Temptation and restraint

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DOI:
10.33612/diss.95014556

Publication date:
2019

Chapter 7

Visual attention to food cues and the course of anorexia nervosa

Based on: Jonker, N. C., Glashouwer, K. A., Ostafin, B. D., & De Jong. P. J. (under review). Visual attention to food cues and the course of anorexia nervosa.

Abstract

Previous research has shown that adolescents with anorexia nervosa (AN) show reduced attentional engagement with food cues (Jonker et al., 2019). To examine the relevance of reduced attentional engagement in the persistence of AN, this study tested whether (i) an increase in attentional engagement with food cues is related to improvement in symptoms and BMI, and whether (ii) relatively low attentional engagement is related to persistent AN symptomatology. This study examined the same sample of adolescents with AN (N = 69) from the study of Jonker et al. (2019). Eating disorder symptoms, BMI, and attention to food cues were measured during baseline and at one year follow-up. Although patients overall showed a substantial improvement in symptoms and BMI from baseline to follow-up, their low attentional engagement with food cues remained generally unchanged. Change in attentional engagement with food was not related to change in symptoms, nor was low baseline attentional engagement with food predictive of symptom persistence. These findings indicate that improvement in AN symptoms does not seem to depend on normalization of attention to food. Future studies should examine related issues, such as whether lowered attentional engagement increases patients' risk for relapse following treatment.

Introduction

Anorexia Nervosa (AN) is a severe mental disorder that mostly affects adolescent girls and young women (Schmidt et al., 2016). Patients with AN are characterized by an extreme restriction of food intake and an intense fear of gaining weight or becoming fat despite being underweight or having lost a significant amount of weight (American Psychiatric Association, 2013). The burden of disease is high for patients as well as their families (Schmidt et al., 2016). Leading therapies for AN, cognitive behavioral therapy and family based treatment, show only limited effectiveness, and relapse after treatment is common (Brockmeyer et al., 2017; Khalsa, Portnoff, McCurdy-McKinnon, & Feusner, 2017; Zipfel et al., 2014). To improve the effectiveness of treatment it is important to increase our understanding of the mechanisms that underlie the development and persistence of eating disorder symptoms (Jansen, 2016). A process that has been of interest in this regard is patients' spatial attentional bias to food (e.g., Lloyd & Steinglass, 2018). In this study we took a prospective approach to examine the role of attentional bias to food cues in changes in symptoms of patients with AN.

People are biased in their attention to cues that are motivationally salient (Pool et al., 2016). Accordingly, several studies showed that when individuals with a healthy weight are deprived of food (i.e., when they are hungry) they show an attentional bias (AB) to food cues (Castellanos et al., 2009; Giel et al., 2011; Nijs, Muris, Euser, & Franken, 2010; Stockburger, Weike, Hamm, & Schupp, 2008; Tapper, Pothos, & Lawrence, 2010; but see, Leland & Pineda, 2006). In addition, there is evidence that healthy weight individuals no longer show an AB for food when they are satiated (Castellanos et al., 2009; Stockburger et al., 2008). This is in line with the suggestion that the reward value of food increases with hunger and decreases with satiation (Charbonnier et al., 2018). Thus, when hungry, an increased reward value of food could strengthen the attention-grabbing properties of food, thereby lowering the threshold for food consumption (cf., Berridge, 2009). From this perspective, heightened AB for food in response to food deprivation might be seen as an adaptive mechanism. In contrast to such adaptive processes, patients with AN are able to restrict their food intake even when they are deprived of food. It is possible that their ability to refrain from food is facilitated by a decreased AB to food cues (Lloyd & Steinglass, 2018). Consequently, low attention to food might be a relevant factor in the persistence of AN and might compromise the efficacy of interventions that are aimed to normalize food-intake of patients with AN.

Previous research has provided mixed evidence for a decreased AB for food in patients with AN (Giel et al., 2011; Jonker et al., 2019; Kim et al., 2014; Veenstra & de Jong, 2012). However, most of these studies relied on AB measures that cannot differentiate between the contribution of early (bottom-up) directed orientation towards food cues (i.e., attentional engagement) and later (top-down) controlled maintenance or redirection of attention (i.e., attentional disengagement) (Grafton & MacLeod, 2014). If these two attentional processes are differentially involved in dysfunctional eating behavior, measures that fail to differentiate between them might provide contrasting and divergent results.

An AB task that was specifically designed to distinguish between attentional engagement and attentional disengagement is the Attentional Response to Distal vs. Proximal Emotional Information (ARDPEI) task (Grafton & MacLeod, 2014). Pointing to the importance of differentiating between both components of AB within the context of eating disorders, a recent study that used the ARDPEI to index AB indicated that patients with AN showed differential attentional engagement to food, but no differential difficulty to disengage from food (Jonker et al., 2019). Specifically, the results showed that when the cues were shown briefly (100 ms), adolescents without an eating disorder showed significantly more attentional engagement with food cues than with neutral cues, and patients with AN showed less attentional engagement with food cues than adolescents without an eating disorder (Jonker et al., 2019). These findings are in line with the idea that a lack of attentional engagement to food facilitates dysfunctional food restriction as seen in patients with AN.

