Temptation and restraint

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Chapter 6

Attentional engagement with and disengagement from food cues in anorexia nervosa

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Abstract

This study examined differences in food-related Attentional Bias (AB) between patients with Anorexia Nervosa (AN) and adolescents without an eating disorder. AB was assessed with an Attentional Response to Distal versus Proximal Emotional Information (ARDPEI) task that was specifically designed to differentiate between attentional engagement with and attentional disengagement from food. We tested if patients with AN would show less attentional engagement and less difficulty to disengage their attention from food cues than individuals without an eating disorder. Both might contribute to patients' ability to refrain from eating even in a state of starvation. Participants were adolescents with AN (*n* = 69) and a comparison group with healthy weight, matched on age and educational level (*n* = 69). No differences were found in attentional disengagement. However, patients with AN did show less attentional engagement when food cues were shown briefly (100 ms). Given that the adolescents without an eating disorder showed a significant engagement bias to food cues, the results suggest that patients with AN lack the bias involved in healthy eating behavior. Future studies should further examine the direction of the relationship between decreased attentional engagement with food cues and anorexia nervosa.

Introduction

Anorexia nervosa is a severe mental disorder that has a large impact on the patient as well as their family (Schmidt et al., 2016). The core symptoms of Anorexia Nervosa (AN) can be summarized as an extreme restriction of food intake leading to significant weight loss, an intense fear of gaining weight or becoming fat, and either an undue influence of body weight or shape on self-evaluation, or a disturbance of body weight or shape experience (American Psychiatric Association, 2013). The severity of AN is reflected in a mortality rate that is five times higher than that of the general population (Kask et al., 2016). Treatments for patients with AN are limited in their effectiveness and relapse after treatment is common (e.g., Brockmeyer, Friederich, & Schmidt, 2017). A better understanding of why the core symptoms of AN are so persistent can help in the development of more effective treatments (Jansen, 2016). An important question in this regard is how patients with AN succeed in restricting their food intake, even when they are in a state of starvation. In the current study, we focused on spatial attentional bias (AB) to food, as this type of bias has been suggested to play a role in eating behavior (e.g., Field et al., 2016; Shafran, Lee, Cooper, Palmer, & Fairburn, 2007).

Individuals' attention has been proposed to be biased towards negative and positive cues in the environment, and this bias seems to be stronger when the cue is relevant to specific concerns of the individual(Field et al., 2016; Pool et al., 2016). In line with this, several studies found that in the general population food deprivation (i.e., hunger) heightens the AB for food cues (Castellanos et al., 2009; Giel et al., 2011; Nijs, Muris, Euser, & Franken, 2010; Stockburger, Weike, Hamm, & Schupp, 2008; Tapper, Pothos, & Lawrence, 2010; although not all, Leland & Pineda, 2006). In addition, there is evidence indicating that healthy weight individuals no longer show an AB for food when they are satiated (e.g., Castellanos et al., 2009; Stockburger et al., 2008). Thus, in healthy weight individuals, AB for food cues seems to depend on the individual's motivational state. Heightened AB for food as a result of food deprivation may be seen as an adaptive mechanism that supports an individual's functional regulation of food intake in response to energy demands. Perhaps then the absence of an AB even when deprived of food might be related to aberrant eating behaviors as seen in patients with eating disorders. In other words, the absence of an AB for food cues might help patients with AN to restrict their food intake.

Attentional bias is a term that has been used to describe different aspects of visual attention, and many different paradigms have been used to measure AB (see for example Mogg & Bradley, 2016). When considering spatial AB, two distinct processes have been proposed to play an important role: automatic orientation towards food cues (i.e., attentional engagement), and maintaining attention on food cues possibly due to a difficulty to disengage from food cues (i.e., attentional disengagement) (Posner et al., 1987). Attentional engagement has been suggested to be an early attentional process mainly directed by bottom-up processes, and attentional disengagement has been suggested to be a later attentional process directed more by top-down processes (Mogg & Bradley, 2016; Pool et al., 2016). Patients' ability to resist food might be related to that their attention is not automatically directed towards food cues (i.e., less attentional engagement to food) and to that they have relatively little difficulty to redirect their attention away from food cues (i.e., less difficulty to disengage from food).

Interestingly, a previous study showed that eating disorder patients showed more instead of less difficulty to disengage their attention from food cues compared to individuals without an eating disorder (Smeets, Roefs, van Furth, & Jansen, 2008). However, since the sample consisted of both patients with AN who are underweight as well as patients with Bulimia Nervosa who have a healthy weight, it is difficult to infer the relationship between AB and food restriction in a state of starvation as seen in patients with AN.

Thus far three studies have examined spatial attention to food cues specifically in patients with AN (Giel et al., 2011; Kim et al., 2014; Veenstra & de Jong, 2012). These studies failed to find consistent evidence for less AB for food cues in patients with AN. However, these studies used AB measures (dot-probe task, exogenous cueing task, and free viewing task) that are unable to capture the distinction between attentional engagement and attentional disengagement. For both the dot-probe (Kim et al., 2014) and the exogenous cueing task (Veenstra & de Jong, 2012), the images of interest (i.e., food or control comparison image) always appear distal to the attended location (MacLeod et al., 1986; Posner, 1980). As such, each trial starts with attentional engagement when a participant notices the image of interest, making it impossible to distinguish between attentional engagement and attentional disengagement (cf. Grafton & MacLeod, 2014). In the free viewing task, participants' spontaneous viewing behavior is examined (Giel et al., 2011). Since participants are not directed to look towards or away from the stimuli, neither attentional engagement nor disengagement is necessary to fulfill the task's requirements. The operationalization of initial orientation (i.e., the initial fixation after the trial's onset) seems quite similar to the definition of attentional engagement. However, in the absence of concurrent task requirements, it remains unclear whether first fixations reflect an early bottom-up process or a later more top-down process. Further, the free viewing task does not provide the opportunity to examine difficulty to disengage from food, since individuals' attention is not directed to the food cues, nor do they receive an assignment to look away from food cues. All in all, it remains unclear whether patients with AN are characterized by a decreased attentional engagement to food and/or decreased difficulty to disengage from food cues.

