



## Research report

# Desire lies in the eyes: Attention bias for chocolate is related to craving and self-endorsed eating permission <sup>☆</sup>



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## ABSTRACT

The present study tested the impact of experimentally manipulated perceived availability of chocolate on attention for chocolate stimuli, momentary (state) craving for chocolate and consumption of chocolate in healthy weight female students. It was hypothesized that eating forbiddance would be related to attentional avoidance (thus diminished attention focus on food cues in an attempt to prevent oneself from processing food cues) and that eating motivation would be related to attentional approach (thus maintained attentional focus on food cues). High chronic chocolate cravers ( $n = 40$ ) and low cravers ( $n = 40$ ) participated in one of four perceived availability contexts (required to eat, forbidden to eat, individual choice to eat, and 50% chance to eat) following a brief chocolate exposure. Attention for chocolate was measured using eye-tracking; momentary craving from self-report; and the consumption of chocolate was assessed from direct observation. The perceived availability of chocolate did not significantly influence attention allocation for chocolate stimuli, momentary craving or chocolate intake. High chocolate cravers reported significantly higher momentary craving for chocolate ( $d = 1.29, p < .001$ ), and showed longer initial duration of gaze on chocolate, than low cravers ( $d = 0.63, p < .01$ ). In contrast, participants who indicated during the manipulation check that they would not have permitted themselves to eat chocolate, irrespective of the availability instruction they received, showed significantly less craving ( $d = 0.96, p < .01$ ) and reduced total dwell time for chocolate stimuli than participants who permitted themselves to eat chocolate ( $d = 0.53, p < .05$ ). Thus, this study provides evidence that attention biases for food stimuli reflect inter-individual differences in eating motivation, – such as chronic chocolate craving, and self-endorsed eating permission.

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## Introduction

Attention biases for food cues have been studied extensively in the last decennia (see e.g., for a review Brooks, Prince, Stahl, Campbell, & Treasure, 2011). An attention bias refers to selective information processing that favours personally salient/relevant information (e.g., food stimuli) over neutral information (MacLeod, Mathews, & Tata, 1986). One unresolved issue is the extent to which attention bias for food cues reflects motivation for food (e.g., eating allowance, (over)eating, craving) and/or a current concern about food (e.g., eating forbiddance, cognitive restraint, trying to avoid food intake) (e.g., Brooks et al., 2011; Dobson & Dozois, 2004; Nijs, Franken, & Muris, 2010). Therefore, the aim of this study is to clarify the role of eating motivation and eating forbiddance in determining cognitive, subjective and behavioural responses to desirable food, by studying the effect of chronic

chocolate craving, and an experimentally controlled manipulation of food availability (i.e., being required to eat chocolate versus being forbidden to eat chocolate) on attentional bias for food, momentary craving, and food intake.

On the one hand, eating disorder patients (ED), that is, individuals who are concerned with eating and obsessed with weight loss (i.e., high “eating forbiddance”), showed elevated attention biases for (high caloric) food stimuli in comparison to healthy controls (for a review see Brooks et al., 2011). For example, a broad range of evidence on the food Stroop task shows an interference effect for food words in eating disorder patients when compared to healthy control participants (Dobson & Dozois, 2004; Lee & Shafan, 2004), however the direction of the attention process (attentional avoidance versus attentional approach) cannot be specified by means of the Stroop task. The direction of an attention bias is important, though, because knowing whether ED patients show an attention bias towards or away from food cues could have important theoretical and clinical implications.

However, also in studies using paradigms that are capable to distinguish attention components, evidence on the direction of this attention bias is mixed. In one study ED-patients showed increased

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distraction specifically for high caloric food words but not low caloric food words during a visual search task, which was interpreted as attention bias towards food cues (i.e., attentional approach) (Smeets, Roefs, van Furth, & Jansen, 2008). In contrast, two studies using pictorial food stimuli reported that ED patients, in comparison to healthy control participants or remitted ED patients expressed significantly negative attention bias scores for (positive) eating related pictures as measured by response latency recordings during a dot-probe task. Thus, ED patients diverted their attention away from food cues (i.e., attentional avoidance) (Shafraan, Lee, Cooper, Palmer, & Fairburn, 2007, 2008). Evidence from attention research in nonclinical populations suggests that dieting and restrained eating might also lead to elevated attention processes towards (or away from) food cues (Boon, Vogelzang, & Jansen, 2000; Brooks et al., 2011; Dobson & Dozois, 2004). Restrained eaters are preoccupied with their food intake and their weight (Jones & Rogers, 2003; Timmerman & Gregg, 2003; Wardle, 1987). Their constant struggle to adhere to their dieting rules could be reflected in biased processing of (high caloric) food cues (Higgs, Rutters, Thomas, Naish, & Humphreys, 2012; Tiggemann & Kemps, 2005). However, empirical evidence for attention biases for food in restrained eaters versus healthy controls remains also inconclusive. Specifically, the direction of the attention bias is not clear yet. One study (Veenstra, de Jong, Koster, & Roefs, 2010) used a paradigm that could distinguish between attentional approach and avoidance processes, and found evidence for an association of restrained eating scores and attentional avoidance (more disengagement from high-fat foods), whereas other studies provided evidence that restrained eaters show increased attention biases towards food stimuli when compared to unrestrained eaters (Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010; Meule, Vögele, & Kübler, 2012), or did not find significant differences in attention biases for food in unrestrained and restrained eaters (Ahern, Field, Yokum, Bohon, & Stice, 2010; Boon et al., 2000). Thus, even though evidence is mixed, research from ED patients and restrained eaters seems to suggest that (extreme) eating forbiddance might be related to differences in attention for food, yet the direction of this effect is unclear.