An important next step would be to examine whether low attentional engagement with food cues is involved in the persistence of AN. In this case, an improvement in eating disorder symptoms would be related with an increase in attentional engagement to food. The current study used a longitudinal design to test whether a reduction in symptoms of AN is indeed paralleled by an increase in attentional engagement to food cues from baseline to one-year follow-up. We also examined the potential impact of low attention to food in the refractoriness of AN by testing whether relatively weak attentional engagement with food cues at baseline is related to less improvement in eating disorder symptoms and BMI from baseline to one year follow-up.

Method

Participants

Participants were 69 adolescents (67 females, M_{age} = 15.55, SD_{age} = 1.70, range = 12 – 22), who fulfilled DSM-5 criteria for Anorexia Nervosa or atypical Anorexia Nervosa, and who were referred for inpatient or outpatient treatment at the Accare department of eating disorders between June 2015 and June 2017. Patients were eligible for participation in the study if they were between the ages of 12 and 23 years. There were no additional inclusion or exclusion criteria. 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). Based on the EDE interview 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). Of the initial 69 participants who were assessed at baseline 62 participants (90%) completed the EDE interview at follow-up, of which 60 participants completed the full follow-up assessment (87%; M_{age} = 16.47, SD_{age} = 1.57). Patients who dropped-out did so because they were not doing well and felt it was too much (3) or they just started a new intensive treatment program and felt they could not manage (3). One patient did not provide a reason. At follow-up 34 patients (49.3%) were still in treatment, 27 were not (39.1%), and 1 patient did not provide this information.

Materials

Body Mass Index

Adjusted BMI was calculated [(actual BMI/Percentile 50 of BMI for age and gender) x 100] to make the BMI’s comparable over the age range of group (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 smaller than 85% are considered as underweight, and between 85% and 120% as healthy weight (Van Winckel & Van Mil, 2001).

Eating disorder symptoms

Eating disorder symptoms were assessed with the Dutch child version of the Eating Disorder Examination (EDE) interview (Bryant-Waugh et al., 1996; Decaluwé & Braet, 1999). During intake patients were diagnosed based on the EDE interview, which was therefore also used as post-measure of eating disorder pathology. An average score of the 22 diagnostic items of the EDE was used as general index of eating disorder symptoms. Additionally, a Dutch version of the Eating Disorder Examination Questionnaire 6.0 (EDE-Q; Fairburn & Beglin, 2008) was used to assess self-reported eating disorder pathology. Adaptations were made to the wording of some items of the EDE-Q to make it appropriate for children and adolescents. These adaptations were made by the first and second authors and were comparable to adaptations that have been made to the previous version of the EDE-Q (Jansen, Mulkens, Hamers, & Jansen, 2007). An average score of the 22 items of the EDE-Q was used as a general index of eating disorder pathology (cf. Aardoom et al., 2012). The average score can range from 0-6, and the internal consistency of this total EDE-Q score at baseline and follow-up was excellent (Cronbach's alpha = .97 and .93 respectively).

Attentional bias to food

Attentional bias to food cues was measured with the Attentional Response to Distal vs. Proximal Emotional Information (ARDPEI) task (Grafton & MacLeod, 2014). Each trial started with two white squares, one left and one right from the middle of the screen, against a middle gray background. One of these squares contained a red outline to which participants had to focus their attention. This outline appeared with equal probability in either the left or the right white square. After a second a red horizontal or vertical line (the anchor) appeared for 150 ms in this red outline. Hereafter two images replaced the white squares for 100 ms (i.e., short cue delay) or 500 ms (i.e., long cue delay). These images were a food or neutral image (i.e., representational image) and an abstract art image. The images appeared with equal probability in either the right or left white square. Last, the probe – another red horizontal or vertical line – appeared on the left or right side of the screen. Participants were instructed to identify whether the probe had the same orientation as the anchor (i.e., both horizontal or both vertical) or a different orientation than the anchor (one horizontal and one vertical) by pressing the corresponding button on the USB response box. The probe remained on the screen until participants responded and a new trial started 1000 ms after the response. The task consisted of 128 trials and was programmed in E-prime 2.0 (Schneider et al., 2002). The task was performed on a HP Probook 650 G1 running Windows 7 on a 15-inch monitor (1366x768). Screen refresh rate was set at 60 Hz. See Figure 1 for an example trial.

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 et al., 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 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).

