, de Ridder, Charbonnier, Viergever, & Smeets, 2014).

Data-analysis

In the first task the mean liking rating of all 40 food items among all participants (n = 136) can be calculated (M = 6.06, SD = 1.00). Not every participant completed the whole experiment. Only participants that completed the choice task were included (n = 117). Given that the amount of choices depended on the amount of items that are equally rated on likeliness, the number of choices they have made may be different per participant. For data cleaning a selection of at least five choice pairs in the choice task has been made. A small number of choices may cause outliers. Therefore only participants that made at least five food choices were included. Hence, fifteen more participants were excluded based on these criterion (n = 102). Furthermore, in the choice task a maximum of 20 choices could be made, this means there were 20 possible matches on likeliness between HE and LE foods. Since no participant had more than 17 matches, maximal 17 choice trials were taken into account.

For the data analysis the success proportion was used as outcome measure. This value shows the proportion that the manipulated stimulus (900ms) was actually chosen by the participant. The success proportion of HE and LE stimuli was calculated. This value shows the choice percentage of a HE stimulus or LE stimulus when it was manipulated. To assess the first question the success proportion, the total of longer exposed stimuli that have been

chosen, was used. To determine the effect of the manipulation of exposure time on choice the success proportion was entered into a one-sample *t* test ($p < .05$). The mean success proportion was compared with the average value of 50.0 (see also Shimojo et al., 2003). To investigate whether there was a difference in the effect of manipulation on HE versus LE stimuli in decision-making, the success proportion between HE and LE foods was compared by performing a paired sample *t* test ($p < .05$) with success proportion of HE and success proportion of LE as variables. To assess the third question, the *restrained eating* scores of the DebQ questionnaire were taken into account. The dietary restraint participants were selected by using the norm-score for the *restrained eating* items (Dutch Eating behavior questionnaire, Van Strien et al., 1986; Van Strien, 2005). The raw scores, calculated by the sum of scores on every question (never: 1, rarely: 2, sometimes 3, often 4, nearly always: 5 points), should be divided by the number of question items to get the mean score (Table 1 & 2). When a participant scored above the mean, (s)he was selected as dietary restraint participant (norm score *above the mean* restraint eating men: $M > 2.26$; norm score *above the mean* restraint eating women: $M > 2.80$) (van Strien, 2005). An ANOVA repeated measures (2x2, within subjects: success proportion HE, LE and between subjects: dietary restraint, not dietary restraint), was used to find out whether there was a difference in success proportion between HE and LE foods in participants that were high in dietary restraint and participants who were not weight-concerned. A pairwise comparison revealed the difference between the two groups. To account for multiple testing, the Bonferroni correction is used in pairwise comparisons for which $p < .05/2 = .025$. All analyses are executed with the program IBM SPSS statistics 23.

Results

Overall participants made 11 choices ($M = 10.6$ $SD = 3.05$). Of all these choices 52.57% was a HE choice ($SD = 19.98$) and 49.97% was a LE choice ($SD = 18.71$). Table 1 shows an overview of demographic data for all participants and participants high and low in dietary restraint.

Table 1a. Demographic data: estimate and standard deviations are displayed for age and BMI for the total sample and participants high in dietary restraint.

		n	Estimate	Std.
Age	Total sample	102	28.63	14.19
BMI	Total sample	102	22.06	3.19
Age	Restraint group	47	29.02	15.35
	No restraint group	55	28.29	13.26
BMI	Restraint group	47	23.10	3.41
	No restraint group	55	21.13	2.69

Success proportion choice

A one sample *t* test with a $p < .05$ was used to compare the average number of success proportion of 102 participants ($M = 50.41$, $SD = 18.29$) against the average of 50.0. The participants scored 0.41, 95% CI [4.00, -3.18] below the average. This value indicates in how many cases the longer-presented stimulus was chosen. A value above 50.0 (*t* test) was considered a preference bias for the stimulus that was longer presented on the screen. This difference was not found to be statistically significant, $t(101) = .226$, $p = .821$. The attention manipulation did not result in an increased choice preference for the manipulated item. There was no choice preference towards the longer exposed item. The manipulation did not affect the participant's choice between the two food items.

