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Reduced automatic approach tendencies towards task-relevant and task-irrelevant food pictures in Anorexia Nervosa

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ABSTRACT

Background and objectives: Anorexia Nervosa (AN) patients are characterized by an excessive restriction of their food-intake. Prior research using an Affective Simon Task (AST) with food as a task-irrelevant feature, provided evidence for the view that AN patients' ability to refrain from food is facilitated by reduced automatic approach tendencies towards food. However, because food was task-irrelevant (i.e., participants had to base their reaction on the perspective of the picture and not on its content), the findings may in fact reflect a relatively strong ability to ignore the content of the food stimuli rather than weakened approach towards food per se. Therefore, this study also included a Stimulus Response Compatibility (SRC) task with food as task-relevant feature that could not be ignored, because the required response depended on the [food vs non-food] content of the pictures.
Methods: AN spectrum patients (n = 63), and a comparison group of adolescents without eating pathology (n = 57) completed both a SRC task with food as task-relevant feature, and an Affective Simon Task AST with food as task-irrelevant feature.
Results: AN patients showed reduced approach tendencies for high caloric food. Only the SRC uniquely predicted the presence of AN.
Limitations: Comparison between tasks was hampered because the SRC only included high caloric food stimuli, whereas the AST included high and low caloric food stimuli.
Conclusion: Patients with AN are characterized by weakened automatic approach of high caloric food. This might 'help' restrict their food-intake even in a condition of starvation.

Anorexia Nervosa (AN) is characterized by a low body weight and a fear of gaining weight. Patients show a disturbance in the way their body weight or shape is experienced, undue influence of body weight or shape on self-evaluation, or denial of the seriousness of the current low body weight (American Psychiatric Association, 1994). A critical question is how individuals with AN manage to succeed in maintaining a restrictive eating pattern, while they actually are in a state of starvation. Food generally has a high reward value, even more for people who have been deprived of food (Stroebe, Papies, & Aarts, 2008), yet individuals with AN manage to overcome the habitual biological drive to eat. One possible factor in the successful restriction of food intake in individuals with AN might be that they show a weakened automatic approach response towards food. Subsequently, repeated food deprivation in general and repeated avoidance of high fat foods specifically can, over time, develop into a persistent habit through a self-reinforcing process: The initial weight loss of individuals with AN provides evidence of impressive self-control and personal accomplishment, leading to enhanced self-esteem. In addition, many individuals who develop AN describe receiving compliments at the beginning of their successful efforts at weight loss. Over time, dieting behavior might become a habit: it takes on rewarding properties itself while requiring little cognitive effort (Walsh, 2013). The weakened automatic approach response towards food could also be a consequence of AN: starvation and repeated exposure to food without eating might have led to the loss of the incentive value of food (Pinel, Assanand, & Lehman, 2000). Although this is initially a consequence, it could develop into a maintaining factor of the disorder.

Prior studies on automatic approach tendencies in the context of AN

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have used Affective Simon tasks (AST). In this paradigm, food is a task-irrelevant feature; that is, participants' response requirements are defined by another feature than food/non food (e.g., format of picture being portrait vs. landscape), while the food/non-food dimension varies over stimuli and is critical in computing the AST-effect. Using the AST, it has been found that adolescents with AN indeed showed weaker automatic approach tendencies towards pictures of both high and low caloric food items than the comparison group with no eating disorder (Veenstra & de Jong, 2011). In another study among adult patients with AN a similar pattern of results was found. Whereas control participants showed an automatic approach bias towards food, individuals with AN did not show such a bias (Paslakis et al., 2016). This finding that food stimuli did not interfere with task performance in individuals with AN, indicates that in AN, patients seem to be relatively insensitive to the common approach-eliciting properties of food.

One explanation for these findings is that individuals with AN are characterized by relatively strong top-down cognitive control, which enables them to focus entirely on the task demands and to overrule the habitual inclination to also process the task-irrelevant food-related content of the stimuli. An alternative explanation is that individuals with AN miss the automatic (bottom-up) tendency to approach food that is evident in controls without an eating disorder, which would also result in the absence of a food-approach bias. Importantly, if the latter account is true, individuals with AN would also fail to show an approach/avoidance bias if food is a task-relevant feature and cannot be ignored because the actual instruction is to approach or avoid stimuli depending on whether they show food or non-food stimuli. Because in such a task the content of the food pictures has to be processed for adequate task performance, the absence of a bias under such conditions can thus not be attributed to a superior ability to ignore the food-related content of the stimuli. It might be that when food stimuli are task-relevant, individuals with AN would show even a tendency to avoid food stimuli. Thus, for a proper understanding of the nature of the weakened automatic approach tendencies towards food pictures that were found in two prior studies using the AST, it is important to also measure approach tendencies in a task with food as a relevant feature so the content of the food stimuli cannot be ignored.