On the other hand, research on attention allocation in obese and overweight populations suggests that attention biases for food are related to craving, overeating and BMI. According to the theory of incentive salience, food cues can acquire motivational properties through a conditioning process: because food cues predict the rewarding experience of eating they can become salient stimuli in the environment, and are then capable of “grabbing” attention, which in turn elicits (conditioned) approach behaviour, such as craving and (over)eating of high caloric food (Berridge, 1996, 2009; Nijs & Franken, 2012). Thus, theoretically, attention biases for craved appetitive stimuli, such as drugs or palatable foods, have a potential role in maintaining a pattern of overconsumption (Berridge, 1996, 2009; Field, Munafó, & Franken, 2009; Franken, 2007; Robbins & Ehrman, 2004). Accordingly, studies have demonstrated selective processing of food cues in overweight/obese individuals when compared to healthy weight controls. Some studies found evidence for an attention bias towards high caloric food stimuli in the direction and duration of gaze for food versus neutral stimuli in obese but not in healthy weight participants when fed (Castellanos et al., 2009), and an attention bias in initial orientation towards food versus neutral stimuli in overweight or obese participants (Nijs et al., 2010; Nijs, Muris, Euser, & Franken, 2010). However, others report an approach-avoidance reaction (initially focussing on high caloric food followed by attentional avoidance in later stages of processing) in overweight participants (Werthmann et al., 2011).

Taken together, results suggest that there is evidence that attention biases for food cues are related to overweight and obesity

(associated with craving and intake of high-fat foods; i.e. high “eating motivation”), possibly apparent in attentional approach of food, as well as to (extreme) restrained eating (thus eating forbiddance in eating disordered patients and restrained eaters), possibly apparent in attentional avoidance of food. It is difficult to draw firm conclusions from previous research though, as body weight and restraint are typically confounded (e.g. Johnson, Pratt, & Wardle, 2011; Snoek, van Strien, Janssens, & Engels, 2008; Werthmann et al., 2013). Moreover, it is not always clear whether the observed effects reflect attentional approach or avoidance. One difficulty regarding the results of former studies is the use of different paradigms and methods to assess attention bias for food, which might have contributed to the inconsistency of previous results. More specifically, variation in the type of target (e.g., high caloric food or different food stimuli) and the contrast category may have led to inconsistencies (Forestell, Lau, Gyurovski, Dickter, & Haque, 2012; Werthmann et al., 2011). Recently, a meta-analysis concluded that the most direct and immediate measure for (visual) attention biases is eye tracking technology (Field et al., 2009). A further advantage of eye tracking is that the direction of attention, thus attention avoidance or attentional approach, can also be directly assessed. Therefore, concurrent recordings of eye movements during a visual probe task were used in the current study to determine the effect of food availability contexts on attention processing.

The current study tried to systematically disentangle the effects of eating motivation and eating forbiddance (as a proxy for (extreme) dietary restraint) on attention bias for food, using an eye-tracking paradigm that can distinguish between attentional approach and attentional avoidance processes. In this study we selected “chocolate” as the target food, as it is both craved and seen as “forbidden” (Hetherington & Macdiarmid, 1993; Kemps & Tiggemann, 2009; Rodin, Mancuso, Granger, & Nelbach, 1991), and tested how the expectancy of imminent chocolate consumption influenced attention bias for chocolate. Similarly, previous research testing whether food expectancies influence cognitive performance also used chocolate as target food (Higgs, 2007).

The main research question concerned whether the manipulation of eating expectancy within four availability contexts (required to eat, forbidden to eat, individual choice, or chance) modulates attention bias for chocolate cues, and affects craving and chocolate intake. Participants who expected to be required to eat chocolate were hypothesized to show attention biases towards chocolate cues (i.e., attentional approach), whereas participants who expected that they were forbidden to eat chocolate were hypothesized to show attention biases away from food (i.e., attentional avoidance), both in comparison to participants who could choose for themselves or who expected a 50% chance to eat chocolate. Participants in those conditions were hypothesized to show an approach-avoidance pattern of attention allocation towards chocolate stimuli (e.g., first directing attention towards chocolate but then reduced maintained attention on chocolate), because of an ambivalence conflict between temptation and self-control. Craving and consumption were supposed to be affected in the same direction as the attention biases for each condition.

To account for possible effects of individual differences in the intrinsic motivational salience of chocolate that might interfere with the effectiveness of our availability manipulation, we tested this objective in high chronic chocolate cravers compared to low cravers. Chronic chocolate craving was thought to be related to an attention bias towards chocolate cues because previous research has indicated that high chocolate cravers showed more pronounced subjective, physiological and hedonic (as marked by elevated event-related potentials in the anterior frontal scalp) reactivity when viewing chocolate images in comparison to low cravers (Asmaro et al., 2012; Rodríguez, Fernández, Cepeda-Benito,

& Vila, 2005). In addition, a manipulation check asking participants about their self-endorsed eating permission was included to account for the possibility that participants did not internalize the experimental manipulation instructions.