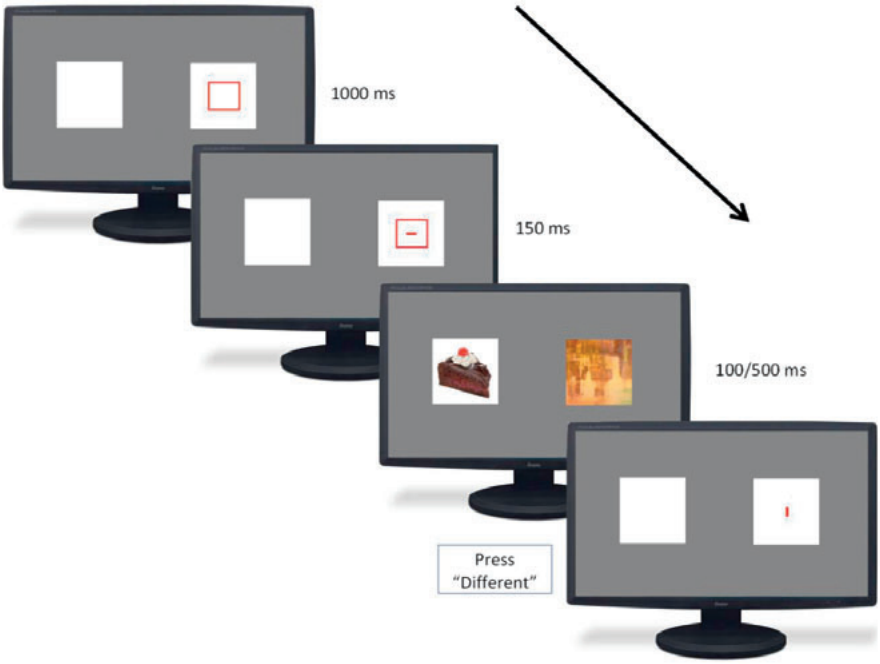

Figure 1. Example of a food trial where the food image appears distal to the anchor, the probe has a different position than the food image, and the orientation of the anchor and the probe is different.

Data reduction

Following 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. In total four AB scores were calculated, an engagement bias for the short (100 ms) and long (500 ms) Image Time trials, and a disengagement bias for the short and long Image Time trials.

Engagement biases were calculated based on trials where participants had to look away from their initial focus point to see the image. Thus, on the trials in which the image position was distal from the anchor position. 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 trials in which participants automatically saw the image since it appeared in the same location as the anchor. Thus, from the trials in which the image position was proximal to the anchor position. 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). The current study is part of a larger project on characteristics that might play a role in disordered eating behavior and data of the baseline measure of this group have already been reported (Jonker et al., 2019).

Baseline

Participants and their parents (when participants were younger than 18) signed informed consent forms. They provided consent for the baseline measure and to be approached for and participate in the follow-up measure one year later. The Eating Disorder Examination interview was part of the regular intake procedure at the Accare department of Eating Disorders and permission was asked to use this information for the current study. Baseline assessment took place at the treatment center as soon as possible after intake (median 53 days after intake). Since the duration from intake to start of treatment usually takes about 4 weeks, baseline assessment for most patients took place at the start of treatment or up to 4 weeks after. However, a couple of patients participated later for reasons such as hospital admittance. Therefore, BMI during intake as well as during baseline assessment will be reported. During baseline assessment, participants performed the ARDPEI and completed the EDE-Q. Last, patients' height and weight were measured.

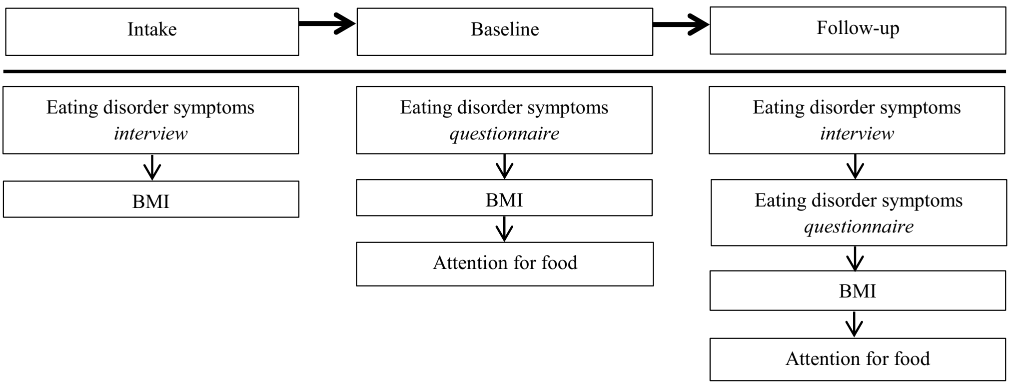

Figure 2. Study design

Follow-up

Approximately 11 months after the baseline assessment, patients were approached for the follow-up assessment. Patients who did not want to participate were asked for the reason and given the option to participate in only the interview part of the follow-up. Patients who wanted to participate did so at the treatment center or at their home if they preferred (n = 2). Follow-up assessment took place approximately one-year after the baseline assessment (median 373 days after baseline). The follow-up session followed the same procedure as baseline, with participants performing the ARDPEI and completing the EDE-Q. After these, the EDE interview was performed. Last, participants' height and weight were measured.