An example of a task with food as a task-relevant feature is the Stimulus Response Compatibility task (SRC; De Houwer, Crombez, Baeyens, & Hermans, 2001). In the SRC, participant's requirement to approach or to avoid a stimulus depends on the content of the stimuli (e.g., whether or not food is presented). However, thus far, no studies into automatic approach tendencies were conducted in a clinical group of patients with AN in which food stimuli were task-relevant. Therefore, the primary aim of this study was to test whether AN and patients with Eating Disorder Not Otherwise Specified with specific characteristics of AN (from now on called AN spectrum patients) patients would show reduced automatic approach or even avoidance tendencies when food is used as a task-relevant feature. As a subsidiary aim, the study tested the robustness of the prior findings that AN spectrum patients would show reduced automatic approach tendencies towards food when food is irrelevant for the task at hand. This provides also the possibility to examine to what extent reduced approach tendencies when food is task-irrelevant vs. task-relevant are independently related to AN.

In sum, the current study was designed to enhance our understanding of why AN is so persistent, and how patients succeed in maintaining their dieting behavior even in a condition of starvation. Therefore, we tested if AN spectrum patients not only show reduced approach tendencies for high caloric food when food is a task-irrelevant feature (cf. Paslakis et al., 2016; Veenstra & de Jong, 2011) but also when food is a task-relevant feature. In addition, we examined to what extent both types of approach/avoidance tendencies are independently related to AN.

1. Method

1.1. Participants

Participants were patients who were all admitted to a specialized Centre for Eating Disorders for youth in the Netherlands. For this study, we included a group of eating disorder patients (age > 12) with AN spectrum symptomatology (n = 63, of whom 1 boy), using the Eating Disorder Examination (EDE: Bryant-Waugh, Cooper, Taylor, & Lask, 1996; Decaluwé, 1999). Data collection started before the DSM-5 was published, so AN criteria of the DSM-IV were used (American Psychiatric Association, 1994). Next to patients who met all of the criteria of the restrictive type of AN (n = 33), we included patients who met most but not all criteria: patients with menses (n = 5), patients who were only mildly underweight, that is less than 15% (n = 14), patients who were nonfat phobic AN (n = 2), and other partial (meeting 2/4 criteria) AN (n = 9) (cf. Thomas, Vartanian, & Brownell, 2009). Age ranged from 12 to 23 years. For the non eating disorder comparison group, we selected adolescents (n = 57) from secondary schools in Groningen. Information about the study was given plenary and by means of a letter, also to inform their parents. There were no additional selection criteria, but EDE-Q scores were used to confirm the absence of an eating disorder. When they agreed on participating in the study, the participants and their parent signed the informed consent and an appointment was made on their school.

1.2. Materials

Computer tasks. The present study included two versions of a computerized speeded approach-avoidance task. The computer tasks were programmed in E-prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002) administered on a laptop. Both in the AST and the SRC, each trial started with a 1000-ms presentation of a fixation dot. Next, a picture appeared in the middle of the screen, and a black manikin appeared above or below the picture. Participants had to move the manikin towards or away from the picture by (repeatedly) pressing the arrow buttons. The picture remained on the screen until the manikin had reached the picture or the edge of the screen. In both computer tasks, a relatively strong automatic tendency to avoid food would express itself in relatively fast responses and/or less errors when the required response is to avoid the food items, together with relatively slow responses and/or more errors when the required response is to approach the food items.

Affective Simon Task. In the Affective Simon task (AST) version of the approach avoidance task, the correct response was determined by stimulus features that were unrelated to the food/non-food content of the pictures, namely the orientation of the stimulus (top versus side view) of the object in the picture (De Houwer et al., 2001).

The AST consisted of a practice block of eight trials (with stimuli not used in the test blocks), followed by two test blocks of 96 trials each. Trials differed in stimulus type (i.e., task-irrelevant feature: high caloric, low caloric, and neutral), the side from which the photograph was taken (i.e., task-relevant feature: top-view vs. side view), and position of the manikin (i.e., above or below the picture). Each stimulus was presented four times in each block (top view: manikin above; top view: manikin below; side view: manikin above; side view: manikin below). Half of the participants were instructed to move the manikin towards top views and away from side views, and half of the participants were instructed to move the manikin towards side views and away from top views. For each participant, trials were presented in a unique random order.