Success proportion HE and LE

To assess the second question, whether there is a difference in success proportion between HE and LE stimuli, a paired sample *t* test with a $p < .05$ was used to compare the mean success proportion of HE stimuli ($M = 47.87$, $SD = 22.76$) and LE stimuli ($M = 51.16$, $SD = 22.21$). On average, the difference between the success proportion on HE versus LE stimuli was not significant, $t(101) = -1.739$, $p = .085$. However there is a trend that shows a difference between the effectiveness of the manipulation on HE and LE items. This trend shows that the success proportion might be higher for LE products in comparison with HE products.

Success proportions HE and LE for (no-)dietary restraint group

The means for men and women for the DebQ items are presented in Table 2 (norm score men $M = 2.16$-2.25; women $M = 2.71$-2.79). The distribution of success proportion between HE and LE item in relation to the mean dietary restraint score per participant is presented in figure 3a and 3b.

Table 2. The mean scores and standard deviations on *restrained eating* are displayed for the whole sample and for the selected dietary restrained group, both for males and females.

		n	Estimate	Std.
Dietary restraint score total sample	Total	102	2.61	.80
	Men	28	2.26	.78
	Women	74	2.75	.77
Dietary restraint score dietary restraint participants	Total	47	3.25	.59
	Men	13	2.93	.54
	Women	34	3.38	.56

Based on the selection criteria there are 47 participants who are in the dietary restraint group and the no-dietary restraint group contains 55 participants. The group with dietary restraint participants consists of 13 males and 34 females (Table 2). A one-way repeated measures analysis of variance (ANOVA) was used to compare the success proportion of HE and LE choices (within-subjects factor) for dietary restraint participants and no-dietary restraint participants (between-subjects factor). The ANOVA results are not statistically significant, but the success proportion for HE and LE tends to be different between dietary restraint participants and no-dietary restraint participants, F (1, 100) = 2.916, p = .091.

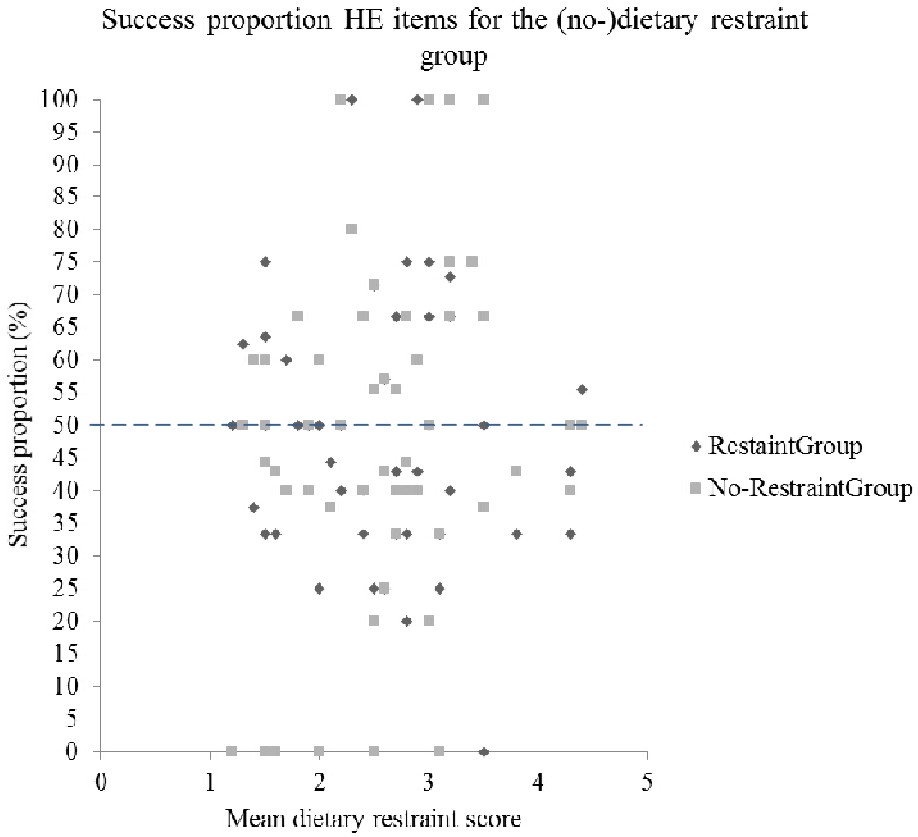

Figure 3a. Distribution success proportion HE items between the no dietary restraint group (n = 47) and the dietary restraint group (n = 55)