## Method

### Participants

A total of 80 female undergraduate students participated in this study. Participants were recruited via flyers, an online recruitment system and via advertisements on the university campus. Only female participants were included to obtain a homogeneous sample and to ensure comparability to previous studies on (chocolate) eating behaviour (e.g., Higgs, 2007; Kemps & Tiggemann, 2009). For the purpose of our study participants were categorized as either high chronic chocolate cravers or low cravers based on a median split ( $Mdn = 39.91$ ) on a trait measure for chocolate craving: the subscale “chocolate craving” of the Attitude to Chocolate Questionnaire (Benton, Greenfield, & Morgan, 1998). See Table 1 for participant characteristics.

### Materials and procedure

#### Craving exposure

To ensure that all participants regarded chocolate, at least momentarily, as “desirable” food item, a chocolate exposure, focusing on palatable features of chocolate, was conducted at the start of the experimental session. Participants were instructed to smell a piece of chocolate (of their choice from a bowl filled with different pieces of chocolate) intensively for 3 min. During this time participants were encouraged to indulge in the experience of their craving by concentrating on different sensual aspects, such as smell and texture of the chocolate pieces, without tasting it. A booster for chocolate craving with a shorter (1 min) similar exposure to chocolate was inserted in a short break during the attention paradigm (i.e. the visual probe task).

#### Manipulation of eating expectancy

Perceived eating opportunity was manipulated in four conditions and participants were randomly, with the restriction of equal group sizes, assigned to one of these conditions. Participants received one of the following instructions: (1) consumption is required (required), (2) consumption is not allowed (forbidden), (3) you can choose whether you want to eat chocolate (choice), or (4) consumption is determined by the roll of a dice (chance).

## Pictorial visual probe paradigm

### Overview

Attention allocation towards chocolate was measured with a visual probe task. During this task two image pairs were presented simultaneously side by side followed by a probe (\*) appearing in the location of one of the images. Participants were instructed to respond as quickly as possible by pressing a corresponding key on a button box to indicate the location of the probe (response latency was registered), while their eye movements during the stimulus presentation were measured, as a direct measure of attention allocation. The complete task was divided into 2 blocks of 60 trials each (total of 120 trials). A break was inserted between these blocks, in which participants were again exposed to the smell of chocolate and the respective instruction. The task included 80 critical trials and 40 filler trials.

### Timing trials

Each trial started with a central fixation cross, which remained on the screen for 100 ms when participants focussed on the cross. Subsequently, the target image pair was presented for 3000 ms. Then the probe, (\*), was presented until the participant responded by pressing a key on the button box.

### Trial types

Critical trials consisted of 20 stimulus pairs, which were each presented four times. In critical trials, the image pair consisted of a picture of a chocolate item and a picture of a musical instrument. Music instruments were used to obtain a close match of colour (mostly brownish for chocolate items and music instruments alike). Filler trials consisted of 10 stimulus pairs, which were also each presented four times. Filler trials consisted of picture pairs depicting two neutral non-food photographs (office supplies and traffic objects). All image pairs were matched as closely as possible with regard to colour, complexity, brightness, and size. The position of the probe was equally distributed per stimulus type and equally often on then left and right side of the screen. The order of trials was randomized uniquely for each participant.

### Eye movement measurements

Eye movements were recorded by a desktop mounted EyeLink 1000 system (SR Research Ltd., Mississauga, Ontario, Canada). A 9-point calibration with subsequent validation procedure was conducted prior to the visual probe paradigm. To assess attention allocation processes, participants' gaze fixations were analysed. Gaze fixations were defined as any period that is not a blink or saccade

**Table 1**  
Descriptive of Sample Characteristics.

Participant characteristics	Overall		Craving status				Self-endorsed eating permission			
	Total sample ( <i>N</i> = 80)		High chocolate cravers ( <i>n</i> = 40)		Low chocolate cravers ( <i>n</i> = 40)		Lack of permission ( <i>n</i> = 20)		Permission ( <i>n</i> = 60)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Trait chocolate craving (ACQ)	39.67	17.48	53.83 <sup>a</sup>	10.17	25.51 <sup>a</sup>	10.23	34.75	15.17	41.31	18.01
Last chocolate consumption (hr)	40.79	51.49	25.70 <sup>a*</sup>	27.51	57.38 <sup>a*</sup>	65.50	55.59	83.57	35.74	34.57
Average chocolate consumption per week (cal)	202.36	172.62	239.67 <sup>*</sup>	169.66	150.14 <sup>*</sup>	166.99	153.27	129.87	216.96	182.39
Dietary Restraint (RS)	11.69	3.33	12.22	3.56	11.16	3.03	10.45 <sub>b</sub>	4.03	12.10 <sub>b</sub>	2.98
BMI	22.20	1.79	22.25	1.86	22.16	1.73	22.34	1.97	22.15	1.74

Note. ACQ = Attitudes to Chocolate Questionnaire; RS = Restraint Scale; BMI = Body Mass Index.

Superscript letter (a) indicates differences between high chronic chocolate cravers and low cravers at  $p < .05$ .

Subscript letter (b) indicates a trend for a significant differences between participants with and without self-endorsed eating permission ( $p = .054$ ).

\* Comparison based on  $df = 61$ , because fifteen participants did, by mistake, not receive these questions. Three participants did not answer the question regarding the time of their last chocolate consumption, suggesting that they either never ate chocolate or could not answer the question.