Stimulus Response Compatibility task (SRC). In the SRC version, the content of the picture (i.e., food/non-food) was a task-relevant

feature (De Houwer et al., 2001). The SRC consisted of two practice blocks with four trials each (with stimuli not used in the test blocks) and two test blocks of 64 trials each. Participants were instructed to approach food (high caloric) and avoid non-food items in one block, whereas the response assignment was reversed in a second block (avoid food and approach non-food items). Trials differed in stimulus type (high caloric food and neutral pictures) and position of the manikin (i.e., above or below the picture). The order of the blocks was balanced over participants: half of the participants had to approach food in the first block and avoid food in the second block. For the other half of the participants, the instructions were reversed. For each participant, trials were presented in a unique random order.

1.2.1. Stimulus selection

Stimuli for the AST and the SRC tasks were adapted from Veenstra and de Jong (2011) with some modifications. For both tasks, the stimuli represented eight high-caloric food items (pizza, croissant, chocolate, crisps, chips, ice-cream, biscuit, and toast with ham and cheese), and eight neutral stimuli (various office items). For the AST, two different pictures (380 × 285 pixels) were constructed for each of these items: one displaying the item from a top view and one from a side view. Although high caloric food items were most critical for the current study, the AST that was used in the previous study (Veenstra & de Jong, 2011) also contained low-caloric food items. For optimizing the comparability of findings, we therefore decided to also include pictures representing low-caloric items in the current AST (strawberries, melon, carrots, cherries, cucumber, tomato, apple, paprika).

1.2.2. Questionnaires

Eating disorder Examination questionnaire (EDE-Q). The child version of the Eating Disorder Examination Questionnaire (Fairburn & Bèglin, 1994) was administered, to allow for a comparison of severity of eating disorder pathology between AN spectrum patients and the comparison group.

Hunger Scale. The Hunger Scale (Grand, 1968) consists of four items (time since last eating, subjective hunger, estimate of the amount of favourite food able to eat, estimate of time until next expected meal).

Visual analogue scale. The explicit proxy of approach tendencies was measured using the question: 'How much do you crave this product at this moment?', which was answered on a scale from 0 (not at all) to 100 (very much).

1.3. Procedure

Approval for the study was given by the Medical Ethical Committee of the University Medical Center Groningen, protocol number 2011.193. Patients in the study were diagnosed with the child version of the Eating Disorder Examination (Decaluwé, 1999). The child version was also used for the participants above 18, for uniformity reasons. The differences between the child and adult versions are small, only the wording is adapted to make it more suitable for adolescents. Before participants were scheduled for the assessment, both patients and their parents gave informed consent. Measurement took place before start of the treatment. The order of the computer tasks was counterbalanced over participants. Half of the participants received first the SRC and the other half first the AST. After the computer tasks, patients completed the questionnaires. Finally, weight and height were measured. Percentage underweight was derived from the 50th percentile of height and age (TNO, 2010).

1.4. Data reduction

Automatic approach tendencies might express themselves in response latencies and errors, and therefore both are used in the analysis. For the response latencies analyses, time until first key press was used. For the error analyses, trials of which the first response was in the wrong direction were identified as errors. Before calculating mean reaction times, error trials and trials with response latencies below 200 ms and above 2000 ms were excluded from analyses (e.g. Veenstra & de Jong, 2010).

AST- and SRC-effect scores were computed by subtracting error percentages and response latencies of approach trials from corresponding avoidance trials (cf. Rinck & Becker, 2007). Higher scores are indicative of an automatic tendency to approach rather than to avoid pictures, and negative effects reflect a tendency to avoid rather than to approach pictures. Subsequently, approach bias was calculated by subtracting SRC- and AST-effects for neutral pictures from respectively SRC- and AST-effects for high and low (for the AST) caloric food items, hereby controlling for non-specific differences in approach and avoidance tendencies. Higher scores on approach bias refer to a tendency to approach food compared to neutral pictures.

1.5. Analyses

To test whether AN spectrum patients showed reduced automatic approach or even avoidance tendencies, for the AST, 2 (stimulus type: high caloric, low caloric) × 2 group (AN, comparison) repeated measures ANOVA's were conducted with both errors and response latencies bias scores. Relevant interactions were followed up by *t*-tests. For the SRC, independent samples *t*-tests were conducted to test the difference between AN spectrum patients and the comparison group for both errors and response latencies bias scores. To examine the independent predictive value of both tasks, a backward logistic regression analyses was conducted with AN (yes/no) as dependent variable and SRC and AST (high caloric) errors and response latencies bias scores as predictors.