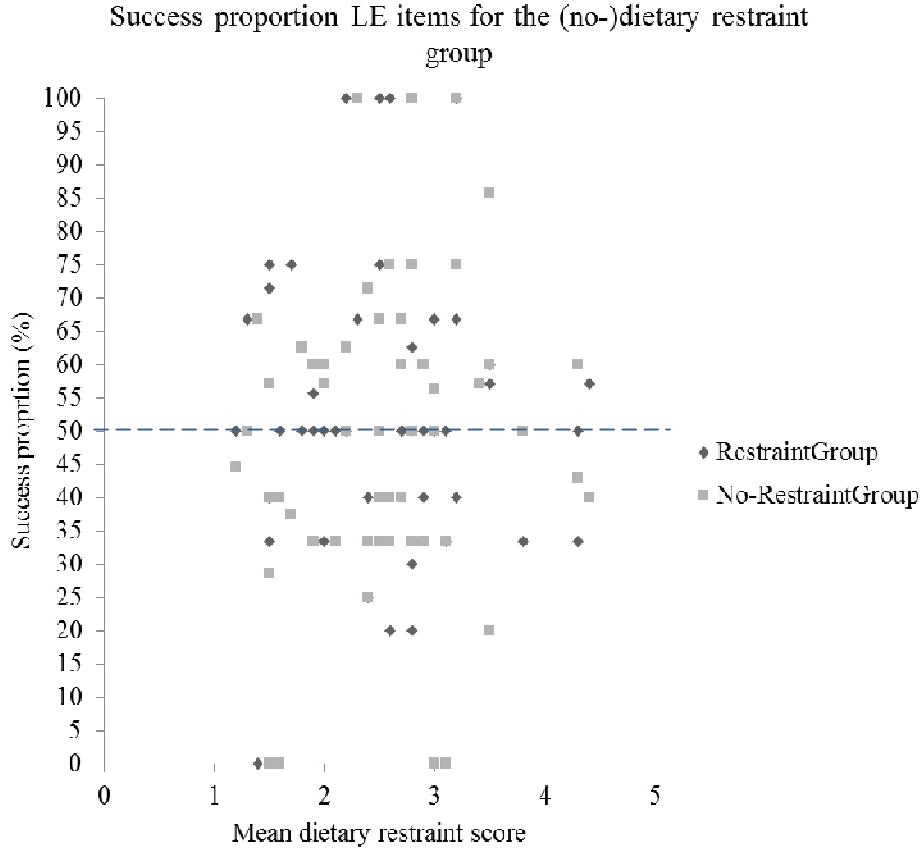

Figure 3b. Distribution success proportion LE items between the no dietary restraint group (n = 47) and the dietary restraint group (n = 55).

A pairwise comparison was used to accomplish further results (Table 3 & Figure 4). In the no-dietary restraint group there was no significant difference in success proportion between HE and LE items t(54) = -.741, p = .462). There is no effect of attention manipulation on HE (M = 47.77, SD = 24.96) or LE items (M = 49.54, SD = 23.06) in the no-restraint group. On the contrary, for the dietary restraint group the manipulation seems to show a trend that the LE items might be more effective in comparison with HE items. A paired sample t test with a $p <$ .05 is used to compare the mean success proportion on HE (M = 47.98, SD = 20.15) and LE (M = 53.06, SD = 21.26) for participants high in dietary restraint. In the dietary restraint group on average the manipulation was effective in 53.06% of all LE manipulated trials, 95% CI [-11.15, 0.10]. This difference was not statistically significant $t(46) = -1.68$, $p = .099$. However, the success proportion on LE items tend to be higher in the dietary restraint group, in comparison with the success proportion on HE items.