Therefore, the main aim of the present study was to differentiate between attentional engagement with food and difficulty to disengage from food when examining differences in AB for food between patients with AN and individuals without eating disorder problems. Accordingly, in this study AB for food was measured with a recently developed performance measure that was specifically designed to differentiate between attentional engagement and attentional disengagement; an adapted version of the Attentional Response to Distal vs. Proximal Emotional Information (ARDPEI) (Grafton & MacLeod, 2014). The ARDPEI consists of trials in which attention is anchored either distally or proximally to the location of the image of interest (food or control image). As such, the task has been proposed to be optimally suited to differentiate between attentional engagement and attentional disengagement (Grafton & MacLeod, 2014). Thus, this task allows to test whether patients with AN are characterized by less attentional engagement with food cues and/or less difficulty to disengage from food cues than individuals without an eating disorder.

In line with the transdiagnostic theory of eating disorders (Fairburn & Cooper, 2014), thus far studies have not differentiated between different subtypes of AN. However, within the

DSM-5 diagnostic group of Anorexia Nervosa there are two subtypes of AN specified that show important differences in (eating) behaviors. The restrictive subtype (AN-R) is characterized by weight loss accomplished primarily through dieting and sporting, and the binge-eating/purging type (AN-BP) is characterized by engaging in binge eating and/or purging behavior (e.g., self-induced vomiting) next to dieting behavior (American Psychiatric Association, 2013). Thus, although the two subtypes both show restrictive eating patterns, AN-BP patients also show episodes of overeating and purging behavior. This difference in eating behaviors might also be reflected in differences in AB to food. The current study is the first to explore differences in AB to food between patients with AN-R and AN-BP.

To sum up, the aim of the current study is to examine differences in AB for food cues between patients with AN and individuals without an eating disorder, by using a recently developed performance measure that was specifically designed to differentiate between attentional engagement and attentional disengagement (ARDPEI) (Grafton & MacLeod, 2014). Since AN typically develops during adolescence (Kask et al., 2016) participants were adolescents with AN and a comparison group matched on age and educational level. The following hypotheses were tested: Compared to individuals without an eating disorder, patients with AN show: (1) less attentional engagement to food cues, and (2) less difficulty to disengage from food cues. Lastly, differences in AB to food between the restrictive and binge/purge AN subtypes were explored.

Method

Participants

Patients between the ages of 12 and 23 who fulfilled DSM-5 criteria for Anorexia Nervosa and atypical Anorexia Nervosa and were referred for inpatient and outpatient treatment to the department of eating disorders of Accare between June 2015 and June 2017, were eligible to participate in this study. There were no additional in- or exclusion criteria. Participants were 69 adolescents with AN (67 females, M_{age} = 15.55, SD_{age} = 1.70, range = 12 – 22), and 69 adolescents without an eating disorder (67 females, M_{age} = 15.48, SD_{age} = 1.82, range = 12 – 22). In the patient group, eating disorder pathology was examined with the Dutch child version of the Eating Disorder Examination (EDE) interview (Bryant-Waugh et al., 1996; Decaluwé & Braet, 1999), and based on this, DSM-5 classifications were made. The patient group fulfilled DSM-5 criteria for Anorexia Nervosa Restrictive type (n = 39), Anorexia Nervosa Binge Purge type (n = 10), atypical Anorexia Nervosa Restrictive type (n = 11), or atypical Anorexia Nervosa Binge Purge type (n = 9). For the exploration of differences between subtypes of AN, the anorexia nervosa restrictive subtype and atypical anorexia nervosa restrictive subtype were combined into one Anorexia Nervosa Restrictive group (AN-R; n = 50). Participants fulfilling the criteria for the anorexia nervosa purge subtype and those fulfilling the criteria for atypical anorexia nervosa purge subtype were combined into an Anorexia Nervosa Binge Purge subtype group (AN-BP; n = 19). Although in the DSM the binge purge subtype includes both binges and purging behaviors, in the current sample objective binge eating was rare. Only one patient was known to have binge eating episodes, 15 did not, and of 3 participants this was unknown[7]. The comparison group consisted of adolescents with a healthy weight that were matched on gender, age, and educational level to the patient group.

Materials

Body mass index

Since Body Mass Index (BMI) changes substantially with age, adjusted BMI was calculated ((actual BMI/Percentile 50 of BMI for age and gender) x 100) to make the BMI's comparable (Cole et al., 2000). The 50th percentile of BMI for age and gender was obtained from the Netherlands Organization for Applied Scientific Research (TNO, 2010). Adjusted BMI scores between 85% and 120% are considered as healthy weight, and smaller than 85% as underweight (Van Winckel & Van Mil, 2001).

Eating disorder symptoms

A Dutch version of the Eating Disorder Examination Questionnaire 6.0 (EDE-Q) (Fairburn & Beglin, 2008) was administered to assess eating disorder pathology within the past 28 days. Since there is no child and adolescent version of this newest version of the EDE-Q adaptations to the wording of some items were made by the first and second author to make the questions more appropriate and understandable for adolescents. These adaptations were comparable to adaptations that were made to the previous version of the EDE-Q to make it appropriate for children and adolescents (Jansen, Mulkens, Hamers, & Jansen, 2007). Since there is no evidence for the theorized four factor structure of the EDE-Q (Aardoom et al., 2012), an average score of the 22 items will be used as general index of eating disorder pathology. Scores can range from 0-6, and the internal reliability of this total EDE-Q score was excellent (Cronbach's alpha = .97).