Analyses

Missing data assessment

We examined differences in baseline eating disorder symptoms, BMI, and attentional engagement between participants who dropped-out and those who participated in the follow-up assessment by performing independent samples *t*-tests.

Change in symptoms, BMI and AB

Paired samples *t*-tests were performed to examine whether patients with AN on average showed a decrease in eating disorder symptoms and an increase in BMI between intake or baseline and follow-up, and whether the AB to food on average changed between baseline and follow-up. Additionally, the relationship between the change in symptoms and change in BMI was assessed with bivariate correlational analyses. Note that a negative difference scores of change in eating disorder symptoms means a decrease in symptoms, and thus an improvement. A positive difference score for change in BMI means an increase in BMI and thus an improvement. Last, we tested whether the amount of days between baseline and follow-up assessment should be included as covariate in the analyses by examining its relation to change in eating disorder symptoms as measured with the interview and questionnaire and change in BMI.

Hypotheses testing

Three linear regression analyses were conducted to test whether a reduction in symptoms of AN was paralleled by an increase in visual attention to food cues from baseline to one-year follow-up and whether relatively weak engagement with food cues at baseline would be related to less improvement in eating disorder symptoms and BMI from baseline to one year follow-up.

Model 1) Change in eating disorder symptoms as reported on the interview (change = follow-up – intake) was entered as dependent variable and intake EDE score as control variable in step 1. Baseline AB to food was entered as independent variable in step 2, and change in AB for food was added in step 3.

Model 2) Change in eating disorder symptoms as reported on the questionnaire (change = follow-up – baseline) was entered as dependent variable and baseline EDE-Q score as control variable in step 1. Baseline AB to food was entered as independent variable of interest in step 2, and change in AB to food was added in step 3.

Model 3) Change in BMI between baseline and follow-up (change = follow-up – baseline) was entered as dependent variable and baseline BMI score as control variable in step 1. Baseline AB to food was entered as independent variable of interest in step 2, and change in AB to food was added in step 3.

The first research question, whether a reduction in symptoms of AN would indeed be paralleled by an increase in visual attention to food cues from baseline to one-year follow-up was answered with the outcomes of step 3 of model 1-3. The second research question, whether relatively weak engagement with food cues at baseline would be related to less improvement in eating disorder symptoms and BMI from baseline to one year follow-up was answered with the outcomes of step 2 of model 1-3. All independent variables were centered before being entered in the models.

Because patients with AN have been found to differ from adolescents without an eating disorder on attentional engagement for food cues when food is shown for 100 ms (Jonker et al., 2019), the engagement measure was the main predictor variable for both research questions. That is, we did not include attentional engagement to food cues 500 ms, attentional disengagement to food cues 100 ms, and attentional disengagement to food cues 500 ms. However, when a model showed that baseline attentional engagement to food (question 1) or change in attentional engagement to food cues (question 2) was a significant predictor of change in eating disorder symptoms or BMI, we planned to additionally explore whether this finding was specific to attentional engagement to food 100 ms. Specifically, we planned to also run a model including the other three bias measures in these cases.

For all models, the assumptions of the multiple regression analyses – multicollinearity, a linear model, homoscedasticity, and normal distribution of the residuals – were checked and any deviations from these assumptions were reported. Since we performed three inferential tests per dependent outcome a Bonferroni-Holm correction was applied to control for increased familywise error rate. That is per model the smallest *p*-value was tested against an alpha of .016, the one following against .025, and the largest against .05.

To complement the results of the statistical analyses following the common frequentist approach, results were also reported with the Bayesian approach. Although the analyses following the frequentist approach have 83% power to find a medium effect size, the power for a small effect size is only 19%. Complementing these analyses with the Bayesian approach increases the confidence in our results, and, in the case of non-significant findings, provides information about the strength of the evidence for the null-hypothesis. Bayesian analyses were conducted with JASP (JASP Team, 2018). Prior was set at the recommended default r = .354 (JASP Team, 2018). We will report BF_{10}, which quantifies the probability of the data under the model including the variable that was included in that step (e.g., Model 1-3 step 2; engagement to food on the short image trials) relative to the model without that variable (i.e., variables included in step 1). It thus provides the Bayesian equivalent to the *F*-change statistic. 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 that the data are more likely under the model including the variable (Wagenmakers et al., 2017). A Bayes factor between 1/3 – 1 *anecdotal*, 1/10 – 1/3 *moderate*, 1/30 – 1/10 *strong*, 1/100 – 1/30 *very strong*, and less than 1/100 *extreme* evidence that the data are more likely under the model not including the variable.