Table 3. Mean scores on success proportion for HE and LE items for dietary restraint participants, no-dietary restraint participants and the total sample.

		n	Estimate	Std.
HE success proportion	Restraint group	47	47.98	20.15
	No restraint group	55	47.77	24.96
LE success proportion	Restraint group	47	53.06	21.26
	No restraint group	55	49.54	23.05
HE success proportion	Total sample	102	47.87	22.76
LE success proportion	Total sample	102	51.16	22.20

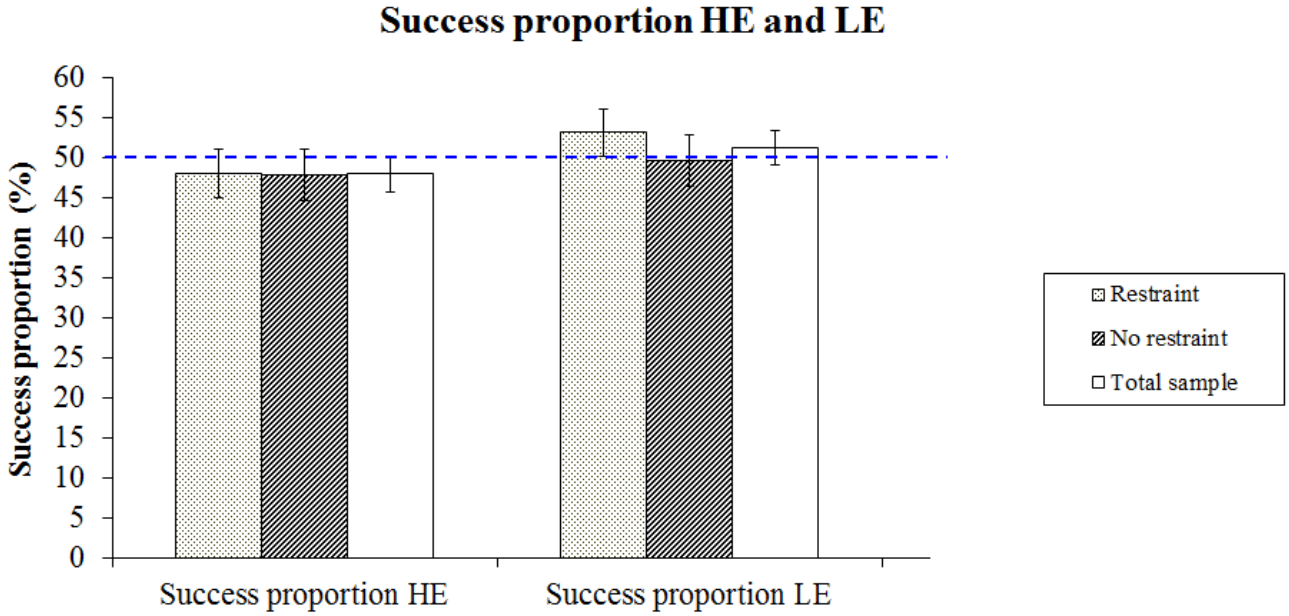

Figure 4. Success proportion for HE and LE items. Mean scores on success proportion for HE and LE items for dietary restraint participants, no-dietary restraint participants and the total sample.

Discussion

The effect of manipulation

Overweight and obesity are caused by unhealthy food choices and cause health problems (Antipatis & Grill, 2001; James, 2004; McLellan, 2002; Swinburn et al., 2011). People have a higher preference for energy-rich foods, therefore individuals find it hard to make healthy food choices (Drewnowski & Greenwood, 1983; Nijs, Muris, Euser, & Franken, 2010). The aim of our study was to investigate whether manipulation of visual attention, by manipulating the exposure time of a food item, affects choice and promotes healthier food choices. It was examined whether the manipulation of exposure time could influence a LE food choice.