State of food deprivation

Food deprivation might influence individuals' attention towards food cues. Therefore, this was assessed with the question; "How long has it been since you last ate?" from the Hunger Scale (Grand, 1968). Scores reflect the amount of hours that have passed since the participant last ate, rounded off to quarters of an hour.

AB to food cues

The Attentional Response to Distal vs. Proximal Emotional Information (ARDPEI) task (Grafton & MacLeod, 2014) was used as a performance measure of spatial attention allocation. It indexes both attentional engagement, and difficulty to disengage attention from food stimuli.

Stimuli. Food stimuli were 64 high caloric food items. Of these, 32 were sweet high caloric food items (e.g., pancakes, cheese cake, and chocolate) selected from the *food-pics* database (Blechert, Meule, Busch, & Ohla, 2014), and 32 were savory high caloric food items (e.g., chips, fries and pizza) of which 22 were selected from the food-pics database. The additional

[7] Score forms of these three participants were not saved in the electronic patient file, and could therefore not be traced back when this information was looked-up.

10 were selected from our own database and were mostly food items specifically known to the Dutch population (e.g., croquette). Control images were 64 office or household related items such as a stapler, paperclips and a bucket. All control images were selected from the food-pics database. The task also included 64 abstract art images, which were the same as in the original ARDPEI (Grafton & MacLeod, 2014).

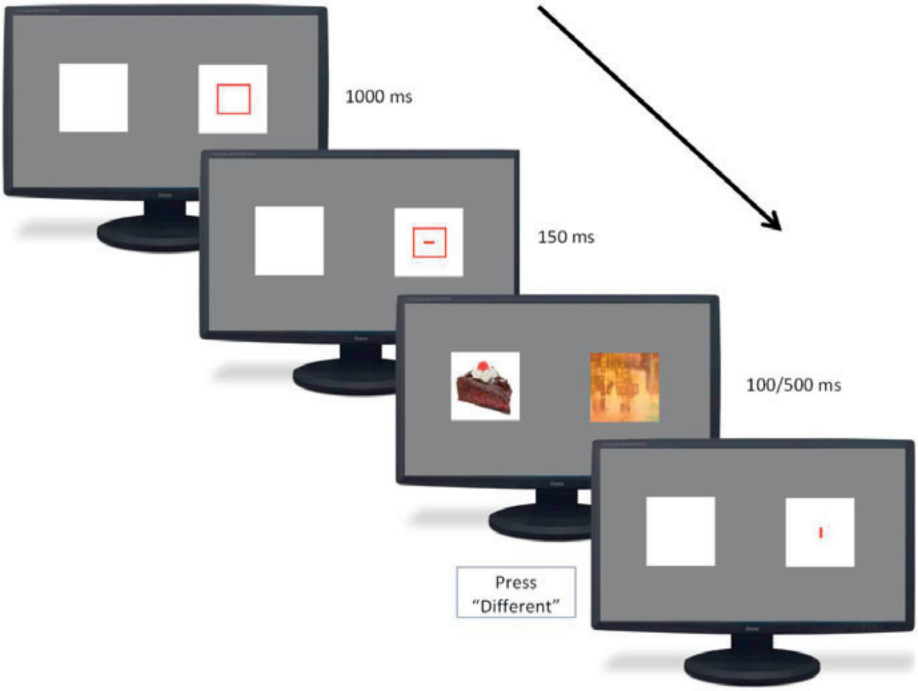

Figure 1. Example of a food trial where the image appears distal to the anchor, the probe has a different position than the image, and the orientation of the anchor and the probe is different.

Task procedure. Each trial started with two white squares, one left and one right from the middle of the screen, against a middle gray background (see Figure 1). One of these squares contains a red outline, half of the time the left and half of the time the right square. Participants had to focus their attention on this red outline. After a second, a red line (the anchor) appeared for 150 ms within this red outline. This anchor was either a horizontal or vertical line. Hereafter two images appeared on the screen, a food or neutral image (i.e., representational image) and an abstract art image, one replacing the left and one replacing the right white square. The images appeared with equal probability in either the left or the right white square. Following Grafton and Macleod (2014) images were shown for either 100 ms or 500 ms to examine the differences between long and short exposure duration. Since attentional engagement is an early attentional process we expected that (differential) engagement would be most pronounced at 100 ms trials. Since attentional disengagement is considered an attentional process that occurs somewhat later, we expected that a (differential) difficulty to disengage would be most pronounced at 500 ms trials. To prevent that the type of trial (as characterized by the location of the image relative to the probe) would acquire signal value for the presentation duration of the images (which may lead to strategic behaviors that may reduce the sensitivity of the task as a measure of AB), we included shorter (100 ms) and longer (500 ms) image presentation trials for both trials to assess engagement and trials to assess disengagement. Lastly, another red line (the probe), either horizontally or vertically, appeared on the left or right side of the screen. Participants had to identify whether the anchor and the probe had the same orientation (both horizontal or both vertical) or a different orientation (one horizontal and one vertical), by pressing the corresponding button on the response box. This probe remained on the screen until participants responded. A new trial started 1000 ms after the response. The task consisted of 128 trials. See figure 1 for an example of a trial. The ARDPEI was performed on a HP Probook 650 G1 running Windows 7 on a 15-inch monitor (1366x768 pixels), and programmed in E-prime 2.0 (Schneider et al., 2002). Screen refresh rate was set at 60Hz. An USB response box with two buttons was used to collect responses.

