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DOI
10.1016/j.appet.2019.104574

Publication date
2020

Document Version
Final published version

Published in
Appetite

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Link to publication

Citation for published version (APA):
Alblas, M. C., Mollen, S., Fransen, M. L., & van den Putte, B. (2020). Food at first sight: Visual attention to palatable food cues on TV and subsequent unhealthy food intake in unsuccessful restrained eaters. *Appetite*, *147*, Article 104574. https://doi.org/10.1016/j.appet.2019.104574

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Download date:12 Oct 2026

Appetite 147 (2020) 104574

Contents lists available at ScienceDirect

Appetite

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Food at first sight: Visual attention to palatable food cues on TV and subsequent unhealthy food intake in unsuccessful restrained eaters

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ARTICLE INFO

Keywords:
Food cues
Eating restraint
Self-regulation
Visual attention
Food intake
Media effects

ABSTRACT

Background: This study investigated whether unsuccessful dieters show heightened visual attention to food cues in TV content and how visual attention influences subsequent unhealthy food intake. This study adds to prior literature by investigating the influence of visual attention to food cues on food intake with actual media content (i.e., instead of isolated food cues such as pictures or words) and by differentiating between chronic dieters (i.e., restrained eaters) who vary in dieting success (i.e., perceived self-regulatory success [PSRS]). To get a more detailed insight into different processes of visual attention, two measures of attention (i.e., initial orientation and attention duration) were examined.

Methods: Unrestrained (n = 34) and restrained eaters (n = 28) varying in PSRS watched a talk show containing subtly depicted, palatable food cues. While watching, their visual attention to the food cues was measured with an eye-tracker. Unhealthy food intake was assessed afterwards in a taste test.

Results: A two-way interaction between eating restraint and PSRS on initial visual orientation was found: unsuccessful restrained eaters' initial orientation to food cues was faster compared to that of successful restrained eaters. There were no significant findings on attention duration. Furthermore, visual attention did not predict unhealthy food intake.

Discussion: Unsuccessful restrained eaters' fast initial orientation, but no longer attention duration, suggests that self-regulation may be important at early stages of visual attention. Future research on this topic should continue to differentiate between initial orientation and attention duration, as well as between more and less successful restrained eaters. The lack of findings on unhealthy food intake suggest that food cues embedded in actual media content might have less influence on eating behavior compared to isolated food cues.

1. Introduction

On a daily basis people are exposed to a variety of palatable, but often unhealthy foods on TV. Food is not only frequently present in TV content where the food cues are central to the content (e.g., in food commercials or cooking contests), but also in more subtle ways, such as in a talk show where snack foods are displayed on the table at which the host is seated. Some experimental studies have shown that exposure to food on TV (i.e., food-related TV content) may increase food intake (Bodenlos & Wormuth, 2013; Harris, Bargh, & Brownell, 2009), while other studies did not report such effects (Bellisle, Dalix, Airinei, Hercberg, & Péneau, 2009; Martin, Coulon, Markward, Greenway, & Anton, 2009).

These inconclusive findings may be explained by individual differences in how susceptible people are to the influence of external food cues (such as food cues on TV), leading to different processing of such cues, which may in turn explain differential effects on food intake (Papies, Stroebe, & Aarts, 2008a). While knowing who is affected and why is crucial in our understanding of potential effects of food-related TV content, research on this topic is scarce. In this study, we therefore investigated for whom and why watching a TV show with food cues may influence subsequent unhealthy food intake. More specifically, we tested whether individual differences in chronic dieting (i.e., restrained eating) and dieting success explained visual attention to food cues in a TV show, and whether visual attention predicted unhealthy food intake.

Visual attention, restrained eating, and dieting success have previously been studied to explain effects of exposure to food pictures or words (e.g., Junghans, Hooge, Maas, Evers, & de Ridder, 2015; Papies et al., 2008a; Werthmann et al., 2014), but to our knowledge not with actual media content. However, actual media content is more complex

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https://doi.org/10.1016/j.appet.2019.104574
Received 28 June 2019; Received in revised form 15 November 2019; Accepted 20 December 2019
Available online 23 December 2019
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than food pictures or words. When food cues are embedded in media content such as a TV show, viewers can also choose to look at other cues (e.g., faces) and process other types of information such as sound (e.g., in a conversation). It is therefore important to study visual attention to food cues the way these cues would naturally occur (e.g., in media content). Furthermore, it is important to differentiate between restrained eaters who are less or more successful in dieting. Although previous research has shown that successful and unsuccessful restrained and unrestrained eaters differ in their responses to food cues (Fishbach, Friedman, & Kruglanski, 2003; Papies et al., 2008a) prior studies on visual attention to food cues have not distinguished between successful and unsuccessful restrained eaters. Moreover, in contrast to most previous research, this study distinguished between two types of visual attention: the initial orientation and the duration of attention to food cues. This provides a more detailed insight into different processes of visual attention (Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010).