To complement the results of the classical statistical analyses, 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). Cauchy priors were set at the recommended default r = 0.707 (Wagenmakers et al., 2017). To facilitate interpretation of the outcomes, BF10, which quantifies the evidence for the alternative hypotheses over the null hypotheses, were reported for those tests that provided significant results in the classical analyses. BF01, which quantifies the evidence for the null hypotheses over the alternative hypotheses were reported when the classical analyses showed insignificant findings. A Bayes factor of 1 is considered no evidence, between 1 and 3 anecdotal, between 3 and 10 moderate, between 10 and 30 strong, between 30 and 100 very strong, and more than 100 extreme evidence that the data are more likely under the null hypotheses is the case of BF01, or under the alternative hypotheses in the case of BF10 (Wagenmakers et al., 2017).

2. Results

2.1. Group characteristics

See Table 1 for a description of the participant characteristics and statistics of the between groups tests. In line with the inclusion criteria, AN spectrum patients showed a higher percentage underweight (range 0–38%), and higher EDE-Q scores. In addition, AN spectrum patients reported longer time since last eating, a longer time until expected next meal, but less subjective hunger, and lower amount of favourite foods that could be eaten right now.

2.2. Automatic approach tendencies measured with the AST (food as task-irrelevant feature)

Error rates. See Table 2 for mean response latencies and error percentage of the AST. The RM-ANOVA showed a main effect of stimulus

Table 1
Group characteristics.

	AN		Control		Between-groups test	
	M	*SD*	*M*	*SD*	*t*	*p*
Age	15.21	1.85	15.49	1.83	0.83	.41
Underweight %	17.62	9.29	−3.68	10.24	11.85	< .001
Body Mass Index	16.11	1.93	20.37	2.13	11.42	< .001
EDE-Q total score	4.04	1.32	1.17	0.99	13.00	< .001
HS- time since last meal (hrs)	8.00	8.49	1.89	2.15	5.29	< .001
HS- Subjective hunger (1–6)	2.19	1.48	3.39	1.8	3.99	< .001
HS- Amount of favourite food able to eat (1–7)	2.05	1.69	3.54	1.80	4.67	< .001
HS- time till next meal (hrs)	9.28	11.86	4.38	4.35	2.5	< .01

Note. Percentage underweight was derived from the 50th percentile of height and age; EDE-Q = Eating disorder Examination – Questionnaire; HS = Hunger Scale.

type, $F(1,118) = 6.74$, $p = .01$, $\eta_p^2 = .05$, $BF_{10} = 3.83$ which was qualified by a stimulus type × group interaction, $F(1,118) = 6.92$, $p = .01$, $\eta_p^2 = .06$, ($BF_{10} = 4.14$), indicating that the effect of stimulus type differed across groups (see Fig. 1A). Bayesian hypotheses testing showed that the evidence for the stimulus type × group interaction was moderate. There was no main effect of group, $F(1,118) = 0.36$, $p = .64$, $\eta_p^2 < .01$. The data are 3.67 times more likely under the hypothesis that AST error rates overall do not differ between the groups ($BF_{01} = 3.67$). Independent samples *t*-tests showed that there was no significant difference between the patients and the comparison group for low caloric food, $t(118) = -0.81$, $p = .42$, $d = .15$, or high caloric food, $t(118) = 1.67$, $p = .10$, $d = .31$. There is moderate evidence that the groups did not differ in the amount of errors on low caloric food trials ($BF_{01} = 3.81$), yet the evidence for high caloric food trials was inconclusive ($BF_{01} = 1.48$). In addition, paired samples *t*-tests showed that AN spectrum patients showed stronger approach bias towards low caloric food than towards high caloric food, $t(62) = 3.39$, $p < .01$, $d = .86$. The evidence for this difference was strong ($BF_{10} = 22.16$). There was no significant difference between low and high caloric food for the comparison group, $t(56) = 0.03$, $p = .98$, $d < .01$. There was moderate evidence in favor of this absence of a difference ($BF_{01} = 6.91$).

Finally, one sample *t*-tests were conducted to determine whether the bias scores differed from zero. For the comparison group there was no significant approach or avoidance bias in errors (no difference from zero), for neither high, $t(56) = 0.71$, $p = .48$, $d = .09$, $BF_{01} = 5.44$, nor low caloric food, $t(56) = 0.64$, $p = .53$, $d = .08$, $BF_{01} = 5.69$. The Bayes factors showed that these data were more than 5 times more likely under the null hypotheses that there was not an approach or avoidance bias for food cues. For the AN spectrum patients the AST-index for high caloric food also did not differ from zero, $t(62) = -1.59$, $p = .12$, $d = .20$, $BF_{01} = 2.19$, the index for the low caloric food was significantly higher than zero $t(62) = 2.07$, $p = .04$, $d = .26$, $BF_{10} = 1.01$. However, the Bayes factor showed that the strength of the evidence is anecdotal and can thus be considered inconclusive.