Data reduction. Data reduction of the ARDPEI followed the same steps as followed by Grafton and Macleod (2014). Participants who fell more than 2.58 *SD* below the mean amount of correct responses were removed from further analysis. Additionally, reaction times that fell more than 2.58 *SD* from the mean reaction time for that trial type were eliminated from the data before the bias scores were computed.

For the AB calculation four aspects of the trials are important; the content of the image (i.e., *Category*; Food vs. Neutral), the position of the image relative to the anchor (i.e., *Image Position*; Proximal vs. Distal), the time the image was shown (*Image Time*; 100 vs. 500), and the position of the probe relative to the image (*Probe Image Position*; Same vs. Different) (see Table 1). In total four AB scores can be calculated, an engagement bias for the short (100 ms) and for the long (500 ms) Image Time trials, and a disengagement bias for the short and for the long Image Time trials.

Table 1. *Types of trial for each representational image category*

Nr.	Image Position	Image Time	Probe Image Position
1	Distal	100	Same
2	Distal	100	Different
3	Distal	500	Same
4	Distal	500	Different
5	Proximal	100	Same
6	Proximal	100	Different
7	Proximal	500	Same
8	Proximal	500	Different

Note. All trial types occurred eight times per category during the task.

Engagement biases were calculated based on the trials in which the Image Position was distal from the anchor position. Thus, on trials where participants had to look away from their initial focus point to see the image. The difference in engagement bias was represented by the difference in reaction times of trials where the probe is in the same position as the image, and trials where the probe is in the opposite position. The engagement bias, with higher scores reflecting facilitated attentional engagement with food stimuli, was calculated as follows:

Engagement bias = (RT for probes in different location as food image – RT for probes in same location as food image) – (RT for probes in different location as neutral image – RT for probes in same location as neutral image).

The disengagement biases were calculated based on the trials in which the image position was proximal to the anchor position. Thus, trials in which participants automatically saw the image since it appeared in the same location as the anchor. The difference in difficulty to disengage was also represented by the difference in reaction times on trials were the probe appears in the same versus the opposite position. The disengagement bias, with higher scores reflecting more difficulty to disengage from food stimuli, was calculated as follows:

Disengagement bias = (RT for probes in different location as food image – RT for probes in same location as food image) – (RT for probes in different location as neutral image – RT for probes in same location as neutral image).

Procedure

This study was approved by the medical ethical committee of the University Medical Center in Groningen, the Netherlands (NL.51694042.14)[8]. Participants, and their parents when they were under 18 years of age, signed informed consent forms. The Eating Disorder Examination interview was part of the intake procedure at the department of Eating Disorders, and permission was asked to use this information for the current study. Participants for the comparison group were recruited at schools. During recruitment we specified that we were looking for adolescents without eating problems and with a healthy weight. For every patient an individually matched comparison participant with a healthy weight was selected based on gender, age, and educational level. For patients the study took place at the treatment center and for the comparison group at their school. On entry participants answered the Hunger Scale. Afterwards, they performed the ARDPEI and completed the EDE-Q. After finishing the questionnaires participants' height and weight were measured.

Analyses

Group differences on age, adjusted BMI, EDE-Q score, and food deprivation were assessed with an independent samples *t*-test. Bivariate correlational analyses were performed to examine the relationship between the AB scores, the EDE-Q score, and food deprivation. To test the differences between patients with AN and adolescents without an eating disorder on attention to food, a Multivariate Analysis of Variance (MANOVA) was performed with the four AB scores (engagement short, engagement long, disengagement short, and disengagement long) as dependent factor, and group (AN or comparison) as fixed factor. If the bivariate correlations showed a significant relationship between food deprivation and the AB scores it was used as covariate in the MANOVA. To explore the difference between patients with AN-R and AN-BP, an additional MANOVA was performed with the four AB scores as dependent factor, and subtype (AN-R or AN-BP) as fixed factor.

[8] This study is part of a larger project on reward and punishment sensitivity in disordered eating. Therefore, additional performance measures were administered of which the ARDPEI was the third. The procedure for the patient and comparison groups were identical, and therefore this is not expected to influence the results.

To complement the results of the statistical analyses following the common frequentist approach, results following the Bayesian approach were reported as well. Hereby we aim to increase the confidence in our results, and in the case of non-significant findings it provides us information about the strength of the evidence for the null-hypothesis. Bayesian analyses were conducted with JASP (JASP Team, 2018). Since to the best of our knowledge there is no option for a Bayesian MANOVA, only *t*-tests were performed. Cauchy prior were set at the recommended default *r*= .707 (Wagenmakers et al., 2017). To facilitate interpretation of the outcomes, $BF_{10,}$ which quantifies the evidence for the alternative hypotheses over the null hypotheses (patients with AN have less engagement with food, and less difficulty to disengage from food than adolescents without an eating disorder), were reported for those tests that provided significant results following the frequentist approach. $BF_{01,}$ which quantifies the evidence for the null hypotheses over the alternative hypotheses (patients with AN do not differ from adolescents without an eating disorder in their AB for food) were reported when the frequentist approach showed insignificant findings. A Bayes factor of 1 is considered *no evidence*, between 1-3 *anecdotal*, between 3-10 *moderate*, between 10-30 *strong*, between 30-100 *very strong*, and more than 100 *extreme* evidence (Wagenmakers et al., 2017).

Results

Group characteristics

Table 2 shows the mean age, BMI, EDE-Q score, and food deprivation, as a function of group. As can be seen, patients with AN and individuals from the comparison group did not differ in age. Further, as would be expected, patients with AN on average had significantly lower BMI's, and a higher EDE-Q score. Lastly, it seems that patients with AN were food deprived for longer as shown by a marginally significant *t*-test.