1.1. Visual attention and restrained eating

Some people are more sensitive to external food cues than others, and in this regard much research has focused on the role of eating restraint (Polivy & Herman, 2017). Under normal circumstances (i.e., without pre-exposure to food cues), restrained eaters restrict their food intake and eat the same or less compared to unrestrained eaters (Lindroos et al., 1997). However, after being exposed to food cues, restrained eaters show more craving and overeating compared to unrestrained eaters (e.g., Fedoroff, Polivy, & Herman, 1997, Fedoroff, Polivy & Herman, 2003). A potential explanation for restrained eaters' responsiveness to food cues is that they have heightened visual attention to food (Werthmann, Jansen, & Roefs, 2015). People's visual attention is automatically drawn to potentially relevant information (Connor, Egeth, & Yantis, 2004). For restrained eaters, who are often preoccupied with food-related information (Timmerman & Gregg, 2003), visual attention may therefore be easily drawn to food cues (Higgs, Rutters, Thomas, Naish, & Humphreys, 2012).

Empirical evidence for increased visual attention to food in restrained eaters, however, is mixed (Werthmann et al., 2015) and various hypotheses regarding restrained compared to unrestrained eaters' attention have been proposed (Werthmann et al., 2013). According to some, restrained eaters may indeed show increased attention to food cues (approach hypothesis, e.g., Meule, Vögele, & Kübler, 2012), while according to others they may show decreased attention to food cues in an attempt to stick to their diet (avoidance hypothesis, e.g., Veenstra, de Jong, Koster, & Roefs, 2010). Alternatively, restrained eaters may show increased initial attention to food cues, but less duration of attention because they disengage from food in later stages (automatic approach, strategic avoidance hypothesis, e.g., Rinck & Becker, 2006). In addition to these possibilities, some studies have found no differences between restrained and unrestrained eaters in their attention to food cues (Boon, Vogelzang, & Jansen, 2000; Werthmann et al., 2013). These inconsistent findings may be partly explained by variation in how successful restrained eaters were in their dieting attempts, and by different processes of visual attention.

1.2. The role of success in restrained eating

Even though all restrained eaters are concerned with dieting and weight regulation, some of them are more successful than others (Fishbach et al., 2003; Wing & Hill, 2001). In contrast to unsuccessful restrained eaters (operationalized as restrained eaters with low perceived self-regulatory success [PSRS]), successful restrained eaters (i.e., restrained eaters with high PSRS) automatically activate self-regulatory resources in response to palatable food cues (Fishbach et al., 2003). This self-regulation is needed to overcome temptation, and thereby protects the long-term dieting goal of restrained eaters.

An important self-regulation strategy is the ability to disengage attention from cues that interfere with long-term goals (Baumeister & Heatherton, 1996; Mischel & Ayduk, 2002). Successful restrained eaters may therefore be better able to disengage attention from tempting food cues than unsuccessful restrained eaters. Some initial evidence showed that when restrained eaters were primed with a dieting goal, compared to a palatability goal (Werthmann, Jansen, & Roefs, 2016) or no goal (Papies, Stroebe, & Aarts, 2008b), their visual attention to palatable food cues attenuated. This may work in a similar way for successful restrained eaters, who automatically activate their dieting goal in response to palatable food cues (Papies et al., 2008a), but this has not been tested yet.

Because initial orientation involuntarily and automatically leads visual attention to potentially relevant stimuli (Connor et al., 2004; Higgs et al., 2012), we hypothesize that all restrained eaters show an initial, automatic approach to palatable food cues due to their preoccupation with food (Timmerman & Gregg, 2003). This should be reflected by a short time until their first fixation on food cues. We propose:

H1. Restrained eaters, compared to unrestrained eaters, show a faster initial visual orientation to palatable food cues in a TV show.

Shortly after exposure to palatable food cues, however, self-regulation strategies become active (Papies et al., 2008a). Whether attention to these cues is subsequently maintained (or disengaged from) is therefore expected to depend on restrained eaters' levels of self-regulatory success. Some initial support for this was found in a study by Junghans et al. (2015) who compared visual attention to unhealthy foods between people with low (i.e., children) and high (i.e., adults) self-regulatory skills. Both groups showed an initial orientation to unhealthy foods. However, the group with low self-regulatory skills showed a longer attention duration to unhealthy foods compared to the group with high self-regulatory skills. A similar pattern may be expected when restrained eaters with low and high self-regulatory success are compared. While all restrained eaters are expected to have a fast initial orientation to unhealthy food cues, successful restrained eaters may show disengagement from the food cues in line with their long-term dieting goal. In contrast, unsuccessful restrained eaters may maintain their attention to these cues, reflected by a longer total duration of fixations on food cues. The following hypothesis is therefore proposed:

H2a. Duration of visual attention to palatable food cues in a TV show is predicted by an interaction between eating restraint and PSRS: unsuccessful restrained eaters, compared to successful restrained eaters, show longer duration of visual attention. Among unrestrained eaters, duration of visual attention is unaffected by PSRS.