+ Comparison based on  $df = 46$ , because fifteen participants did, by mistake, not receive these questions. 17 participants did not answer the question regarding their average consumption, suggesting that they either never ate chocolate or could not answer the question.

and lasted at least 100 ms (Eyelink Dataviewer User's Manual, 2002–2008, SR Research Ltd.). Eye movements that occurred before the presentation of an image pair were excluded, because these movements could represent anticipatory fixations.

For analyses purposes, the computer screen was, invisible for participants, divided in three areas of interest: the mid-section, which indicates the location of the fixation cross, and the left and right section, representing the locations of the picture stimuli. Only eye movements in critical trials directed either to the left or the right section of the screen were extracted for further analyses. Eye movements in filler trials and gaze fixations in the mid area were excluded from further analyses. Eye movements were extracted using Data Viewer (SR Research Ltd., Mississauga, Ontario, Canada).

#### Attention bias scores

Three attention bias scores were derived from the eye movement data: gaze direction bias, initial gaze duration bias and dwell time bias.

A gaze direction bias is described as a measure for initial orientation towards relevant stimuli. The gaze direction bias was based on the proportion of trials in which the first fixation was directed to a chocolate stimulus instead of a neutral control stimulus. A bias score greater than 50% represents a higher proportion of first fixations directed to chocolate stimuli, whereas a bias score less than 50% indicates a higher proportion of first fixations directed to neutral stimuli.

Initial gaze duration bias is the sum of multiple fixations occurring within the region of the initially fixated picture before gaze is shifted away from it and can be seen as a measure for early attention maintenance (e.g. Mogg, Bradley, Field, & De Houwer, 2003). Bias scores for the initial gaze duration were computed by subtracting the mean duration of initial fixations directed to neutral images from the mean duration of initial fixations directed to chocolate images. Thus, a positive score is indicative of longer initial attention maintenance on chocolate stimuli, whereas a negative score is indicative of the reverse: longer initial maintenance on neutral stimuli.

Dwell time bias is informative regarding the maintenance of attention on critical stimuli (e.g. Mogg, Field, & Bradley, 2005). Overall dwell time per image category (chocolate vs. neutral) was calculated for each critical trial, and then averaged per image category over all trials, resulting in an average total dwell time per image category. For the gaze dwell time bias score, the mean dwell time on neutral images was subtracted from the mean dwell time on chocolate images. Thus, a positive score indicates that attention was maintained longer on chocolate items than on neutral items, whereas a negative score indicates the reverse: longer maintained attention on neutral items.

#### Manual response latencies to probes

Calculations of response latency bias scores were based on the recordings of the participant's manual response latency when indicating the location of the probe. Response latencies were excluded from further analyses if they were faster than 200 ms, slower than 2000 ms, and then if they deviated more than 3 SDs from each participant's mean (e.g. Castellanos et al., 2009; Mogg, Bradley, Hyare, & Lee, 1998). Bias scores were then calculated by subtracting the mean response latency on trials when the probe replaced a chocolate image (i.e. chocolate – congruent trials) from the mean response latency on trials when the probe appeared in the same location as the preceding neutral image (i.e. chocolate – incongruent trials). A positive bias score can be interpreted as an attention bias towards chocolate, whereas a negative bias score indicates an attention bias away from chocolate, thus attentional avoidance.

#### Questionnaires

##### State chocolate craving

State craving for chocolate was assessed by a 100 mm visual analogue scale (VAS) indicating "How strong is your desire for chocolate right now?" (0 = I have no desire for chocolate at all at the moment; 100 = I have an extreme desire for chocolate at the moment"). Participants were asked to fill in this VAS at four successive time points during the experimental procedure: when entering the lab (VAS1); after the exposure procedure (VAS2); after the booster exposure during the break of the visual probe task (VAS3); shortly before the taste test (VAS4).

##### Trait chocolate craving

Trait chocolate craving was assessed with the "Attitudes to Chocolate Questionnaire" (ACQ; Benton et al., 1998). This questionnaire can be divided into three subscales (chocolate craving, guilt for chocolate, functional approach to chocolate eating) and mean subscale scores can be calculated. Chocolate craving is assessed on 24 items measuring the characteristics of typically experienced craving for chocolate on 100 mm VAS ranging from "Not at all like me" (0) to "Very much like me" (100). Higher scores are indicative of stronger trait chocolate craving (Benton et al., 1998).

##### Habitual chocolate consumption

Participants were asked to indicate their estimated average chocolate consumption per week and the time passed since they last ate chocolate with two open ended questions.

##### Restraint scale (RS; Herman & Polivy, 1980)

To characterize the participant groups, restrained eating style was assessed by means of the restraint scale. This 10 item self-report questionnaire assesses weight concerns, weight fluctuations and self-reported attempts to diet, on a scale ranging from 0 (concerns absent) to 3 or 4 (concerns present); with higher scores indicating more concern for weight and difficulties with control over eating behaviour.

##### Body mass index (BMI)

Height and weight were measured at the end of the experimental session to calculate BMI.