Table 2. *Group characteristics*

	Comparison group (*n*=69)		**Patients with AN (*n*=69)**		**Between-groups test**	
	M	***SD***	***M***	***SD***	***t***	***p***
Age	15.48	1.82	15.55	1.70	0.24	.81
BMI	102.87	9.62	84.69	12.16	-9.74	< .001
EDE-Q	1.30	1.10	4.16	1.11	15.17	< .001
Food deprivation	2.14	2.44	3.91	7.63	1.82	.07

Note. Comparison group = adolescents without an eating disorder, BMI = Adjusted Body Mass Index, EDE-Q = total score on the Eating Disorder Examination Questionnaire, Food deprivation = time since eaten in hours.

Data reduction

Outliers were deleted following Grafton and MacLeod (2014), and this was done separately for the patient and the comparison group. One participant from the comparison group (51% correct responses), and two from the patient group were removed (48% and 63% correct responses) because they fell more than 2.58 *SD* below the mean amount of correct responses. After removing these participants mean accuracy of the patient and the comparison group were comparable (HC *Mean* = 91%, *SD* = 7%; AN *Mean* = 92%, *SD* = 8%), however somewhat lower than the 95% that was found in the study of Grafton and MacLeod (2014).

Incorrect trials were deleted. Of the correct trials, 2.3% of the trials of the healthy controls, and 2.4% of the trials of the patients fell more than 2.58 *SD* from the mean reaction time for that trial type and were therefore eliminated from the data before bias scores were calculated (3.34% in Grafton & MacLeod, 2014). Lastly, in addition to the steps taken by Grafton and MacLeod (2014) reaction times faster than 200 ms were deleted, since they are most likely anticipation errors. There was only one anorexia patient who had such fast RTs, and this was only on 1.8% of the trials. In the HC group there were no RTs faster than 200 ms.

Descriptives

Mean reaction times per group, per trial can be found in the appendix. From these mean reaction times the AB scores were calculated (see Table 3). One sample *t*-tests were performed per group, for each of the AB indices, to examine whether the AB scores deviated significantly from zero. A significant deviation from zero would mean that there is engagement for food, or difficulty to disengage from food, compared to the non-food image. This was only the case for engagement on the short image time trials, and only for the adolescents without an eating disorder ($t(67) = 3.57$, $p < .001$). Adolescents without an eating disorder showed an engagement bias for food on the short image time trials. None of the other mean AB scores for neither of both groups deviated significantly from zero. Thus, no other ABs were found.

Table 3. *Mean AB scores in ms from the ARDPEI per group*

	Comparison group (*n* = 68)		Patients with AN (*n* = 67)	
	M	***SD***	***M***	***SD***
Engagement short	71.48	165.27	-14.65	153.35
Engagement long	30.44	211.29	-13.87	184.10
Disengagement short	-35.09	232.55	-28.97	191.96
Disengagement long	-3.18	177.40	-31.77	181.01

Note. Comparison group = adolescents without an eating disorder.

Table 4. *Correlations between the AB scores in the complete sample*

	EDE-Q	Food deprivation	Engagement short	Engagement long	Disengagement short
Food deprivation	.24**	-	-	-	-
Engagement short	-.29**	-.09	-	-	-
Engagement long	-.07	.04	.04	-	-
Disengagement short	-.01	.06	-.23**	-.05	-
Disengagement long	-.05	.06	-.11	.08	.23**

Note. $N = 137$, ** $p < .01$, EDE-Q = total score on the Eating Disorder Examination Questionnaire, Food deprivation = time since eaten in hours.

Bivariate correlational analyses were performed to examine the relationship between the AB scores, the EDE-Q score, and food deprivation (see Table 4). We found a positive relation between eating disorder symptomatology and food deprivation. Additionally, eating disorder symptomatology was negatively related to attentional engagement to food. Further, the analyses showed that most bias scores were unrelated to each other. Yet, attentional engagement with food on the short image time trials was weakly negatively related to the difficulty to disengage attention from food on the long image time trials. Thus, individuals with a relatively strong attentional engagement with food cues showed relatively little difficulty in looking away from food cues. Difficulty to disengage from food on the short image time trials was weakly positively related to difficulty to disengage from food on the long image time trials. Food deprivation was not related to any of the AB measures and will therefore not be included as covariate in the MANOVA. Since in healthy weight individuals food deprivation has been found to result in increased AB to food we performed a post-hoc exploration to examine whether food deprivation was related to AB to food in adolescents without an eating disorder, but not in patients with AN. However, when looking at specifically adolescents without an eating disorder, food deprivation was also not related to any of the AB measures. Tables presenting the relevant correlations separately for patients with AN and adolescents without an eating disorder can be found in the Appendix.

Do patients with AN differ from adolescents without an eating disorder in their AB for food?

Frequentist hypothesis testing

To examine whether patients with AN differ in their AB from adolescents without an eating disorder, a MANOVA[9] was performed. The MANOVA showed a significant multivariate effect for the AB scores in relation to group (Λ = .86, $F(4,130) = 3.12$, $p < .014$, $\eta^2_p = .09$, *CI* [.01, .17]). Between subjects tests showed that this was mainly due to less attentional engagement with food cues in patients with AN on the trials where the images were shown for a relatively short time ($F(1,133) = 9.85$, $p = .002$, $\eta^2_p = .07$, *CI* [.02, .15]). No significant differences were found for attentional engagement on the long image time trials ($F(1,133) = 1.69$, $p = .196$, $\eta^2_p = .01$, *CI* [.00, .06]). Additionally, no differences were found between the patient and the comparison group on disengagement from food stimuli on the short image time trials ($F(1,133) = 0.03$, $p = .87$, $\eta^2_p = .00$, *CI* [.00, .01]), or the long image time trials ($F(1,133) = 0.86$, $p = .36$, $\eta^2_p = .01$, *CI* [.00, .05]).