1.3. Attention duration and unhealthy food intake

A longer duration of visual attention to food cues, which is thought to be a goal-directed process, has shown to be positively related to food choices (Armel, Beaumel, & Rangel, 2008; van der Laan, Papies, Hooge, & Smeets, 2017; Wang, Cakmak, & Peng, 2018) and food intake (Werthmann et al., 2014). For example, Werthmann et al. (2014) exposed participants to pictures of palatable food cues and nonfood cues in a visual probe task, and found that a longer duration of attention to food cues was related to increased food intake in a taste test afterwards. Other studies showed similar findings on the relationship between attention duration and subsequent food choices (Armel et al., 2008; van der Laan et al., 2017; Wang et al., 2018). We therefore propose:

H2b. Duration of visual attention to palatable food cues in a TV show is positively related to subsequent unhealthy food intake.

A faster initial orientation to the food cues is not expected to result in unhealthy food intake, because this implies that food intake would increase for all restrained eaters (as proposed in H1) and thus ignore the

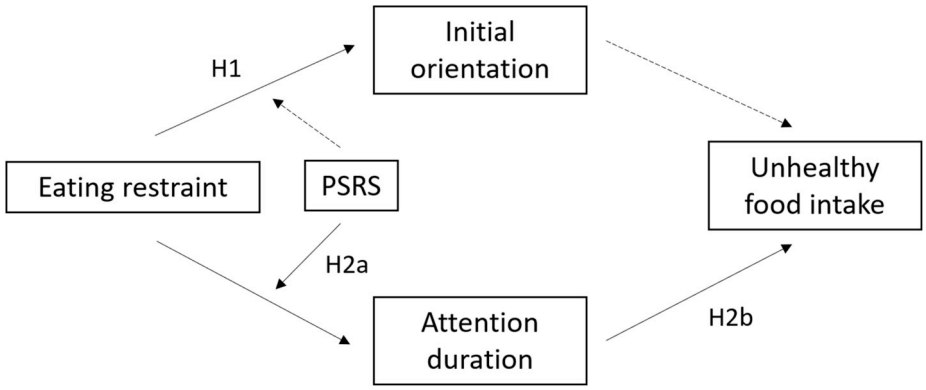

Fig. 1. Overview of all hypotheses. The two interrupted paths (between eating restraint x perceived self-regulatory success [PSRS] on initial orientation, and between initial orientation and unhealthy food intake) indicate that no association was expected.

influence of success in applying self-regulatory strategies to avoid food cues. In line with this, empirical studies found that initial orientation to food cues did not influence food choice (Danner et al., 2016; van der Laan, Hooge, de Ridder, Viergever, & Smeets, 2015). Please see Fig. 1 for an overview of the hypotheses.

2. Methods

2.1. Participants

In total, 75 female participants completed the full study, which consisted of an online questionnaire to select participants scoring low and high on eating restraint and a lab session. Large sex differences in eating restraint scores were detected after inspection of the first fifty participants in the selection questionnaire (in line with previous studies, e.g., Neumark-Sztainer, Sherwood, French, & Jeffery, 1999; Schur, Heckbert, & Goldberg, 2010). We therefore decided to include only female participants to prevent sex from becoming a confound.

After obtaining all data, and before testing the hypotheses, participants were excluded from the analyses if they indicated to not eat at least two of the three types of foods that were clearly visible in the TV show (i.e., cake, salty snacks, profiteroles) due to allergies or other restrictions ($n = 7$), or if they strongly disliked at least two of the three foods ($n = 1$). Furthermore, participants with unreliable eye-tracking data (based on inspection of the tracking ratio, eye-deviations, scan path, and line graph for every participant) were also excluded ($n = 3$). In addition, two participants were excluded because they caused high skewness (5.28, $SE = 0.30$) and kurtosis (34.60, $SE = 0.59$) on initial orientation ($n = 2$).

The final sample consisted of 62 female participants: 34 unrestrained eaters (age: $M = 21.79$, $SD = 2.73$, range 18–30; BMI: $M = 20.72$, $SD = 1.68$, range 17–25) and 28 restrained eaters (age: $M = 21.29$, $SD = 2.81$, range 18–29; BMI: $M = 22.11$, $SD = 3.97$, range 16–35). All participants were highly educated and all participants had normal or corrected-to-normal vision using contact lenses. Wearing glasses on a daily basis was not allowed to prevent poor eye-tracking quality. In exchange for participation, participants received course credit or €7.50. The study was approved by the Ethics Review Board of the Faculty of Social and Behavioral Science of the University of Amsterdam and informed consent was obtained from all participants at the beginning of the study. Upon finishing the data collection, all participants were debriefed by e-mail to inform them about the true purpose of the study.