##### Taste test

Chocolate intake was measured by means of a bogus "taste test". The participant was instructed to rate four bowls (mean weight = 762.97 g, SD = 50.01) of chocolate pellets (white chocolate, milk chocolate, 53.8% cacao dark chocolate, 70.3% cacao dark chocolate) on visual attractiveness, smell, and taste while the experimenter left the room for 10 min. The instruction procedures for the "forbidden" and for the "chance" condition were slightly adjusted to avoid contradictions with the expectancy instruction they received earlier. In condition 4 ("Chance") the participant was informed that there would be a chance that they had to eat chocolate; yet the chance element (i.e. a digital dice) was manipulated in a way that all participants received the instruction to eat chocolate. For participants in condition 2 ("Forbidden") the instruction for the taste test included the adjunct "You will not really be eating chocolate, however, you will be participating in a taste test about chocolate." followed by the standard instruction "You can try as much as you want, to be able to judge the different sorts of chocolate adequately". Chocolate intake was determined by difference in weight of bowls before and after the taste test.

##### Manipulation check

To check whether the manipulation instructions about eating opportunity produced indeed different perceptions and feelings to-

wards chocolate consumption a short manipulation check was conducted at the end of the experiment. Participants were probed for suspicion: Participants were asked to identify the correct instruction that they received among all available instructions to check whether the instructions were understood (and remembered) well by participants. Then, all participants were asked to answer the question “Were you allowed by yourself to eat chocolate?”, to see to what extent they internalized the instructions they received. This measure was later used in analyses to account for the possibility that participants did not internalize the experimental manipulation instructions and to explore how self-endorsed eating permission contributed to differences in attention, craving or intake.

### Procedure

All participants provided informed consent prior to participation and each participant was tested individually. Participants were tested between 11 am and 5 pm. Upon arrival at the laboratory participants filled in VAS1 to indicate baseline craving for chocolate and were then subjected to 3 min of chocolate exposure to cause an increase in chocolate craving, and reported their craving after the exposure on VAS2. Subsequently, participants received instructions about their eating opportunity according to their condition (required/forbidden/choice/chance). Participants then conducted the visual probe task while eye movements towards chocolate versus non-chocolate stimuli and manual response latencies were recorded as measures of attention biases for chocolate. In the short break during this task the participant again underwent a brief (1 min) exposure to chocolate to ‘boost’ the craving, and the respective chocolate availability instruction was repeated. At the end of the short break, participants reported their craving for chocolate on VAS3 before continuing with the second part of the visual probe task. After the visual probe task, participants again indicated their craving for chocolate on VAS4 and subsequently took part in the bogus taste test. Participants then filled in the questionnaires (trait chocolate craving measure (ACQ; Benton et al., 1998); dietary restraint (RS; Herman & Polivy, 1980); manipulation check) and height and weight were measured. Participants were thanked at the end of the procedure and received either course credit or a gift certificate of €7,50 for their participation. The current study was reviewed and approved by the local ethics committee.

## Results

### Chocolate craving

Changes in self-reported momentary craving were analysed in a full factorial mixed model analysis of variance (ANOVA) with time (4 time points) as a within subjects factor, and condition (required, no consumption, choice, chance), and chocolate craving status (high chocolate craver vs. low craver) as between subjects factors. Overall, craving was significantly different over the four time points, as was evident from a main effect of time,  $F(2.31, 166.09)^1 = 112.92$ ,  $p < .001$ . High chronic chocolate cravers reported generally higher levels ( $M = 67.70$ ,  $SD = 17.06$ ) of momentary craving than did low cravers ( $M = 45.98$ ,  $SD = 17.06$ ), as evidenced by a main effect of chocolate craver status,  $F(1, 72) = 31.87$ ,  $p < .001$ . None of the other effects in the ANOVA reached significance, all  $F_s < 2.00$ , all  $p_s > .13$ . Pairwise comparisons revealed a significant increase in chocolate craving at time 2 ( $M = 59.94$ ,  $SD = 2.08$ ;

$p < .001$ ), time 3 ( $M = 65.84$ ,  $SD = 2.11$ ;  $p < .001$ ) and time 4 ( $M = 62.21$ ,  $SD = 2.3$ ;  $p < .001$ ) in comparison to craving at time 1 ( $M = 39.36$ ,  $SD = 2.12$ ).

### Attention biases

To test whether attention bias scores differed between conditions and to account for chronic chocolate craving separate full factorial ANOVAs were conducted for each measure of attention bias (direction bias, initial gaze duration bias, dwell time bias, response latency bias) with condition (required, no consumption, choice, chance) and chocolate craver status (high chocolate craver, low craver) as between subject variables.

Results showed a main effect of chronic chocolate craver status on two measures of attention bias: High chronic chocolate cravers had significantly higher initial gaze duration bias scores,  $F(1, 72) = 7.70$ ,  $p = .007$ , and marginally significantly higher dwell time scores than low cravers,  $F(1, 72) = 3.61$ ,  $p = .062$ , see Fig. 1. No other effects in the ANOVAs on initial gaze duration bias and dwell time reached significance, all  $F_s < 1.56$ , all  $p_s > .21$  (for initial fixation duration) and all  $F_s < 0.77$ , all  $p_s > .51$  (for dwell time bias). The ANOVAs on direction bias and on response latency bias revealed no significant effects at all, all  $F_s < 1.86$ , all  $p_s > .14$  (for direction bias) and all  $F_s < 2.38$ , all  $p_s > .13$  (for response latency bias).