Bayesian hypotheses testing

Bayesian independent samples *t*-tests were performed on the four AB measures. Firstly, we tested the hypothesis that patients with AN showed less attentional engagement for food on the short image time trials. BF_{10} is 29.66 for this test, thus the observed data are 29.66 times more likely under the alternative hypothesis that patients have less engagement for food than adolescents without an eating disorder. The BF_{01} of the tests on engagement on the long image time trials, disengagement on the short image time trials, and disengagement on the long image time trials are 1.41, 6.13, and 2.26, respectively. This means that the observed data are more likely under the null hypothesis. Importantly, only the evidence for the null hypotheses that the groups do not differ in their attentional disengagement on the short image time trials is strong. The evidence for engagement on the long image time trials, and disengagement on the long image time trials is anecdotal and can be considered inconclusive.

[9] The analysis was also performed excluding healthy controls who scored high on the eating disorder examination questionnaire (2.3 or higher (Mond et al., 2004); $n = 17$). Although these controls were not in treatment for an eating disorder and had a healthy weight, they could be considered symptomatic. However, results were comparable when excluding these individuals (Attentional engagement 100 ms: $F(1,119) = 12.27$, $p < .001$, $\eta^2_p = .09$, other measures n.s.).

Do patients with AN-R and AN-BP differ in their AB for food?

Group characteristics

Differences between patients with AN-R and AN-BP on the general characteristics were examined (see Table 5). The groups did not differ in age ($t(67) = -1.04$, $p = .300$). However, AN-BP had a significantly higher BMI ($t(67) = -2.24$, $p = .028$), a significantly higher score on food deprivation ($t(18.38) = -2.69$, $p = .015$), and a marginally significant higher score on the EDE-Q ($t(67) = -1.80$, $p = .077$).

Frequentist hypothesis testing

To explore whether there are differences in AB between patients with AN-R and AN-BP a MANOVA was performed. The multivariate effect for the AB scores in relation to the subtype was marginally significant ($\Lambda = .86$, $F(4,62) = 2.52$, $p = .05$, $\eta^2_p = .14$, *CI* [.00, .23]). Between subjects tests showed that this was mainly due to less difficulty to disengage from food cues in patients with AN-BP on the trials when the images were shown for a relatively long time ($F(1,65) = 5.74$, $p = .019$, $\eta^2_p = .08$, *CI* [.07, .20]). Although there also seems to be a tendency of patients with AN-BP to have less attentional engagement with food cues on the short image time trials ($F(1,65) = 3.02$, $p = .087$, $\eta^2_p = .04$, *CI* [.00, .16]).

Table 5. *Group characteristics of patients with AN-R and AN-BP*

	AN-R (*n* = 50)		**AN-BP (*n* = 17)**		**Between groups test**	
	M	***SD***	***M***	***SD***	***t***	***p***
Age	15.42	1.55	15.94	2.11	-1.09	.280
BMI	82.72	10.86	88.45	13.01	-1.86	.067
EDE-Q	4.01	1.14	4.58	0.90	-1.89	.064
Food deprivation	1.75	2.11	9.49	13.01	-4.11	< .001
Engagement short	4.06	151.89	-69.66	148.47		
Engagement long	-4.62	176.78	-41.07	207.48		
Disengagement short	-36.70	199.53	-6.23	171.31		
Disengagement long	-1.94	172.06	-119.53	183.12		

Note. BMI = Adjusted Body Mass Index, EDE-Q = total score on the Eating Disorder Examination Questionnaire, Food deprivation = time since eaten in hours.

Bayesian hypotheses testing

Bayesian independent samples *t*-tests were used to explore the differences between the restrictive and purging subtypes of anorexia nervosa. Firstly, we examined the BF_{10} factor for the difference in attentional engagement on the short image time trials, and difficulty to disengage on the long image time trials. The evidence for a difference between the two groups on attentional engagement towards food on the short image time trials is weak, with a BF_{10} of 0.96. Thus, there is no evidence for a difference between patients with AN-R and AN-BP in their attentional engagement on the short image time trials. The evidence for a difference in attentional disengagement on the long image time trials is anecdotal with a BF_{10} of 2.85. Thus, there is anecdotal evidence that the patients with AN-BP have less difficulty to disengage from food cues than the patients with AN-R. Secondly, we examined the BF_{01} factor to examine the evidence for the null hypothesis of no difference between the two groups on attentional engagement on the long image time trials, and attentional disengagement on the short image time trials. The BF_{01} were 2.91 and 3.13 respectively. Thus, there is anecdotal/moderate evidence in favor for no difference between patients with AN-R and AN-BP with regard to their attentional engagement on the long image time trials, and attentional disengagement on short image time trials.

Discussion

The aim of the current study was to examine whether adolescents with AN differ in their AB for food compared to individuals without an eating disorder. In this study we used a paradigm that was specifically designed to differentiate between attentional engagement and attentional disengagement. The main findings of the study can be summarized as follows: (1) adolescents without an eating disorder showed an engagement bias to food relative to neutral cues on the short image time trials (100 ms), but not on the other AB measures, (2) patients with AN did not show an AB on any of the AB measures, (3) patients with AN showed less attentional engagement with food cues than adolescents without an eating disorder on the short image time (100 ms) trials, but not on the long image time (500 ms) trials, and (4) patients with AN and adolescents without an eating disorder did not differ in their difficulty to disengage from food cues on the short or long image time trials. Furthermore, explorative analyses showed that patients with AN-BP had less difficulty to disengage from food cues than patients with AN-R on the long image time trials; no differences were found between patients with AN-R and AN-BP on the other AB measures.