2.2. Procedure

Participants between 18 and 30 years old were recruited from the university subject pool and invited to complete the online questionnaire. To mask the study purpose, participants were told that they took part in two different studies: one on media and physiological measures, and the other on preferences and personality. The online questionnaire therefore consisted of two blocks with questions, including filler questions congruent with the cover story. In this questionnaire eating restraint and PSRS were assessed, as well as several participant characteristics (i.e., BMI, age, educational level).

Based on the results of the online questionnaire ($N = 457$), female participants with low and high scores on eating restraint were selected for the lab session. We invited participants who scored at least 1 *SD* below (score ≤ 10) or 1 *SD* above (score ≥ 17) the mean of eating restraint, based on the results of the female participants of the first fifty participants who completed the questionnaire. With the full sample of participants who completed the online questionnaire, calculating 1 *SD* below and above the mean of eating restraint led to the same cut-off scores. This procedure of inviting people scoring either low or high on eating restraint was followed to enable a clear distinction between restrained and unrestrained eaters, because in a previous study with a similar sample it was observed that many participants scored around the midpoint of the scale (Alblas, Mollen, Fransen, & van den Putte, 2019).

The lab session took place at least one day after completion of the online questionnaire. All participants were individually tested. To minimize the potential influence of time of the day, participants were only tested in the afternoon (between 12 h and 18 h). Time of the day did not influence visual attention nor unhealthy food intake (all $ps > .10$). Further, participants were not allowed to eat 2 h before taking part in the lab session. Upon arrival in the lab, participants were again told they participated in two separate studies in line with the cover story. They first completed a short questionnaire in which hunger was assessed. Then they watched a TV segment including palatable food cues, during which participants' eye-movements were measured. After viewing the segment, participants rated the entertainment level of the segment and their familiarity with the TV show. Next, participants were told they finished the first study, and that they would now continue with the second study on preferences and personality, which took place in a separate part of the room. They first completed two short filler tasks (i.e., indicating preferences for shapes and colors) and then took part in the taste test. Lastly, participants completed a short questionnaire to assess whether they were aware of the study goal. Excluding participants who showed insight in the study goal ($n = 2$) did not change the conclusion regarding significance of any of the hypotheses (tested at $p < .05$), therefore these participants were retained in the dataset.

2.3. TV content

During the lab session, participants watched an 8-min segment of a

Dutch TV talk show called *Life 4 You*. Throughout the segment, several types of palatable, but unhealthy foods (e.g., cakes, salty snacks, profiteroles) were displayed on the table at which the talk show hosts and their guests were seated. Nobody in the TV show explicitly talked about the displayed food or food in general, nor ate food during the segment.

2.4. Measures

Eating restraint. Eating restraint was measured in the online questionnaire using the Concern for Dieting subscale of the Restraint Scale (Jansen, Oosterlaan, Merckelbach, & van den Hout, 1988). This scale includes six items, such as 'How conscious are you of what you are eating?' (1 = *not at all*, 4 = *extremely*) and 'How often are you dieting?' (1 = *never*, 5 = *always;* α = 0.90). The possible range of the scale is 6–25. The mean score was 9.29 (*SD* = 1.00) among unrestrained eaters and 19.21 (*SD* = 2.11) among restrained eaters.

PSRS. PSRS was measured with three items: 'How successful are you in losing weight?' (1 = *not successful*, 7 = *very successful*), 'How successful are you in watching your weight?' (1 = *not successful*, 7 = *very successful*), and 'How difficult do you find it to stay in shape?' (1 = *not difficult*, 7 = *very difficult*, reversed coding; Fishbach et al., 2003). The mean score was 4.41 (*SD* = 1.27, α = 0.72).

Visual attention. Visual attention was measured with eye-tracking, which is the most direct measure of visual attention (Field, Munafò, & Franken, 2009). Participants' eye movements were recorded during the entire segment at a sampling rate of 120 Hz per second. An SMI RED eye-tracker was attached to a computer screen with a resolution of 1680 × 1050 pixels. Participants were seated at approximately 60 cm from the computer screen, and they were asked to place their chin on a chin rest while watching the TV show to minimize head movements during recording. Before starting the data collection, the area of interest (AOI) "food" was defined by determining the location of the food cues for every frame of the TV segment. The AOI was visible for 55% of the total TV segment. Participants' eye-movements on the AOI were automatically coded as visual attention, and more specifically, two measures of visual attention were assessed. The first was initial orientation, measured as the time in milliseconds (ms) between the first appearance of food in the TV segment and the first fixation of the participant on the AOI. A short time to the first fixation reflected a fast initial orientation to the food cues (Danner et al., 2016). Second, attention duration was measured with the total fixation time, which is the sum of the duration of all fixations on the AOI in ms (van der Laan et al., 2015). A long total fixation time reflected a long attention duration. A fixation was defined according to the default values of the SMI eye-tracking software, with a minimum duration of 80 ms at which the participants' eyes stayed within a window of 100 pixels at maximum. In the analyses, initial orientation and attention duration were converted to seconds (s). On average, participants first fixated on the food after 10.56 s (*SD* = 11.42) and had a total mean fixation time of 13.06 s (*SD* = 6.00).