Response latencies. The same analyses were conducted for approach bias based on response latencies. Although the pattern of the interaction was in the same direction as in the error analyses, it was not significant, $F(1,118) = 0.88$, $p = .35$, $\eta_p^2 = .01$, $BF_{01} = 3.45$. There was a main effect of stimulus type, $F(1,118) = 0.92$, $p = .34$, $\eta_p^2 = .01$, $BF_{01} = 4.55$, but no main effect of group, $F(1,118) = 1.44$, $p = .23$, $\eta_p^2 = .01$, $BF_{01} = 2.01$ (see Fig. 1C). Independent samples *t*-tests showed no differences between AN spectrum patients and the comparison group on high caloric $t(118) = 1.69$, $p = .09$, $BF_{01} = 1.42$, or low caloric food trials, $t(118) = 0.63$, $p = .53$, $BF_{01} = 4.31$. The data are 4 times more likely under the hypothesis that there were no differences between the groups in approach bias to low caloric food, but the evidence for high caloric food is inconclusive. Paired samples *t*-tests showed no difference between high and low caloric food stimuli in patients $t(62) = -1.80$, $p = .08$, $BF_{01} = 1.58$, or in the comparison group $t(56) = -0.01$, $p = .99$, $BF_{01} = 6.91$.

Finally, one sample *t*-tests showed no significant approach or avoidance bias in patients for high caloric food, -0.36, $p = .72$, with moderate evidence for the null hypothesis $BF_{01} = 6.82$. There was a significant approach bias for low caloric food $t(62) = 2.10$, $p = .04$, however the strength of the evidence that the observed data are more likely under the alternative hypothesis was only anecdotal, $BF_{10} = 1.06$. There was no significant approach or avoidance bias in the comparison group for high caloric food $t(56) = 1.75$, $p = .09$, although the strength of the evidence that the data are more likely under the null hypothesis was anecdotal and this finding can thus be considered inconclusive ($BF_{01} = 1.67$). There was also no evidence for an approach or avoidance bias for low caloric food in the comparison group $t(56) = 1.18$, $p = .25$, $BF_{01} = 3.60$.

2.3. Automatic approach tendencies measured with the SRC (food as task-relevant feature)

Error rates. See Table 3 for mean response latencies and error percentage of the SRC. There was no difference between the AN spectrum patients and the comparison group $t(118) = 1.05$, $p = .30$, $d = .19$, $BF_{01} = 3.13$. Moreover, the bias scores for both the AN spectrum group, $t(62) = -1.30$, $p = .20$, $d = .33$, $BF_{01} = 3.26$, and for the comparison group, $t(56) = 0.19$, $p = .85$, $d = .05$, $BF_{01} = 6.80$, did not deviate significantly from zero (see Fig. 1B). The Bayesian independent *t*-tests and one sample *t*-tests showed that the strength of the evidence that the observed data are more likely under the null hypotheses was moderate.

Response latencies. Patients showed less approach tendencies for high caloric food than the comparison group, $t(118) = 2.30$, $p = .02$, $d = .42$, however the strength of the evidence that the observed data were more likely under the alternative hypothesis was in the range of anecdotal evidence $BF_{10} = 2.06$. A one sample *t*-test showed that the approach bias score differed significantly from zero for the comparison group, $t(56) = 2.76$, $p < .01$, $d = .74$, $BF_{10} = 4.42$, but not for AN

Table 2
AST Percentage errors and response latencies as a function of group and stimulus.

	AN spectrum patients			Control group		
	HC	LC	Neutral	HC	LC	Neutral
Percentage errors						
Approach	16.90 (13.26)	14.30 (9.82)	17.70 (9.94)	14.89 (10.52)	14.56 (10.94)	17.19 (9.64)
Avoidance	24.76 (14.52)	30.25 (14.87)	29.78 (16.19)	29.21 (14.61)	28.82 (16.99)	29.98 (14.97)
Reaction time						
Approach	841 (246)	787 (229)	831 (213)	845 (304)	850 (313)	928 (492)
Avoidance	942 (198)	929 (212)	941 (210)	989 (382)	994 (480)	1004 (486)

Note. AST = Affective Simon task, AN = Anorexia Nervosa, HC = high caloric, LC = low caloric.