In line with our hypothesis, patients with AN showed less attentional engagement with food cues than adolescents without an eating disorder. Previous studies, did not show consistent differences in AB between patients with AN and comparison groups (Giel et al., 2011; Kim et al., 2014; Veenstra & de Jong, 2012). That a difference was found in AB for food between patients with AN and adolescents without an eating disorder in the current study might be due to using an AB measure that is able to distinguish between attentional engagement and attentional disengagement. However, since the difference in attentional engagement was found on trials were the images were shown for a short time period (100 ms), it might also be that part of the previous studies did not find a difference because they did not use such a short stimulus presentation time. Both patients with AN as well as adolescents without an eating disorder did not show an attentional engagement to food when the images were shown for a relatively longer time period (500 ms). This is in line with theory suggesting that attentional engagement is an early attentional process (Mogg & Bradley, 2016; Pool et al., 2016). Since an AB for food has been suggested to play a role in food intake (e.g., Castellanos et al., 2009; Stockburger, Schmälzle, Flaisch, Bublatzky, & Schupp, 2009), a lack of this bias might play an important role in patients´ ability to restrict their food intake. Since the current design prohibits conclusions about the causal relationships, future studies should further examine the direction of this relationship. A first step to further explore the relationship between AN and AB to food might be to examine whether AB to food can predict changes in eating disorder symptoms over time, or whether eating disorder symptoms can predict changes in AB. Furthermore, it might be important to examine whether modification of this decreased attentional engagement, for example by means of attentional bias modification tasks (e.g., Price, Greven, Siegle, Koster, & De Raedt, 2015), influences patients' eating behavior.

Inconsistent with our hypothesis, patients with AN did not differ from adolescents without an eating disorder in difficulty to disengage from food cues. Importantly, in the current study neither patients with AN nor adolescents without an eating disorder showed a significant disengagement bias from food cues. Thus, perhaps the more unexpected finding is that the adolescents without an eating disorder did not show a difficulty to disengage from food cues. Disengagement from food cues has been suggested to be a more top-down controlled process (Mogg & Bradley, 2016), and both groups thus seem to be able to control their attention to the same degree. Once their attention is on a food cue they do not differ in their tendency to keep looking at it. In healthy weight individuals, the ability to control behavior (e.g., food related attention) has been suggested to be negatively influenced by food deprivation (e.g., Loeber, Grosshans, Herpertz, Kiefer, & Herpertz, 2013). As such a disengagement bias for food cues might be specifically found when individuals have not eaten for a long time. In the current study, adolescents without an eating disorder ate, on average, a little less than 2 hours before the study, which is most likely not long enough for them to become food deprived and physically hungry. This might also explain the lack of correlation between food deprivation and AB scores in adolescents without an eating disorder. It might be that after a longer period of food-deprivation (e.g., 8 hours), non-eating disordered individuals do show difficulty to disengage their attention from food. Patients with AN did not eat for 4 hours on average, and also did not show an attentional disengagement bias. It might be that patients with AN are less influenced by food deprivation than non-eating disorder comparisons, and that a difference in difficulty to disengage might be found when both groups are in a state of food deprivation. Yet, future studies should further examine this hypothesis. As a first step, it could be examined whether a healthy non-eating disordered group that fasted for 8 hours differs in their attentional disengagement from a healthy non-eating disordered group that ate directly prior to the study. Additionally, it might be beneficial to combine the ARDPEI task with eye-tracking to get more information about individuals viewing behaviors in response to food images. However, it should be kept in mind that this will provide insight into overt attention, and not covert attention that reaction time tasks such as the ARDPEI aim to measure (Posner, 1980).

The current findings on disengagement from food cues seem in contrast with previous research showing that for AN participants, food cues resulted in task interference in a single target Rapid Serial Visual Presentation (RSVP) paradigm (Neimeijer, Roefs, & de Jong, 2017). Specifically, this earlier study showed that patients with AN were more likely than adolescents without an eating disorder to make errors in identifying a target later in the stream when the target was preceded by a food image. Although this interference effect might be explained by an AB for the food cue, it may also be due to cognitive avoidance of the food cue (De Ruiter & Brosschot, 1994). Since no difficulty to disengage was found in patients with AN in the current study, it seems that the Neimeijer et al. (2017) finding could be due to processes other than spatial AB for food cues. Nevertheless, since ARDPEI trials in which attention was anchored proximal to the food image seem similar to RSVP trials with food distractors, one still might expect that patients would make more errors or respond slower to the target in these ARDPEI trials. However, a post-hoc examination showed no differences in RTs between trials with a food image and the same type of trials with a neutral image . Additionally, patients with AN did not differ in this regard from the adolescents without an eating disorder. Several differences between the two tasks might explain these results. For example, it has been suggested that some time needs to pass between the target and the distractor for an interference effect to take place (MacLean & Arnell, 2012). In the ARDPEI the food image and the target follow each other directly and as such no interference effect might appear. Additionally, it has been suggested that performing a task with a high cognitive load results in increased distractibility (Lavie, 2005). During the RSVP participants have to identify the content of the target image which appears at an unpredictable time. In other words, they have to process the content of all the images in the stream to make sure that they do not miss the target. The RSVP thus likely produces a greater cognitive load than the ARPDEI, during which participants have to identify the orientation of two red bars and can ignore all other information, thereby resulting in an increased interference effect in patients with AN. When interpreting the apparent contrast in findings between the current study and the prior study of Neimeijer et al. (2017) it is important to consider that different types of AB tasks were used. The earlier study of Neimeijer et al. (2017) used a task designed to assess temporal attention bias, whereas the ARDPEI that was used in the current study was designed to assess spatial attentional bias, and both types of AB may be differentially involved in (dysfunctional) eating behavior (Neimeijer, de Jong, & Roefs, 2013).