Unhealthy food intake. To measure unhealthy food intake, participants took part in an alleged taste test. Participants were asked to taste and evaluate four unhealthy foods (i.e., M&Ms, chocolate chip cookies, salty crackers, crunchy peanuts) and four healthy foods (i.e., tangerines, grapes, cherry tomatoes, cucumber slices; cf. Mollen, Holland, Ruiter, Rimal, & Kok, 2016). Including both unhealthy and healthy foods fitted the cover story about food and taste preferences, but for the analyses only the data of unhealthy food intake was used. Participants were told they could taste as much as they liked for 10 min, while they rated each of the snacks and indicated their preferences. The experimenter left the room during the taste test. Unhealthy food intake was measured in grams by deducting the weight of each of the bowls with unhealthy snacks after the taste test from the weight before the taste test. For the analyses, intake in grams was subsequently converted to kilocalories (kcal) because this is more insightful in terms of implications for one's diet and weight (e.g., eating 100 g of cucumber slices has far less caloric value compared to 100 g of cookies). On average, participants consumed 186.55 calories from unhealthy foods (*SD* = 97.89).

Participant characteristics and control variables. Participants were asked to report their age, education level, body height, and weight. BMI was calculated afterwards as weight in kilograms divided by height in meters squared. In addition to these participant characteristics, we also assessed hunger before watching the TV segment, participants' familiarity with and liking of the TV show in general, as well as how entertaining participants found the TV segment (Edwards, Li, & Lee, 2002).

Additionally, we measured several other operationalizations of restrained eating and dieting success (e.g., the Brief Self-Control Scale instead of PSRS; Tangney, Baumeister, & Boone, 2004). We also added several recall questions to check whether participants paid attention to the content of the TV show and whether they were consciously aware of the presence of food in the show. However, these additional measures were assessed for exploratory purposes and did not lead to different conclusions, so they are not further discussed.

2.5. Analyses

Initial checks showed that, after excluding two participants causing high values of skewness and kurtosis on initial orientation of visual attention (see 'Participants' section), the data met the assumptions for parametric statistics. Correlation analyses were then performed to check for the influence of participant characteristics and control variables on visual attention and unhealthy food intake.

A power calculation in G*Power for linear multiple regression with a medium effect size of F^2 = 0.15 as our smallest effect size of interest (based on previous research reporting medium to large effect sizes; Meule, Vögele, et al., 2012; Papies et al., 2008a), α of 0.05 and power of .80 resulted in a required sample size of N = 68. Power is likely higher in the current study because of our sampling method of only selecting participants with extreme scores (−1 *SD* or +1 *SD* on the eating restraint scale; (Meyvis & van Osselaer, 2018). Our final sample size of N = 62 should therefore be sufficient to test the proposed hypotheses. It should be noted that the relationships depicted in Fig. 1 also suggest a mediation analysis to test whether the interaction between eating restraint and PSRS on unhealthy food intake was mediated by attention duration. However, a power analysis for mediation (Schoemann, Boulton, & Short, 2017) showed that our sample size was too low for detecting a mediation. We therefore decided to not perform the mediation analyses.

To test the hypotheses, we used PROCESS as a macro in SPSS (Hayes, 2013) and multiple linear regression. First, in PROCESS, a moderation model (number 1) was tested with eating restraint (restrained vs. unrestrained) as the independent variable, PSRS as continuous moderator, and initial orientation as the dependent variable. A second model was tested with attention duration as the dependent variable. Third, a multiple linear regression model was tested with initial orientation and attention duration as the independent variables and unhealthy food intake as the dependent variable. This way, it could be tested whether eating restraint predicted initial orientation to food cues (H1), whether the interaction between restrained eating and PSRS predicted attention duration (H2a), and whether attention duration predicted unhealthy food intake (H2b). Additionally, with these models, the relations which were expected to be non-significant could also be tested (i.e., the interaction between eating restraint and PSRS on initial orientation, and the relationship between initial orientation and unhealthy food intake). Hunger was included as covariate in all analyses because it was related to other variables in the model (see 'Results' section). All predictors were mean centered in the analyses (Aiken & West, 1991).

3. Results

3.1. Influence of participant characteristics and control variables

To check for potential confounding variables, the relationships between participant characteristics, control variables and visual attention (i.e., initial orientation and attention duration) as well as unhealthy food intake were examined. Age, BMI, entertainment level of the TV segment, and familiarity with and liking of the TV show were not related to initial orientation, attention duration, and unhealthy food intake (all $ps > .10$). However, hunger was (marginally) significantly related to attention duration ($r = 0.22$, $p = .086$) and to unhealthy food intake ($r = 0.28$, $p = .026$), indicating that participants fixated longer on the food cues and consumed more unhealthy foods if they were hungrier. Hunger was therefore included as covariate in the analyses. The analyses were also conducted without including hunger as a covariate but this did not change the conclusion regarding significance of any of the hypotheses (tested at $p < .05$).