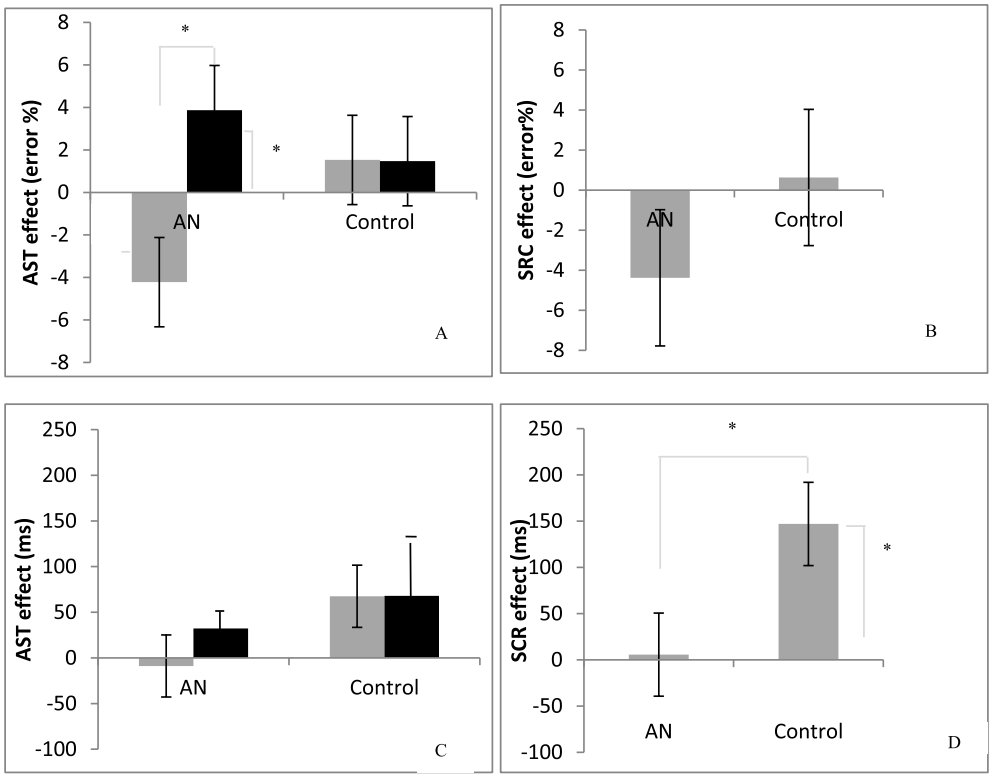

Fig. 1. AST and SRC effects of response latencies and error scores. Higher scores indicate an approach tendency for food. Error bars represent ± 1 standard error of the mean. * = $p < .05$. ■ = High caloric ■ = Low caloric.

Table 3
SRC Percentage errors and response latencies as a function of group and stimulus.

	AN spectrum patients		Control group	
	HC	Neutral	HC	Neutral
Percentage errors				
Approach	13.51 (14.22)	12.38 (10.82)	7.40 (6.86)	16.16 (13.91)
Avoidance	17.62 (15.74)	20.87 (15.12)	13.09 (13.91)	21.21 (17.76)
Reaction time				
Approach	638 (176)	663 (126)	611 (137)	721 (242)
Avoidance	697 (144)	717 (140)	745 (287)	707 (140)

Note. SRC = stimulus response compatibility task, AN = Anorexia Nervosa, HC = high caloric.

spectrum patients, $t(62) = 0.17$, $p = .87$, $d = .04$, $BF_{01} = 7.15$. Thus, whereas the comparison group showed an approach bias for high caloric food, patients did not show a significant bias (see Fig. 1D).[1]

2.4. Independent predictive value of the AST and SRC

There was a significant relationship between the AST and SRC high caloric bias scores for both response latencies and error rates (see Table 4). To test to what extent SRC and AST high caloric indices were independently related to the presence of AN, a backward logistic regression analyses was done. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a problem, SRC errors VIF = 1.12, response latencies VIF = 1.12, AST errors VIF = 1.18 and response latencies VIF = 1.19. In the regression analysis, only the SRC response latencies index remained as a significant predictor in the final equation, $\chi 2\ (1) = 5.55$, $p = .02$, indicating that only the SRC response latencies index had a unique relationship with the presence of AN, B = -.001, SE .001, $p = .04$.

Table 4
Correlations between SRC and AST HC indices and group (AN/control).

	Group	SRC errors	SRC RL	AST errors
Group				
SRC errors	-.10			
SRC RL	-.21*	-.05		
AST errors	-.15	.29**	.15	
AST RL	-.15	.16	.29**	.29**

Note. AN = Anorexia Nervosa, AST = Affective Simon task, SRC = stimulus response compatibility task, HC = high caloric, RL = response latencies, * = $p < .05$, **$p = < .01$.

2.5. Explicit proxies of approach tendencies

The analysis of craving scores revealed a main effect of group, $t(128) = 7.50$, $p < .001$, $d = 1.33$. Overall, restricting AN spectrum patients reported less craving for food compared to the non eating disorder comparison group. There was no significant correlation between the measures of approach-avoidance as derived from the AST or SRC and the craving scores, all $r < .16$, all $p < .08$.