Additional one sample *t*-tests were conducted to test whether chocolate cues attracted more attention than neutral stimuli, overall. A one sample *t*-test against 50 (which indicates no direction bias) revealed that all participants directed their first gaze on average significantly more often than chance towards chocolate stimuli than towards neutral stimuli,  $t(79) = 8.10$ ,  $p < .001$ . In addition, all participants looked longer towards chocolate than neutral stimuli in later attention processes, as revealed by elevated bias scores in one-sample *t*-tests against 0 (indicating no bias) for initial duration fixation bias ( $t(79) = 6.46$ ,  $p < .001$ ) and dwell time bias ( $t(79) = 6.46$ ,  $p < .0001$ ). Similarly, all participants had a significantly elevated response latency bias, indicating faster response latencies when a probe replaced a chocolate stimulus in comparison to neutral stimulus,  $t(79) = 4.94$ ,  $p < .001$ , as qualified by a one sample *t*-test against 0 (indicating no bias in response latencies). In sum, results of one sample *t*-tests showed that all participants generally expressed elevated approach attention processes for chocolate stimuli vs. neutral stimuli on all measured attention bias scores.

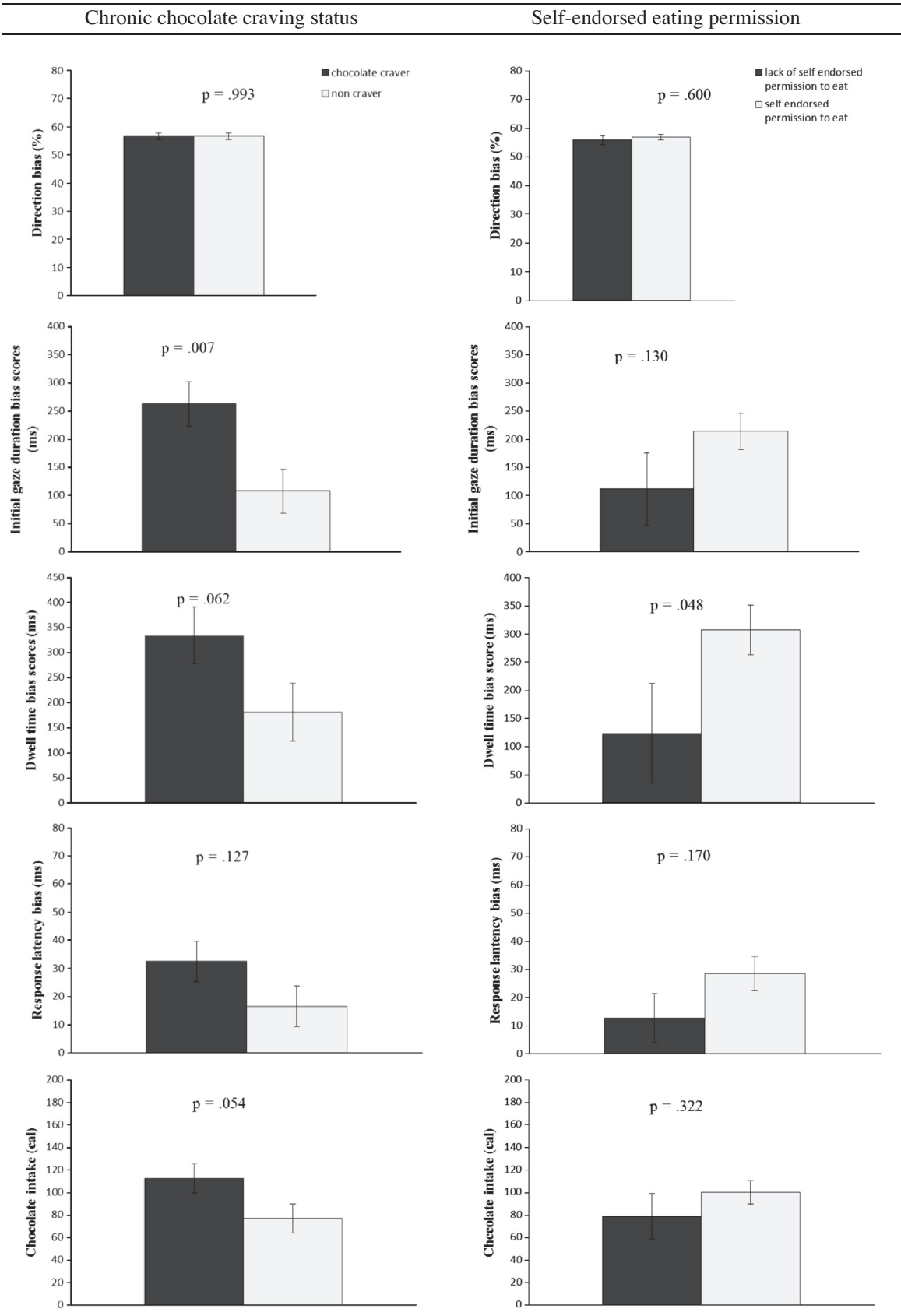
### Chocolate intake

To test whether the expectancy to eat chocolate or whether chronic chocolate craving affected food intake, a full factorial ANOVA on chocolate intake (in calories) with condition (required, no consumption, choice, chance) and chocolate craver status (high chronic chocolate craver vs. low craver) was conducted. Results indicated a marginally significant main effect of chronic chocolate craving on chocolate intake. High chronic chocolate cravers tended to consume significantly more chocolate than low cravers,  $F(1, 72) = 3.84$ ,  $p = .054$ . See Fig. 1.