Results

Data reduction

Outliers were deleted following Grafton and MacLeod (2014). *Pretest:* Two patients were removed (48% and 63% correct responses) from the pre-test because they fell more than 2.58 *SD* below the mean amount of correct responses. After removing these patients, mean accuracy rate was 92% (*SD* = 8%). Incorrect trials were deleted. Of the correct trials, 2.4% of the trials 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. 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 patient who had such fast RTs, and this was only on 1.8% of the trials. *Follow-up:* One patient was removed from follow-up because of the low accuracy rate (50.8%). This participant was also one of the two patients who were removed from baseline. After removing this patient mean accuracy was 94% (*SD* = 4%). Of the correct trials 2.3% 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. Lastly, four trials (<0.001%) contained reaction times faster than 200 ms and were therefore deleted.

Missing data assessment

Nine participants did not participate in the follow-up assessment, of which two however did participate in the EDE interview at post-test. Independent samples *t*-tests showed no significant group difference in EDE score ($t(12{,}28) = 1.39$, $p = .188$), EDE-Q score ($t(65) = 1.78$, $p = .080$), and BMI ($t(65) = 1.80$, $p = .077$) on pre-test between people who did and did not participate in the follow-up of the study. Nevertheless, since the sample sizes are small, it should be mentioned that there seemed to be a trend for higher self-reported eating disorder symptoms and higher adjusted BMI in the patients who did not participate in the post-test. The groups did not differ in attentional engagement on pre-test ($t(63) = 0.11$, $p = .915$).

Change in symptoms, BMI and AB

To examine whether patients on average changed between intake, baseline and follow-up in their BMI, eating disorder symptoms, and attentional bias to food, paired samples *t*-tests were performed. Bonferroni-Holm correction was applied to correct for the amount of *t*-tests that were performed. Patients showed a decrease in eating disorder symptoms between intake and follow-up as measured with the EDE interview (Table 1). Further, they showed a decrease in eating disorder symptoms as measured with the EDE-Q, and an increase in BMI between baseline and follow-up. There was a small change in BMI between intake and baseline, although after alpha correction this was not significant. Attentional engagement for food cues when food is shown for 100 ms did not change between baseline and follow-up, nor did the other three attentional bias measures.

Correlational analyses showed that change in BMI between intake and follow-up was not significantly related to change in eating disorder symptoms as measured with the interview ($r = -.25$, $p = .061$). Change in BMI between baseline and follow-up was similarly not related to change in eating disorder symptoms as measured with the questionnaire ($r = .06$, $p = .629$).

However, the sample included patients who were not underweight during baseline assessment, including patients with an atypical AN diagnosis (n = 14) and patients who gained weight between intake and baseline assessment (n = 8). As we expected that AB to food plays a role in patients with AN who restrict their food intake even when deprived of food, we decided to additionally examine these hypotheses in the sub-group of patients who were underweight at baseline (n = 37). In this group of patients, change in BMI between intake and follow-up was related to change in eating disorder symptoms as measured with the interview (r = -.39, p = .016). Change in BMI between baseline and follow-up was still unrelated to change in eating disorder symptoms as measured with the questionnaire (r = -.02, p = .908).

Table 1. *Group characteristics*

	Intake (*N* = 69)		**Baseline (*N* = 69)**		**Follow-up (*N* = 60)**		**Paired samples *t*-test**			
	M	***SD***	***M***	***SD***	***M***	***SD***	***t***	***p***	***Cohen's d***	***α***
BMI	83.36	12.08	84.69	12.16			2.43	.018	0.29	.01
EDE			84.69	12.16	95.20[a]	15.03	7.37	< .001	0.97	.0083
EDE-Q [b]	3.74	1.10			1.81[c]	1.51	-9.49	< .001	1.22	.0063
Engagement short			4.20	1.12	2.57	1.58	-8.41	< .001	1.09	.0071
Engagement long [b]			-14.65	153.35	-22.31[d]	130.45	-0.29	.77	n.a.	.025
Disengagement short [b]			-13.87	184.10	-2.73[d]	147.09	0.02	.98	n.a.	.05
Disengagement long [b]			-28.97	191.96	-8.03[d]	133.98	0.90	.37	n.a.	.0125

Note. [a] BMI was available for 61 participants at posttest, [b] EDE and attentional bias for food was available for 67 participants at pretest, [c] EDE was available for 62 participants at follow-up, and [d] attentional bias for food was available for 59 participants at follow-up. BMI = Adjusted Body Mass Index, EDE = Eating Disorder Examination interview, EDE-Q = total score on the Eating Disorder Examination Questionnaire.