3.2. Initial orientation of visual attention

The regression model for predicting initial orientation of visual attention was significant, $F(4, 57) = 3.98$, $p = .006$, $R^2 = .22$. However, restrained eaters showed no faster initial visual orientation to the food cues compared to unrestrained eaters, $B = 4.75$, $SE = 2.86$, $t = 1.66$, $p = .103$, *95% CI* [−0.98, 10.48]. H1 was therefore not supported. Initial orientation was also not predicted by PSRS, $p = .862$ (please find an overview of all statistics in the Supplementary Material). Unexpectedly, the interaction between eating restraint and PSRS was significant, $B = 7.69$, $SE = 2.36$, $t = 3.26$, $p = .002$, *95% CI* [2.97, 12.41], and this interaction significantly improved prediction of the model ($\Delta R^2 = 0.15$, $p = .002$). To explore this significant two-way interaction, simple slopes were estimated at low (−1 *SD* from the mean) and high (+1 *SD* from the mean) levels of PSRS for restrained eaters and unrestrained eaters separately. Among restrained eaters, initial orientation was predicted by PSRS, $B = 4.42$, $SE = 1.58$, $t = 2.79$, $p = .007$, *95% CI* [1.25, 7.59]. Unsuccessful restrained eaters fixated faster on the food cues compared to successful restrained eaters (see Fig. 2). Among unrestrained eaters, initial orientation was marginally significantly predicted by PSRS, $B = -3.27$, $SE = 1.69$, $t = -1.94$, $p = .058$, *95% CI* [−6.65, 0.11], and in the opposite direction: successful unrestrained eaters fixated faster on the food cues compared to unsuccessful unrestrained eaters.

3.3. Duration of visual attention

The regression model for predicting attention duration was not significant, $F(4, 57) = 1.29$, $p = .284$, $R^2 = .08$. In contrast to H2a, unsuccessful restrained eaters did not show a longer duration of visual attention to food cues compared to successful restrained eaters, as the interaction between eating restraint and PSRS on attention duration was not significant, $B = -1.89$, $SE = 1.34$, $t = -1.41$, $p = .164$, *95% CI* [−4.58, 0.80]. In addition, attention duration was also not predicted by eating restraint, $p = .663$, nor by PSRS, $p = .953$.

3.4. Unhealthy food intake

The regression model for predicting unhealthy food intake was marginally significant, $F(3, 58) = 2.60$, $p = .061$, $R^2 = .12$. In contrast to H2b, a longer duration of visual attention to the food cues did not predict unhealthy food intake, $B = 0.38$, $SE = 2.13$, $t = 0.18$, $p = .859$, *95% CI* [−3.88, 4.63]. No relationship between initial orientation to the food cues and unhealthy food intake was found either, $p = .139$.

Additional analyses were conducted to test whether unhealthy food intake was predicted by eating restraint and PSRS, independent of visual attention. This regression model was marginally significant, $F(4, 57) = 2.30$, $p = .070$, $R^2 = .14$. Unhealthy food intake was not predicted by eating restraint, $p = .816$, nor by PSRS, $p = .290$. However, the interaction between eating restraint and PSRS was marginally significant, $B = -36.73$, $SE = 21.22$, $t = -1.73$, $p = .089$, *95% CI* [−79.21, 5.76] and marginally improved the model ($\Delta R^2 = 0.05$, $p = .089$). Simple slopes estimated at low and high levels of PSRS for restrained and unrestrained eaters separately showed an unexpected pattern: among restrained eaters, unhealthy food intake was not predicted by PSRS, $B = -9.10$, $SE = 14.25$, $t = -0.64$, $p = .526$, *95% CI* [−37.62, 19.43]. Among unrestrained eaters, however, unhealthy food intake was marginally predicted by PSRS, $B = 27.63$, $SE = 15.20$, $t = 1.82$, $p = .074$, *95% CI* [−2.80, 58.06]: successful unrestrained eaters consumed more calories from unhealthy food compared to unsuccessful unrestrained eaters.

4. Discussion

The goal of this study was to explain why and for whom food-related TV content influences unhealthy food intake. To this end, it was investigated whether unsuccessful restrained eaters showed heightened visual attention to food cues and whether visual attention to these cues predicted subsequent food intake. To our knowledge, this study was the