### Subjective permission to eat chocolate

Although attention bias and chocolate intake were not affected by the experimental manipulation of eating expectancy (i.e. externally controlled permission to eat), we also explored whether attention biases for chocolate and chocolate intake were associated with subjective (self-endorsed, thus internalized) permission to eat. Based on the question if participants permitted themselves to eat chocolate (yes/no) two groups were created: participants

<sup>1</sup> Assumption of sphericity has been violated, therefore Greenhouse-Geisser correction are reported.



**Fig. 1.** Mean attention bias scores (direction bias (in%), initial gaze duration, total dwell time and response latency bias (all in ms) and chocolate intake (in calories) for high chronic chocolate cravers (black column) and low cravers (white column) (left panel) and for participants who reported that they would not have permitted themselves to eat chocolate (black column) and participants reported that they permitted themselves to eat chocolate (white column) (right panel). Note. P-values are reported based on estimated marginal means, for high chocolate cravers and low cravers, and on raw means for participants with and without self-endorsed permission to eat.

**Table 2**

Self-reported craving in participant with and without self-endorsed eating permission at four timepoints.

Self-reported craving	Lack of permission (n = 20)		Permission (n = 60)	
	M	SD	M	SD
Craving at t1	28.90	23.74	42.91	21.10
Craving at t2	45.85	21.26	64.80	19.17
Craving at t3	52.55	22.62	70.27	17.57
Craving at t4	47.75	24.06	67.03	19.28

Note. Craving reports were significant different between groups at all four timepoints ( $p < .05$ ).

who reported that permission to eat chocolate was not self-endorsed ( $n = 20$ ) and participants whose permission to eat chocolate was self-endorsed ( $n = 60$ ).<sup>2</sup> The effect of self-endorsed permission to eat was tested by means of independent samples  $t$ -tests with the attentional bias measures (four bias measures), self-reported craving (at four time points) and chocolate intake (in calories) as the dependent variables. Results revealed that participants who reported a lack of self-endorsed eating permission had significantly lower craving ratings throughout the experiment, all  $t$ s  $> 2.49$ , all  $ps < .02$ , see Table 2, and significantly lower dwell time bias scores,  $t(78) = 2.01$ ,  $p < .05$ , in contrast to participants whose permission to eat was self-endorsed. No significant differences between these groups emerged with regard to other attention bias scores, all  $t$ s  $< 1.53$ , all  $ps > .13$  or food intake,  $t(78) = 1.00$ ,  $p = .32$ . See Fig. 1.

#### Correlations of craving, attention biases and chocolate intake

In the whole sample, both initial gaze duration bias and dwell time bias correlated with craving at all time points (all  $rs(80) > .29$ , all  $ps < .01$  for initial gaze duration; all  $rs(80) > .28$ , all  $ps < .01$  for dwell time bias). Correlation analyses further showed that chocolate intake was also significantly correlated with all four measures of attention biases. See Table 3.

#### Discussion

Attention biases for food have been associated with (extreme) dieting as well as with (chronic) craving and eating enjoyment. The aim of this study was to systematically examine the effects of eating motivation and food forbiddance on attention for food, momentary craving, and food intake during four experimentally manipulated availability contexts. Our results showed that the manipulation of (perceived) availability of chocolate did not influence participants attention, momentary craving or chocolate intake, which leads to the conclusion that this manipulation did not affect the eating motivation of participants. Maybe a short-termed manipulation of anticipated consumption does not affect attention to a similar extent as trait-like variables, such as chronic chocolate craving. This is in line with previous findings, showing that an experimental instruction to manipulate anticipated consumption did not modulated cognitive processing in participants (Higgs, 2007). To strengthen the effect of the availability manipulation the integration of direct reinforcement of the respective manipulation instructions on a trial-by-trial basis could possibly

<sup>2</sup> A significant  $\chi^2$ -test between conditions indicated that the conditions differed significantly regarding the number of participants who indicated self-endorsed eating permission ( $p$ -value of  $\chi^2 = .028$ ): In the “chance” condition, only one participant indicated that she did not self-endorse eating permission, yet self-endorsed eating permission did not differ between participants in the “required to eat”, “forbidden” or “choice” condition ( $p$ -value of  $\chi^2 = .231$ ). Results remained the same when analyses were repeated including only participants of the required/forbiddance/choice condition. Results reported here are based on the data of all participants.

be helpful, as for example, has successfully been applied in recent studies on alcohol and reward expectancies (Field et al., 2011; Jones et al., 2012).

In general, the current findings indicate that chocolate stimuli attracted more attention than neutral stimuli, because all participants paid more attention to chocolate cues than to neutral cues, as was evident for all attention bias scores (i.e., for direction bias, initial gaze duration bias, dwell time bias and response latency bias). This finding might not be entirely surprising because noticing food stimuli has always been important for our survival and food cues might therefore inherently possess more motivational salience than neutral stimuli.

More importantly, results also confirm that attention biases for food were related distinctly to chronic craving and self-endorsed permission to eat. Specifically, chronic chocolate craving was related to elevated approach attention biases for chocolate cues in later stages of attention allocation, that is, the duration of initial gaze and (marginally) total dwell time on chocolate stimuli. In contrast, total dwell time on chocolate was significantly reduced in participants who subsequently indicated that they would not have permitted themselves to eat chocolate (i.e., those with lack of self-endorsed eating permission).