3. Discussion

The aim of the current study was to test whether AN-patients show reduced automatic approach tendencies towards food, and to examine whether this effect would be evident both in a paradigm in which food was task-irrelevant (AST), as well as in a paradigm in which food was relevant for correct task performance (SRC). Previous studies only used a paradigm with food as a task-irrelevant feature and, therefore, it remained unclear if AN spectrum patients are characterized by a relatively weak automatic approach for high caloric food, or by relatively

[1] To check if the order of the computer tasks affected the results, the analysis was also done with order of the computer task added as a factor. There was no significant effect of order, nor any interactions involving order, and the pattern of outcomes remained the same.

strong top-down cognitive control enabling them to ignore food when irrelevant for the task at hand. In short, in the SRC (response latencies) AN spectrum patients failed to show a significant automatic approach for high caloric food that was evident in the non eating disordered comparison group. Regression analysis further indicated that only the SRC response latencies index showed an independent relationship with the presence of AN.

3.1. Reduced automatic approach tendencies for food in AN

The results indicate that AN spectrum patients show weaker automatic approach tendencies toward high caloric food, especially when food is task-relevant. In the AST, AN spectrum patients showed stronger approach tendencies for low caloric than high caloric food, but the approach bias for high caloric food did not differ from the non-eating disorder comparison group. The AST results did thereby partly replicate previous findings that AN spectrum patients show reduced approach of high caloric food in paradigms where food is task-irrelevant (Paslakis et al., 2016; Veenstra & de Jong, 2011). Low interference of food items in the AST could be due to superior executive control, low motivational salience, or both. Independent of the exact underlying mechanism low bottom up interference would help control one's food intake. In order to have more insight in which mechanism is involved, also the SRC was administered. In this task, food is task relevant and thus cannot be ignored.

Findings with the SRC showed that AN spectrum patients were also characterized by reduced automatic approach towards high caloric food where food is task-relevant (SRC). Thus, when the content of food stimuli could not be ignored, AN spectrum patients did not show a significant food-approach bias that was evident in the non-eating disorder comparison group. The relatively weak automatic approach tendencies as indexed by the SRC cannot be attributed to a superior ability to ignore food cues. Although also top-down control may be involved in the SRC (for instance by the ability to prevent further processing of food cues), it requires more cognitive effort to ignore the food. Therefore, the most parsimonious explanation for the current pattern of findings is that individuals with AN are characterized by a relatively weak tendency to approach high caloric food.

Taken together, the current performance-based measures revealed that AN spectrum patients showed reduced automatic approach tendencies towards high caloric food compared to adolescents without an eating disorder. These findings are consistent with earlier studies using indirect performance-based measures to examine more automatic responses toward food in AN (Paslakis et al., 2016; Veenstra & de Jong, 2011). These outcomes might help explain why individuals with AN, in contrast to unsuccessful dieters and people with obesity, manage to succeed in complying with their deliberate intention to restrain from high caloric food even in situations where others often fail (e.g., stress, feelings of hunger).

For the AST, the effects were most pronounced in the error analysis, whereas for the SRC the effect was most pronounced in the response latencies analysis. One explanation for this finding might be that the task to approach or avoid high caloric food pictures (SRC) is easier than the task to approach or avoid top/side view pictures (AST). Indeed, overall fewer errors were made during the SRC than during the AST (see Table 3). This may have rendered the SRC less sensitive for finding differential effects in terms of error rates, but more sensitive for finding differential effects in terms of response latencies, whereas the opposite would be true for the AST. Consistent with the view that the AST is relatively sensitive for finding differential effects in terms of error rates, it is more often reported that AST-effects were only evident as indexed by error rates (Vervoort et al., 2010). Furthermore, it was found that the SRC was more sensitive in finding group differences using response latencies (Field, Caren, Fernie, & De Houwer, 2011). The AST and the SRC indices showed a relatively weak relationship. It might be that differences in behavioral data are the result of differences between the constructs that are being measured by each of the tasks (e.g., inclination to approach food when in the focus of attention, versus the inclination to approach food even when food is task irrelevant). Differences in outcomes between both tasks may also just reflect differences in task demands; the same construct might express itself more easily in one compared to another task. Individual differences with regard to participants' ability to comply with the task demands (e.g., ability to ignore task irrelevant features) might then explain the low correlation between the AST and SRC variants of the food-AAT.