The amount of days between baseline and follow-up was not related to the change in eating disorder symptoms as measured with the interview (r = -.12, p = .364), as measured with the questionnaire (r = .05, p = 0.685), or related to change in BMI (r = .14, p = .296), and therefore this variable is not included in the analyses as covariate.

Hypotheses testing

Regression analyses showed strong evidence that baseline EDE scores were predictive for change in eating disorder symptoms as measured with the EDE (Table 2, model 1 step 1). Patients with more symptoms at baseline showed a larger improvement over one year. Interestingly, baseline EDE-Q scores were not predictive of change in eating disorder symptoms as measured with the EDE-Q, nor was baseline BMI predictive of change in BMI (Table 2, model 2 and 3 step 1).

<u>Is a reduction in symptoms of AN paralleled by an increase in visual attention to food cues from baseline to one-year follow-up?</u>

Change in eating disorder symptoms as measured with the EDE or EDE-Q, and change in BMI were not paralleled by a change in attentional engagement with food cues (Table 2, model 1-3 step 3).

Is relatively weak attentional engagement with food cues at baseline related to less improvement in eating disorder symptoms and BMI from baseline to one year follow-up?

Baseline engagement bias for food was not predictive of change in eating disorder symptoms as measured with the EDE or EDE-Q, nor was it predictive of change in BMI (Table 2, model 1-3 step 2).

Table 2. *Regression models of complete sample*

Model	Dependent	Step	Independent	*β*	*T*	R^2	F_{change}	*p (F)*	*α*	BF_{10}
1	Change in EDE	1	Baseline EDE	-0.39	-3.11**	0.15	9.68	.003	.0167	20.80
		2	Baseline EDE	-0.39	-3.10**	0.15	0.07	.789	.025	0.31
			Baseline engagement	-0.03	-0.27					
		3	Baseline EDE	-0.40	-3.04**	0.15	0.04	.844	.05	0.38
			Baseline engagement	-0.08	-0.30					
			Change in engagement	-0.05	-0.20					
2	Change in EDE-Q	1	Baseline EDE-Q	-0.24	-1.85	0.06	3.42	.070	.0167	1.34
		2	Baseline EDE-Q	-0.24	-1.85	0.06	0.07	.788	.05	0.36
			Baseline engagement	-0.04	-0.27					
		3	Baseline EDE-Q	-0.25	-1.91	0.07	0.52	.475	.025	0.51
			Baseline engagement	-0.21	-0.76					
			Change in engagement	-0.19	-0.72					
3	Change in BMI	1	Baseline BMI	-0.19	-1.41	0.03	1.98	.165	.0167	0.54
		2	Baseline BMI	-0.17	-1.29	0.06	1.75	.192	.025	0.77
			Baseline engagement	0.17	1.32					
		3	Baseline BMI	-0.16	-1.16	0.07	0.15	.700	.05	0.44
			Baseline engagement	0.27	0.96					
			Change in engagement	0.11	0.39					

Note. ** $p < .01$, $n_{Model1} = 57$, $n_{Model2} = 59$, $n_{Model3} = 58$, Negative change in EDE and EDE-Q symptoms means an improvement, Positive change in BMI means an improvement.

Post-hoc analyses

We performed post-hoc analyses including only patients who were underweight at baseline, and thus had to increase their food intake and weight (Table 3). The power of this analyses was 63% to find a medium effects size. Similar to the main analyses, baseline EDE scores were marginally significantly predictive for change in eating disorder symptoms as measured with the EDE. That is, patients with more symptoms at baseline showed more improvement over one year. Additionally, baseline BMI was not predictive for change in BMI in this subgroup. The findings differed from the main analyses in showing that baseline EDE-Q scores were marginally significantly predictive for change in eating disorder symptoms as measured with the EDE-Q.

Step 3 for all outcome variables showed that there was no relation between change in AB and change in eating disorder symptoms or BMI. Furthermore, there was no significant change in explained variance of change in eating disorder symptoms as measured with the EDE-Q or BMI when baseline engagement with food was included in the model. However, there seemed to be a trend in change in explained variance of change in eating disorder symptoms as reported on the interview when baseline engagement with food was included in the model. The Bayes factor shows that there is anecdotal evidence that patients who had less attentional engagement to food cues showed less improvement in eating disorder symptoms.