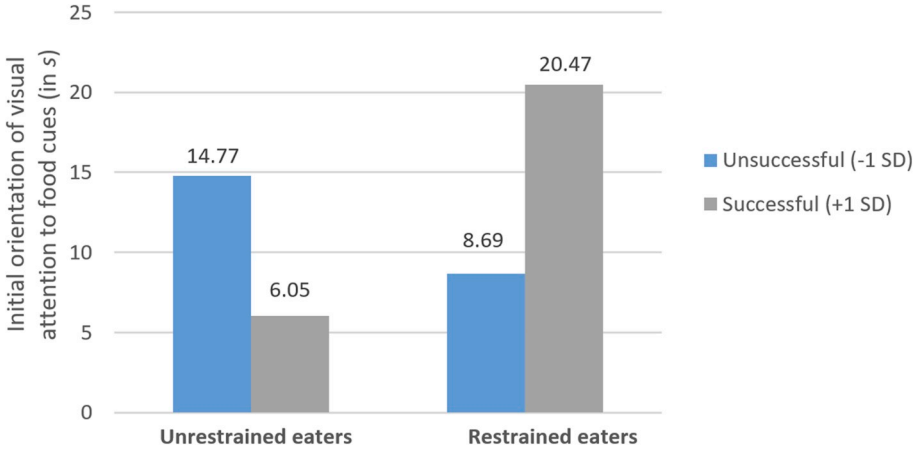

Fig. 2. Initial orientation of visual attention (in *s*) to food cues in the TV show among unrestrained and restrained eaters at low (−1 *SD*) and high (+1 *SD*) levels of perceived self-regulatory success (PSRS).

first to examine the relationship between visual attention and food intake in adults using food cues embedded in actual media content (i.e., a TV show). It was also the first to distinguish between two types of restrained eaters (i.e., successful and unsuccessful) in research on visual attention to food cues. In addition, in contrast to most studies on visual attention to food cues, this study distinguished between two measures of visual attention: initial orientation and attention duration.

Our first aim was to predict visual attention to palatable food cues on TV and examine the role of eating restraint and self-regulatory success in this. It was expected that the food cues would automatically attract attention of all restrained eaters because food-related information is relevant for them (Connor et al., 2004; Higgs et al., 2012). However, restrained eaters did not show faster initial visual orientation to the palatable food cues on TV compared to unrestrained eaters, but an interaction between eating restraint and PSRS was found. This unexpected finding will be discussed later. In contrast to initial orientation, attention duration was expected to be influenced by self-regulatory strategies (Junghans et al., 2015). It was therefore hypothesized that self-regulatory success would moderate the relationship between eating restraint and attention duration. In contrast to these expectations, however, no evidence was found for a longer duration of visual attention among unsuccessful restrained eaters compared to successful restrained eaters. Our second aim was to investigate whether attention duration predicted subsequent unhealthy food intake. No evidence for this was found either. Instead, an additional analysis showed there was an unexpected trend among successful unrestrained eaters to eat more unhealthy food, but this was unrelated to visual attention.

The results are inconsistent with previous empirical research showing that attention duration predicts food intake (Armel et al., 2008; Junghans et al., 2015; van der Laan et al., 2017; Werthmann et al., 2014). However, the results corroborate findings from another study in which no differences were found between obese and normal-weight participants – who differ in self-regulatory success (Meule, Lutz, Vögele, & Kübler, 2012) – on attention duration (Nijs, Muris, Euser, & Franken, 2010). Furthermore, in the same study no relationship between attention duration and unhealthy food intake was found. In addition to this study that did not find significant results using food pictures of words, in our study no significant results were found with actual media content.

Unexpectedly, unsuccessful restrained eaters had a faster initial orientation to food cues compared to successful restrained eaters. This fast initial focus of unsuccessful restrained eaters – and not all restrained eaters – on food cues suggests that self-regulation may already be important at early stages of visual attention. For successful restrained eaters, simply the presence of food cues may have already been sufficient to automatically trigger their self-regulatory strategies, preventing themselves from focusing on the food cues and thereby from the potential consequences of attending to these cues. In future research, it should be explored how self-regulation plays a role in early detection of food cues.

An alternative explanation for unsuccessful compared to successful restrained eaters' fast focus on food cues may be that they were more easily attracted to all cues in the TV show that were not central to the talk show (i.e., the talk show hosts and the guests), and therefore fixated on all non-central cues faster instead of only the food cues. This could be explained by the more impulsive nature of unsuccessful, compared to successful restrained eaters (van Koningsbruggen, Stroebe, & Aarts, 2013). However, this explanation seems unlikely, because repeated impulsive attention to food cues would also result in a longer duration of attention for unsuccessful restrained eaters compared to successful restrained eaters, which was not found.

Despite unsuccessful restrained eaters' quick initial orientation to food cues, they did not show a longer duration of attention to these cues compared to successful restrained eaters. A potential explanation for this finding is that unsuccessful restrained eaters, after initially looking at the food cues, avoided these cues in an attempt to stick to their diet – and evidently succeeded in these attempts. This may seem contradictory, because unsuccessful restrained eaters are thought to have little self-regulatory resources to avoid food cues (Fishbach et al., 2003). However, this may be explained by the way food cues were presented in the current study. In previous studies on visual attention where food pictures or words were used, it was difficult for the participants to distract themselves from tempting food cues because looking at the food cues was part of the task. However, in the current study where the food cues were embedded in a TV show, one may look at the people in the show and listen to their conversations instead of looking at the food cues. Since avoiding tempting food cues may be much easier when exposed to the TV show compared to food pictures or words, less self-regulatory resources may be needed and therefore, unsuccessful restrained eaters may also be able to successfully avoid a long duration of attention to the food cues.