These effects on attention allocation for chocolate cues were only apparent in a more controlled and later stage of attention processing, in this study. No distinctive effects of chronic craving or self-endorsed eating permission on attention for chocolate cues were observed on early/automatic (direction bias) and indirect (response latency bias) attention measures. These findings of attention biases in later processing stages match with results of basic attention research showing that goal motivation steers *voluntary* attentional processing (Vogt, De Houwer, & Crombez, 2011) and contribute further to the suggestion that particularly the maintenance of attention mirrors top-down attentional control processes, that take longer and reflect motivation (LaBerge, 2002). In this respect, it is interesting to note that specifically the duration measures of attention were positively related to craving and chocolate consumption in our study. Maybe prolonged attention maintenance, as studied here, is an expression of heightened eating motivation.

Even though speculative at this point, because of the correlational nature of our findings, this might further suggest that attention biases towards food cues could function as a maintenance factor for overeating. If individuals with chronic craving for food spend more time looking at food and if this bias is related to their food consumption, attention biases for food might be particularly problematic in an obesogenic food environment with highly salient and tempting food cues. In this respect, our findings support evidence from previous studies that reported approach attention bias for food cues in obese, in hungry and in craving participants (elevated eating motivation for food, e.g.; Castellanos et al., 2009; Piech, Pastorino, & Zald, 2010; Smeets, Roefs, & Jansen, 2009).

Whereas high intrinsic eating motivation (i.e., chronic chocolate craving) was associated with attentional approach for chocolate cues, our results also showed that a lack of self-endorsed eating permission was associated with a diminished attention bias for chocolate cues. One possible explanation is that a lack of self-endorsed eating permission leads to both lower craving and reduced attention of chocolate cues. Or, the effect of self-endorsed eating permission on reduced attention may be mediated by experienced craving. However, the reverse chain of events may also be possible, as another explanation can be that decreased craving at baseline led both to a lack of self-endorsed eating permission and diminished attention for chocolate.

At this point, these explanations remain speculative because it is not possible to statistically disentangle the temporal order of

**Table 3**  
Pearson correlation between four measures of attention bias (direction bias, initial gaze duration bias, dwell time bias and response latency bias) and chocolate intake (in cal.).

Variable	1	2	3	4	5	6	7	8	9
1. Direction bias	56.58 (7.26)								
2. Initial gaze duration bias	.20	188.74 (261.26)							
3. Dwell time bias	.29*	.86*	261.15 (360.61)						
4. Response latency bias	.03	.38*	.45*	24.64 (44.65)					
5. Chocolate intake (in cal.)	.27*	.25*	.33*	.35*	94.96 (82.45)				
6. Craving at time 1	-.04	.29*	.28*	.13	.31*	39.41 (22.48)			
7. Craving at time 2	-.06	.36*	.35*	.19	.33*	.79*	60.06 (21.24)		
8. Craving at time 3	-.03	.39*	.40*	.30*	.42*	.70*	.92*	65.84 (20.33)	
9. Craving at time 4	.11	.35*	.34*	.21	.48*	.72*	.80*	.82*	62.21 (22.08)

Note. Off-diagonal shows correlation coefficients; Diagonal shows means and standard deviations.

\* Correlations are significant ( $p < .05$ , two tailed).

craving reports and reports of self endorsed eating permission.<sup>3</sup> Thus, results concerning the possible influence of self-endorsed eating permission on attention and craving should be viewed under this limitation and a replication of our results under experimental conditions is warranted. An implication of this finding could be that individuals who follow strict dieting rules (or who have less intrinsic motivation to eat) pay less attention to food cues and experience less cravings. In this respect, our finding dovetails previous evidence hinting at attentional avoidance of food cues in eating disorder patients and restrained eaters (Brooks et al., 2011; Shafran et al., 2007, 2008; Veenstra et al., 2010). Moreover, our results also correspond with recent findings of an eye tracking study showing attentional avoidance of food cues, only in later stages of attentional processing, in anorexic patients but not in healthy participants (Giel et al., 2011). In addition, this finding also corroborates previous research indicating that highly restrained eaters down-regulate their hedonic response to food, when food is available (Blechert, Feige, Hajcak, & Tuschen-Caffier, 2010). In general, our findings that differences in chronic craving and eating permission result in different attention allocation patterns fits with recent neuroimaging studies showing that attention focus (e.g. focussing on palatability versus free viewing) modulates neuro-cognitive reactivity for food in healthy weight and overweight samples (Frankort et al., 2012; Siep et al., 2009).

In conclusion, this is the first study showing the differential effect of chronic craving and self-endorsed eating permission on the strength and the direction of attention biases for food cues by means of eye-tracking. Results suggest that chocolate cues, in comparison to neutral cues, are highly salient stimuli in our environment and generally attract more attention than neutral cues. Moreover, chronic craving and self-endorsed eating permission determine the extent and the time we keep focussing on food: The voluntary decision to refrain from eating chocolates was related to reduced attention for chocolate whereas chronic chocolate craving was related to attentional approach of chocolate cues.

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<sup>3</sup> We measured self-endorsed eating permission only once, at the end of the experiment, but craving was measured consecutively throughout the experiment. Therefore we do not have data that informs on the temporal order of craving or eating permission.



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