The results showed that the manipulation did not influence individuals' choice between HE and LE items. An increase in exposure time of one out of two items did not result

in the expected choice preference for this item. This does not hold the *mere exposure* theory for HE versus LE choices, which states that looking at a stimulus increases preference for that item (Kunst-Wilson & Zajonc, 1980; Moreland & Zajonc, 1977, 1982; Zajonc, 1968; Birch et al., 1985; Frantz, 1964). In our study the probability of choosing one item above the other item did not increase with the excess time for which is fixated (Orquin, & Mueller Loose, 2013). Although, our findings for the effect of the manipulation on HE versus LE items did show a trend. Even though it is clear that the manipulation did not affect choice, the results direct to higher success proportion for LE items in comparison with HE items. This means that there may be a trend for a small difference between the effectiveness of the manipulation between the two categories. This trend shows us that, compared to the success proportion of HE items, the LE items might be chosen more often when they are manipulated. A comparable, but smaller non-significant trend is noticeable in the dietary restraint group. In contrast to the no-dietary restraint group it is indicated that there is a trend for a difference in the effect of manipulation between HE and LE items. Here, the manipulation may be more effective on LE items.

Based on this data we can conclude that the manipulation is not effective on HE stimuli. To our knowledge, this is the first study that experimentally manipulated both HE and LE items, whereas other studies used HE foods only (Armel et al., 2008; Krajbich, 2010; Krajbich & Rangel, 2011). When we take the total amount of HE and LE choices into consideration, participants are more likely to choose a HE item. This is in agreement with the fact that foods that are energy-rich are preferred over LE foods (Drewnowski and Greenwood, 1983; Nijs, Muris, Euser, & Franken, 2010). A HE choice is often the default and is picked more often, regardless of the manipulation. This may be the reason why the results show no effect of manipulation on HE stimuli. When we take into account the manipulation of LE items, the results show a trend that the manipulation does affect a LE choice, especially in the dietary restraint group. When we accept the results that follow from our study, it turns out that a HE versus HE choice differs from a HE versus LE choice. Krajbich et al. (2010) stated that the RDV and the corresponding choice is only influenced by looking time. Armel et al. (2008) showed that the RDV and choice is also influenced by liking. Since we controlled for liking rating and the liking ratings between HE/LE choice pairs are equal, this aspect will no longer influence choice preference. Even then we found a trend in LE versus HE choice. Thereby the RDV may be mostly affected by energy content. Apparently, calorie content plays an important role in food decision-making. In line with our expectations, even though the effect was not significant, participants tend to show a choice preference for the item with greater

healthiness value; the LE item. It was also hypothesized that, given that the dietary restraint group is more weight concerned, and calorie content is an important motivation for food choice, they will also be searching for healthy alternatives in food consumption. The results show a trend that the dietary restraint group might chose the LE item more often when it is manipulated. This is in agreement with our expectations. All in all we conclude that calorie content may have some influence on the RDV and thereby food choice.

Strength and weaknesses

The effect of attention manipulation did not hold for HE and LE choices. However, our experimental design was optimized to detect the effect of manipulation. First, because we matched choice pairs on self-reported liking ratings. Given that choice is mainly based on pre-existing preference, this could not influence the decision-making process (Orquin & Mueller Loose, 2013). Second, a great diversity of products are used; foods high and low in calorie content and both sweet and savory. However, since the small amount of choices per participant, the product diversity decreased. Third, we controlled for first position and manipulation on left and right side of the screen. At last, the number of participants should result in enough power for our results. The absence of the effect of manipulation on choice may be caused by the number of choice pairs. Armel et al. (2008) used 35 choice pairs and Shimojo et al. (2003) used 30 choice pairs. In our study some participants only made five or six choices and seventeen choice pairs were the maximum. This may be the reason why the effect of the manipulation was statistically not above chance. It is also important to notice that our experimental design did not contain a control condition where no manipulations were used. Hence, we cannot conclude whether there is a difference in decision-making between manipulated and non-manipulated foods. Furthermore, the trials did not include HE-HE or LE-LE choice pairs. Therefore we cannot compare the results of different trials and we cannot make an assumption about the influence of different calorie contents. Besides, given that this was an online experiment we did not receive feedback on fixations, fixation duration, looking time or saccades (e.g. in eye tracking studies). Therefore we are not entirely sure that participants attended to the presented images during the whole trial and visual attention was increased.