Only the SRC index showed an independent relationship with the presence of AN. Thus, the current findings indicate that reduced approach when food is task-relevant, is most critically related to AN. It must however be acknowledged that this effect was quite small and that, more generally, the Bayesian analysis indicated that the evidence for relatively weak approach of high caloric food compared to non eating disordered individuals was still in the range of anecdotal evidence. The small effect might of course imply that automatic approach-avoidance of food is not a very important factor in AN. Yet, performance measures within the context of a particular task only provide a rough (and noisy) approximation of the actual target behaviours (e.g.,'real' approach tendencies under naturalistic circumstances, when confronted with real food items). There may be various reasons why results of a lab-model may underestimate the "actual" effect size. For example, it might be that effects are attenuated because food pictures induce less craving than actual food in the non-eating disorder comparison group, and less anxiety in the AN spectrum group. In light of such more specific together with more general short comings of lab models, also small between group differences might still reflect meaningful and theoretical relevant effects. However, before more final conclusions can be drawn, the current findings require further replication preferably with further improved (less "noisy") measures.

3.2. Future research

Apart from direct replications, it would also be helpful to test whether automatic approach tendencies are subject to change (e.g., becoming more similar to the pattern of adolescents without an eating disorder) following successful treatment, or remain different from those without an eating disorder and could be a risk factor for relapse. So far, only one study has explored the pattern of automatic approach/avoidance tendencies over time. This earlier study showed that one year after the start of treatment, automatic approach tendencies for high caloric food measured with an AST increased (Neimeijer, de Jong, & Roefs, 2015), and was comparable with the pattern found in a comparison group of adolescents without an eating disorder. This suggests that overall automatic approach towards food recovered back to normal after one year. However, this was not directly associated with actual improvement in terms of reduced eating disorders symptoms (EDE scores and underweight), nor were baseline levels of approach/avoidance tendencies predictive of the eating disorder symptoms at one year follow-up. The current finding that specifically the SRC is related to AN points to the relevance to replicate that prior study with also including a task in which food is task-relevant.

To determine whether reduced automatic approach tendencies for food are a causal factor in maintaining eating disorder symptoms, an important next step would be to directly manipulate food-approach/avoidance tendencies. Prior studies using a cognitive bias modification procedure showed the possibility of retraining an approach/avoidance bias. In individuals with obesity, approach tendencies could be diminished for unhealthy food while in normal-weight participants, approach tendencies towards healthy food could be enhanced (Mehl, Mueller-Wieland, Mathar, & Horstmann, 2018). Furthermore, as an indication that a training could influence actual behavior, participants trained to avoid chocolate in a cognitive bias modification procedure ate significantly less of a chocolate muffin in a subsequent taste test than participants trained to approach chocolate (Schumacher, Kemps, &

Tiggemann, 2016). The latter indicates that modifying automatic approach tendencies might not only have an influence on the tendencies itself, but also on actual behavior. Perhaps targeting both explicit processes (e.g., cognitive therapy) and automatic processes (e.g., enhancing the automatic tendency to approach food with cognitive bias modification) eventually can lead to a more successful decrease of AN-patients' inclination to restrict their food-intake.

3.3. Limitations

One limitation of the current study concerns the balanced order of the performance measures, to control for carry-over effects. It cannot be ruled out that the carry-over effect of the SRC on the AST was more pronounced than vice versa. Furthermore, we did not include low caloric food pictures in the SRC to keep the number of pictures that had to be approached and avoided within one block equal. It could however be that the absence/presence of low caloric food has influenced the automatic response towards high caloric food. Lastly, the underlying assumption of the AST and SRC is that relatively fast responses and/or less errors when the required response is to avoid the food items, together with relatively slow responses and/or more errors when the required response is to approach the food items reflect a relatively strong automatic tendency to avoid food (and vice versa). However, it should be acknowledged that it cannot be ruled out that also other processes may influence participants' responses in the AST and SRC. For example, it could be that errors on trials where approaching food are in fact a result of an attempt to suppress a tendency to approach food. A next step could then be to examine the underlying processes of the AAT effects.

4. Conclusions

Previous studies that were designed to test the hypothesis that individuals with AN show relatively weak approach tendencies towards food used a paradigm with food as a task-irrelevant feature. It remained therefore unclear whether individuals with AN are characterized by a weakened tendency to approach high caloric food, or by relatively strong top down cognitive control enabling them to ignore food when irrelevant for the task at hand. Therefore, the current study also included a task with food as a task-relevant feature (SRC). Importantly, the SRC findings indicated that also when food was task-relevant and could not be ignored. AN spectrum patients showed less approach to high caloric food than the comparison group without an eating disorder. Therefore, the most parsimonious explanation for the available evidence is that individuals with AN are characterized by a weakened tendency to approach high caloric food. Such reduced automatic approach tendencies might 'help' patients with AN to restrict their food-intake even in a condition of starvation.

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Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Conflicts of interest

None.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbtep.2019.101496.

Appendix A. Example of an AST-manikin trial

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