To examine the specificity of the finding that attentional engagement with food cues on the short trials was predictive for change in eating disorder symptoms as measured with the EDE, we performed a follow-up analysis in which we examined whether we would find the same predictive validity for the other three attentional bias measures in predicting change in eating disorder symptoms. Attentional engagement for food on the long image time trials ($\beta = 0.09$, $t = 0.54$, $p = .591$, $BF_{10} = 0.39$), and disengagement from food on the short ($\beta = -0.15$, $t = -0.88$, $p = .387$, $BF_{10} = 0.57$), and long image time trials ($\beta = -0.17$, $t = -1.02$, $p = .316$ $BF_{10} = 0.40$) all failed to significantly predict change in eating disorder symptoms as measured with the interview.

Table 3. *Regression models of patients who were underweight at intake*

Model	Dependent	Step	Independent	β	T	R^2	F_{change}	p (F)	α	BF_{10}
1	Change in EDE	1	Baseline EDE	-0.38	-2.29*	0.14	5.25	.029	.0167	2.44
		2	Baseline EDE	-0.45	-2.80**	0.25	4.47	.043	.025	2.04
			Baseline engagement	-0.34	-2.12					
		3	Baseline EDE	-0.45	-2.83**	0.27	1.00	.325	.05	0.60
			Baseline engagement	-0.56	-2.05*					
			Change in engagement	-0.27	-1.00					
2	Change in EDE-Q	1	Baseline EDE-Q	-0.34	-2.09*	0.11	4.37	.044	.0167	2.03
		2	Baseline EDE-Q	-0.40	-2.44*	0.17	2.19	.148	.05	0.90
			Baseline engagement	-0.24	-1.48					
		3	Baseline EDE-Q	-0.40	-2.49*	0.22	2.21	.147	.025	1.01
			Baseline engagement	-0.60	-2.08*					
			Change in engagement	-0.42	-1.49					
3	Change in BMI	1	Baseline BMI	-0.09	-0.50	0.01	0.25	.618	.05	0.35
		2	Baseline BMI	-0.07	-0.39	0.08	2.69	.110	.0167	1.19
			Baseline engagement	0.27	1.64					
		3	Baseline BMI	-0.02	-0.11	0.10	0.62	.436	.025	0.61
			Baseline engagement	0.49	1.52					
			Change in engagement	0.26	0.79					

Note. ** $p < .01$, * $p < .05$, $n_{Model1} = 34$, $n_{Model2} = 36$, $n_{Model3} = 36$, Negative change in EDE and EDE-Q symptoms means an improvement, Positive change in BMI means an improvement.

Discussion

The major findings of the current study can be summarized as follows: (1) patients with AN showed on average an improvement in eating disorder symptoms and BMI after one year but attentional engagement with food cues did not change during this period, (2) change in eating disorder symptoms was not related to change in attentional engagement with food cues (3) attentional engagement with food cues at baseline was not related to the change in eating disorder symptoms or BMI over the course of a year.

In a prior study, we found that patients with AN showed less attentional engagement with briefly (100 ms) presented food cues than adolescents without an eating disorder (Jonker et al., 2019). We expected that such absence of attentional bias to food might facilitate dysfunctional food restriction as seen in patients with AN. In other words, a lowered attentional engagement with food cues may play a role in the persistence of AN and attempts to reduce eating disorder symptoms might be hampered in the absence of a concurrent increase in attention to food cues. To test the validity of these hypotheses, we examined whether improvement in eating disorder symptoms and BMI was paralleled by an increase in attentional engagement with food cues. The current findings did not provide evidence for such a relationship between change in eating disorder symptoms or BMI and a change in attentional engagement with food cues. This trend occurred both for the full sample of patients with AN as well as for the subsample comprising of only patients who were underweight at baseline. In sum, the current study does not support the idea that improvement of AN symptoms and BMI is related to the normalization of attentional engagement with food cues.

As a second approach to examine the relevance of lowered attentional engagement with food cues for the persistence of AN, we tested whether a relatively weak attentional engagement with food cues at baseline would be related to less improvement in eating disorder symptoms and BMI over the course of a year. In the full sample of patients with AN, attentional engagement to food cues was not predictive of change in eating disorder symptoms or BMI. Because we expected that attentional engagement might facilitate food restriction in patients with AN who are underweight and thus deprived of food, we explored whether a relatively weak attentional engagement with food cues would relate to less change in symptoms of patients with AN who were underweight at baseline. In this subsample, there was a trend for the expected relationship in that low attentional engagement with food cues at baseline was related to less improvement on eating disorder symptoms. Similar effects were not present for attentional engagement when food was shown for 500ms or attentional disengagement when food was shown for 100 ms or 500 ms. That is, the relation was specific for attentional engagement when food was shown for 100 ms. This is the same category of attentional bias that differentiated patients with AN from healthy controls at baseline (Jonker et al., 2019). However, the Bayes factor showed that the evidence for this relationship was anecdotal. Taken together with the relatively small sample size that remained after exclusion of patients with a healthy weight at baseline, this finding needs replication before solid conclusions can be drawn.