In addition to this, we should bear in mind the actual effect of looking time and exposure time. The finding in previous studies that chosen products were looked at longer, suggests that attention might play a role in (food) choice. However, it is still unclear whether this is a *mere exposure effect*, where looking at an item increases preference for that item, or

whether it is a *preferential looking effect* where one tends to look longer at the item that one likes better (Kunst-Wilson & Zajonc, 1980; Moreland & Zajonc, 1977, 1982; Zajonc, 1968; Birch et al., 1985; Frantz, 1964). Our study did not confirm the *mere exposure theory* for HE versus LE items. However, in our study the *preferential looking effect* does not hold either, because both items are equally liked and a participants' looking time cannot be increased for preferred items given that exposure time is controlled and limited. Therefore, further research is needed to investigate whether mere exposure or pre-existing preference influences decision-making.

For future research the experimental design should include a control condition where no manipulation is used. Furthermore, for the sake of completeness HE-HE, LE-LE and HE-LE trials should be included. It is also important to create more choice pairs in the choice task. An extensive collection of food images should be rated on a self-reported liking scale, by this the amount of choice pairs will be bigger. At last, to receive feedback on looking time, an eye-tracker can be used.

Practical implications

Our results only show trends and this might be caused by lack of power due to the small amount of choice pairs. However, perhaps the manipulation of visual attention does not have the desired effect on food choice. In accordance to Amel et al. (2008) attention manipulation is effective in a HE versus HE choice, for example a choice between a chocolate cookie and a donut. In this case the manipulation of visual attention, by increasing the exposure time, will result in a choice preference for the longer exposed item, for instance the donut. Armel et al. (2008) showed that the effect of picking the longer exposed item above the other item is 7,34%. This means that in 57.34% of all manipulated trials the longer exposed item is chosen. This might be useful information for retailers and commercial producers. They can implement this information and use it in their commercials by exposing an item for a longer duration. However, this effect will be too little when public health is taken into consideration. Furthermore, when we take our results into account, where actual LE products are used, only 51.16% of all LE manipulated items will be in favour of the longer exposed item, compared to 47.87% of all HE manipulated items. Not only is the effect non-significant, moreover the difference between the mean success proportions for HE and LE is also small. This is also the case for the differences in mean success proportion of HE and LE in the dietary restraint group.

Based on our results and Armel et al. (2008), from the viewpoint of healthiness the effect of manipulation of visual attention will be too small. Perhaps we should focus on other aspects that influence a healthy food choice, since the *mere exposure* theory lacks effectiveness in healthy food choice. For instance, other ways to manipulate visual attention should be taken into account. In stead of bottom up control of attention, where attention is stimulus driven, e.g. items which are longer exposed, also top down control of attention can be used. In this case attention is goal directed. Individuals attend to task relevant items, as a result of a specific instruction, such as *look at …; try to find out …; consider …*. Furthermore, it is also important to consider other aspects that influence food choice. Previous research found that aspects such as saliency, situation, task relevance, brightness, instruction and colors also affect choice and can steer attention (Orquin & Mueller Loose, 2013; Milosavljevic, Navalpakkam, Koch, & Rangel, 2012). Moreover, not only stimulus characteristics influence food choice, also personal aspects, such as BMI, impulsiveness, and eating behavior influence food choice (Sengupta & Zhou, 2007; Verplanken, Herabadi, Perry, & Silvera, 2005; Carrillo et al., 2011). Furthermore, we should take into account the ability to generate our findings into real-life settings. Watching a food item image (e.g. in a commercial) may be different from looking at an actual food item (e.g. in a supermarket shelf). This may affect decision-making. Aspects like, smell, feeling, environment may influence decision-making in real-life situations whereas these aspects might be absent while looking at images. Therefore, it may result in different decision-making processes. Apparently there are many factors that influence food choice. Manipulation of visual attention by exposure time only will not be enough to affect a healthy food choice. Other means should be used to encourage a healthy food choice.

Conclusion

To conclude, in contrast with common assumptions that visual attention influences choice we found no such effect for food choice between HE and LE items. Even though our results show a trend for effectiveness of manipulation on LE items, our findings do not support the idea that manipulation of visual attention can be used to promote a healthier food choice. The effect is too small for implementation in real-life situations. However, other manipulations of visual attention might be more effective to support a healthy food choice. Further research is needed to investigate the effectiveness of manipulating visual attention in healthy food choice.

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