The differences between isolated food pictures or words compared to food cues in actual media content may also explain why attention duration did not influence food intake. Because there were not only other visual cues (e.g., people), but also other types of information such as auditory cues that had to be processed in addition to the visual cues, it is likely that people generally had little attention left to spend on the food cues. Variation in attention duration may have been too small (SD = 6.00 s, while the food was visible for more than 4 min) to explain variation in actual food intake.

Whether it is goal-directed distraction from the food cues or simply the presence of other cues leaving less resources to attend the food cues, the availability of non-food related cues in the TV show may have resulted in weaker influences of food cues embedded in media content compared to isolated food pictures or words. This may be interpreted as an effect of cue salience. In support of this, previous studies that experimentally manipulated cue salience found that more salient food cues resulted in more craving and unhealthy food intake compared to less salient food cues (Coelho, Jansen, Roefs, & Nederkoorn, 2009; Coelho, Nederkoorn, & Jansen, 2014). Future research could directly compare both types of cues (i.e., isolated food cues vs. food cues in media content) to see whether this explanation holds true. Furthermore, it may be useful to also study other types of TV content in which food cues are more prominent and harder to avoid than in a talk show, such as cooking shows or food commercials. Higher levels of self-regulation may be needed to counter the influences of such food cues.

The findings of this study lead to at least two recommendations for future research on visual attention to food cues. First, it is important to distinguish between successful and unsuccessful restrained eaters, as initial orientation to food cues depended on self-regulatory success in restrained eating. These findings thereby also provide some explanation for the inconsistencies in evidence for heightened visual attention to food cues in restrained eaters (Werthmann et al., 2015). Second, because no such differences were found for attention duration, this study again confirms that visual attention has multiple components (Hollitt et al., 2010; Junghans et al., 2015). Reaction times, which are often used to measure attention to food, are less able to distinguish between these components which could also partly account for inconsistencies in previous research on attention (Werthmann et al., 2015). Eye-tracking measures should therefore be used to capture these different components (Field et al., 2009).

The current study has several limitations that should be addressed in future research. First, since no experimental design was used, we cannot draw causal inferences about food intake. As the main goal of this study was to investigate the influence of visual attention to food cues, it was found less useful to include a non-food condition in which attention to food cues was not possible. Future research could include a TV show without food cues and experimentally investigate whether food on TV increases unsuccessful restrained eaters' food intake. In such a study, food intake could also be measured in a more naturalistic way by allowing people to freely eat snacks *during* watching the TV show, instead of afterwards in a taste test. This was not possible in the current

study due to the eye-tracking measurement during watching.

Second, with the final sample size, power was too low to perform a mediation analysis to test whether the interaction between eating restraint and PSRS on unhealthy food intake was mediated by attention duration. We obtained a relatively small sample size because we only recruited people with extreme scores on the restrained eating scale. This did allow us, however, to really differentiate between restrained and unrestrained eaters. Such a differentiation is important, particularly when also distinguishing successful and unsuccessful restrained eaters. People who define themselves as successful self-regulators are more likely unrestrained eaters, so without a clear differentiation between restrained and unrestrained eaters people defined as successful restrained eaters may actually be those who are rather unconcerned with their weight and dieting (Nguyen & Polivy, 2014). Nonetheless, in future research a larger sample size should be aimed for. This way, the mediation via visual attention could be tested which may provide better understanding of the processes underlying the relationship between exposure to food on TV and unhealthy food intake.

Third, external validity could be improved by investigating effects among male participants as well. We now only recruited female participants because we found that sex highly correlated with eating restraint and we did not want this to confound our results. However, as men respond differently to food cues than women (e.g., Anschutz, Engels, van der Zwaluw, & van Strien, 2011), the study should be replicated among male participants. In addition, our sample consisted of mostly healthy-weight participants, even those who reported to be restrained eaters. Results of the current study are therefore not generalizable to the overweight population, and this study should be replicated with a sample of overweight or obese participants to explore whether this results in similar findings.

5. Conclusions

The goal of this study was to investigate why and for whom exposure to palatable, unhealthy food cues on TV may predict subsequent unhealthy food intake. Unsuccessful restrained eaters, compared to successful restrained eaters, show a faster initial visual orientation to palatable food cues in a TV show but do not show a longer duration of attention to these cues. This suggests that self-regulation is already important at early stages of visual attention. In sum, the results of this research show the need to distinguish between different components of visual attention to food cues, as well as between different types of restrained eaters.

Funding

Funding for this work was provided by the Graduate School of Communication of the University of Amsterdam. The funding source had no involvement in any aspect pertinent to the study.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2019.104574.

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