An additional aim of the current study was to explore differences between patients with AN who mainly restrict their food intake, and patients who additionally show binge eating episodes and use purging behaviors. Since patients with AN-R and AN-BP were expected to differ in their eating behaviors, it was expected that they might also differ in their attention to food cues. Interestingly, the AN-BP patients in the current study consisted of patients with AN who use purging behaviors, but only one patient who was known to have objective binge eating episodes. Nevertheless there is some indication that AN-BP and AN-R patients in the current study differ in their eating behavior. Firstly, patients with AN-BP reported a much longer time since their last meal (i.e., food deprivation) than patients with AN-R. Secondly, AN-BP patients had a higher BMI than AN-R patients and there was a marginally significant difference in eating disorder pathology between the two groups. We found that patients with AN-BP showed less difficulty to disengage from food cues on the long image time trials than patients with AN-R. This finding should be interpreted with some caution since the AN-BP group was quite small. Additionally, the evidence from the Bayesian analyses for a difference in attentional disengagement was only anecdotal. Even so, the current study provides some first evidence that patients with AN-R and AN-BP might differ in their AB to food. Importantly, the negative score on the difficulty to disengage of the patients with AN-BP indicates that when their attention is on a position where a food cue appears, they subsequently redirect their attention away from the food cue. It might be that patients with AN-BP are able to restrict their food intake for a longer time than patients with AN-R due to this attentional disengagement from food cues. However, it might also be that they have a stronger tendency to avoid food which is reflected by their AB, but also by their purging behavior.

The current study has several strengths. One important strength is that this is one of the few studies examining spatial AB for food in patients with AN. Importantly, a large group of patients with AN was included providing enough power to find medium sized effects, and individually matched comparisons were included based on gender, age and educational level. Another important strength is that the current study uses a task that was designed to distinguish between attentional engagement and disengagement. However, there are also some limitations that should be considered. Importantly, the current study is cross-sectional, and we can thus not specify the direction of the found relationship. Another limitation of this study regards participant selection. Even though we specifically recruited adolescents without eating problems for the control group, this was not verified with a diagnostic (EDE) interview. However, BMI was checked and had to be within healthy ranges, and the EDE-Q was used to assess eating disorder symptoms. Another potential limitation is that pictures of meat were included in the task regardless of whether participants were vegetarian. Post-hoc analyses restricted to participants who were not vegetarian resulted in similar findings as the analyses of the total group , nevertheless future studies might want to take vegetarianism into account in the image selection. Lastly, results of the exploratory analyses should be interpreted with some caution since the observed power of these analyses was 64%, due to the relatively small size of the AN-BP group.

Conclusion

To conclude, this is the first study to examine an AB for food in patients with AN with a task that is specifically designed to distinguish between attentional engagement and attentional disengagement. The main finding of the current study is that patients with AN have less attentional engagement with food cues when these cues were shown only briefly. The comparison group specifically showed an attentional engagement bias for food cues when they were shown only briefly, indicating that patients with AN lack a bias that is related to healthy eating behavior. Thus, (in)attention to food might play an important role in the restrictive eating pattern of patients with AN. Furthermore, this is the first study to explore differences between patients with AN-R and AN-BP in AB to food cues. There was some indication that patients with AN-BP showed a tendency to redirect their attention away from food cues when their attention was on a position where a food cue appeared. The current study provides some first evidence that it might be important to differentiate between AN-R and AN-BP patients when examining characteristics such as an AB to food. Future studies should further examine the direction of the relationship between decreased attentional engagement with food cues and anorexia nervosa. All in all, this study provides a first indication that it might be important to integrate modifying attention to food in current treatments, for example by means of attentional bias modification tasks (e.g., Price et al., 2015).

Appendix

Table A. *Mean reaction times for all trial types per group*

			Patients with AN		Comparison group	
			M	***SD***	***M***	***SD***
ImageTime	**ImagePosition**	**ProbeImagePos**		**Food**		
100	**Distal**	**Same**	870.55	168.16	854.06	159.14
		Different	860.96	184.62	943.84	221.44
	Proximal	**Same**	892.10	182.24	930.95	225.35
		Different	886.35	171.18	881.64	164.83
500	**Distal**	**Same**	845.02	178.50	823.61	166.02
		Different	855.31	193.24	885.45	205.52
	Proximal	**Same**	868.79	185.87	860.99	178.60
		Different	829.36	192.08	818.01	158.30
			Patients with AN		**Comparison group**	
			M	***SD***	***M***	***SD***
ImageTime	**ImagePosition**	**ProbeImagePos**		**Neutral**		
100	**Distal**	**Same**	861.60	167.48	895.73	207.37
		Different	870.12	179.78	914.02	190.22
	Proximal	**Same**	864.69	166.52	885.53	185.92
		Different	885.18	172.99	871.31	178.98
500	**Distal**	**Same**	814.00	174.00	836.23	168.46
		Different	840.35	197.74	867.64	182.83
	Proximal	**Same**	836.99	182.75	863.63	176.69
		Different	829.33	180.72	823.82	169.32

Table B. *Correlations between the AB scores in patients with AN and the comparison group separately*

Patients with AN (*n* = 67)				
	Food deprivation	**Engagement short**	**Engagement long**	**Disengagement short**
Engagement short	-.05	-	-	-
Engagement long	.05	.04	-	-
Disengagement short	.12	-.14	.00	-
Disengagement long	.10	.02	-.03	.19
Comparison group (*n* = 68)				
	Food deprivation	**Engagement short**	**Engagement long**	**Disengagement short**
Engagement short	-.09	-	-	-
Engagement long	.13	-.02	-	-
Disengagement short	-.04	-.30*	-.08	-
Disengagement long	.02	-.29*	.16	-.27*

Note. * p <.05, Food deprivation = time since eaten in hours.