Although patients showed a large reduction in eating disorder symptoms and BMI between the baseline and follow-up measure, their attentional engagement with food cues did not systematically change between baseline and follow-up. This pattern of results is in line with the suggestion that automatic processes might be difficult to change (Vartanian, Polivy, & Herman, 2004) and that current treatment for eating disorders might have a limited effect on automatic processes (e.g., Neimeijer, de Jong, & Roefs, 2015). It has been suggested that weight restoration in patients with AN does not necessarily coincide with a normalization of eating behavior, and that persisting aberrant eating may increase the risk for relapse (Hansson, Björck, Birgegard, & Clinton, 2011; Lloyd & Steinglass, 2018). As it is expected that attentional engagement with food cues is related to patients' eating behavior, this would explain why no changes were found. It may be that an (unchanged) lack of attentional engagement increases patients' risk for relapse after treatment. The current study was not equipped to examine this because we only assessed individuals at two time points. Future studies should explore the possibility that decreased attentional engagement with food cues might be a risk factor for relapse in patients with AN.

The present study has several strengths. Importantly, a large number of patients with AN was included and a prospective approach was taken to examine the relationship between attention with food and eating disorder symptoms. Furthermore, we used a task that was designed to differentiate between attentional engagement and attentional disengagement. Last, change in eating disorder symptoms was assessed not only with a self-report questionnaire, but also with an interview. Although both measures showed a strong improvement in symptoms, change in BMI was only related to change in eating disorder symptoms reported in the interview. One reason for the discrepant findings is that patients may not always have good insight into their own improvement. For example, it might be that patients report doing well because compared to a year before they consider themselves to be substantially improved but that compared to adolescents without an eating disorder, they still might show a considerable amount of symptoms.

In addition to the study strengths, there are a couple of limitations. First, 10% of patients participating at baseline did not participate in the follow-up. Although this is a relatively small drop-out number (e.g., Glashouwer et al., 2014; Neimeijer et al., 2015), patients who dropped-out reported doing so mainly because they were not doing well. Because patients were not missing at random and the drop-out was limited, no imputation was performed. However, the drop-outs might have influenced the results. Second, the post-hoc exploration of the relationship between attentional engagement and change in eating disorder symptoms and BMI in the group of patients who were underweight at baseline had only limited power to find medium effects (63%). Third, because patients with AN received treatment as usual, diversity in treatment content and targets might have resulted in noise that lowered the chance to find a relationship between attention to food and change in eating disorders and BMI. Future studies should examine whether attentional engagement influences the effectiveness, and/or changes as a result of interventions specifically aiming at changing eating behavior, such as food exposure.

To conclude, the current study shows no evidence that the improvement of eating disorders symptoms and BMI of patients with AN critically depends on the normalization of the attentional bias for food cues. Further, the study provided preliminary evidence that a lack of attentional engagement with food cues is prospectively related to the persistence of anorexia nervosa in patients who are underweight. However, this finding should be interpreted with caution because of the relatively small sample size. Patients showed a strong improvement in eating disorder symptoms and BMI, but overall the attentional engagement with food cues remained unchanged. As it has been suggested that patients might persist in aberrant eating even after weight restoration, such unchanged aberrant eating behavior might explain the unchanged attentional engagement with food cues. Moreover, since persisting aberrant eating may increase the risk for relapse (Hansson et al., 2011; Lloyd & Steinglass, 2018), it should be examined if the unchanged lack of attentional engagement increases patients' risk for relapse.

Appendix

Table A. *Mean reaction times for all trial types on pre- and posttest*

			Pretest		**Posttest**	
			M	***SD***	***M***	***SD***
ImageTime	**ImagePosition**	**ProbeImagePos**		**Food**		
100	**Distal**	**Same**	875.32	171.91	752.99	135.51
		Different	861.77	133.14	729.27	133.14
	Proximal	**Same**	894.83	188.37	742.95	136.64
		Different	885.71	177.56	752.09	132.15
500	**Distal**	**Same**	838.54	180.43	690.36	126.66
		Different	862.59	201.31	718.04	133.89
	Proximal	**Same**	874.26	195.00	715.40	143.21
		Different	834.38	201.30	700.04	124.63
ImageTime	**ImagePosition**	**ProbeImagePos**		**Neutral**		
100	**Distal**	**Same**	863.85	167.32	741.29	150.06
		Different	863.41	182.80	739.89	139.29
	Proximal	**Same**	863.96	172.21	733.61	128.22
		Different	889.10	178.29	750.79	138.68
500	**Distal**	**Same**	816.94	182.66	689.98	140.90
		Different	844.30	206.22	720.40	157.97
	Proximal	**Same**	837.83	186.36	716.35	152.67
		Different	829.76	185.89	711.44	170.35

Note. $N = 59$.