Temptation and restraint

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Chapter 4

Heightened self-reported punishment sensitivity, but no differential attention to cues signaling punishment or reward in anorexia nervosa

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Abstract

This study examined whether patients with anorexia nervosa (AN) are more sensitive to punishment and less sensitive to reward than a non-eating disorder comparison group. This is the first study to use both self-report and performance measures to index reward and punishment sensitivity. Participants were adolescents with AN (n = 69) and an individually matched comparison group with healthy weight (n = 69), who completed the Behavioral Inhibition Scale/Behavioral Activation Scale and the Sensitivity to Punishment and Sensitivity to Reward Questionnaire to index self-reported reward and punishment sensitivity, and performed the Spatial Orientation Task to index attention to cues signaling reward and punishment. No differences were found on self-reported reward sensitivity, attention to cues signaling reward, and attention to cues signaling punishment between patients with AN and the comparison group. However, compared to adolescents without an eating disorder, patients with AN reported higher sensitivity to punishment on both questionnaires. The evidence for this difference between the groups is extremely strong ($BF_{10} > 100$), and in line with previous findings. Thus, patients with AN are clearly characterized by heightened punishment sensitivity. Yet, there was no evidence to indicate that this heightened punishment sensitivity was paralleled by a heightened proneness to detect signals of punishment. An important next step would be to examine whether punishment sensitivity is a reliable risk factor for the development or maintenance of AN.

Introduction

Anorexia nervosa (AN) is a severe mental disorder with a high mortality rate (e.g., Smink, van Hoeken, & Hoek, 2013) that typically develops during adolescence (Kask et al., 2016). Patients' weight and shape are overly important in their self-evaluation, they have an intense fear of gaining weight or becoming fat, and they show a striking ability to restrict their food intake even though they are often (severely) underweight (American Psychiatric Association, 2013). Two main subtypes of AN are distinguished in the DSM-5: the restrictive type characterized by weight loss primarily accomplished through dieting and exercise, and the binge-eating/purging type when the individual also engages in binge eating and/or purging behavior (e.g., self-induced vomiting) (American Psychiatric Association, 2013). The disorder is difficult to treat as many patients do not respond to treatment, drop-out of treatment, or relapse after successful treatment (Berends, Boonstra, & van Elburg, 2018; Brockmeyer et al., 2017; Byrne, Fursland, Allen, & Watson, 2011; DeJong, Broadbent, & Schmidt, 2012; Lock et al., 2010). It is therefore essential to improve our understanding of the underlying factors of the development and maintenance of AN. In the current study, we focused on the personality characteristics of reward and punishment sensitivity, as these have been suggested to play an important role in AN (Harrison, O'Brien, Lopez, & Treasure, 2010).

Individuals who are sensitive to reward are thought to respond more positively to reward (e.g., hedonic response), have more attention to cues of reward, and show more approach behavior in response to cues of reward in the environment (Gray, 1970; Gray & McNaughton, 2000). Individuals who are sensitive to punishment are thought to respond more negatively to punishment (e.g., aversive response), have more attention to cues of punishment, and show more avoidance behavior in response to cues of punishment in the environment (Gray, 1970; Gray & McNaughton, 2000). Patients with AN have been suggested to be sensitive to punishment (e.g., Harrison et al., 2010). Behaviors such as food restriction and purging which are likely related to an intense fear of gaining weight or becoming fat (i.e., avoiding punishment), as well as the high comorbidity with anxiety disorders, and high trait anxiety and harm avoidance that are characteristic of patients with AN (Kaye et al., 2004; Klump et al., 2000), might be the result of this relatively high punishment sensitivity. On the other hand, a relatively low sensitivity to reward might also play a role in the development and maintenance of AN. Whereas food has a high intrinsic rewarding value (Davis & Fox, 2008), especially when hungry (Stroebe, Papies, & Aarts, 2008), this might not apply to patients with AN. The ability to restrict their food intake even though deprived of food might result from a lowered general sensitivity to reward. When behaviors such as food restriction and purging are indeed the result of a more general low sensitivity to reward and/or high sensitivity to punishment, treatment might benefit from addressing these general underlying personality characteristics.

Studies that were set out to examine whether patients with AN differ from non-eating disordered comparison groups on sensitivity to reward and punishment by means of self-report measures have consistently shown that both adolescent and young adult patients with AN reported higher sensitivity to punishment compared to participants without eating disorders (Claes et al., 2006; Glashouwer et al., 2014; Jappe et al., 2011; Matton et al., 2015;

Monteleone et al., 2014). Findings are less consistent when looking at the AN subtypes separately. One study showed that patients with a binge-eating/purging subtype reported higher sensitivity to punishment than patients with a restrictive subtype and a non-eating disorder comparison group (Glashouwer et al., 2014), whereas another study reported that patients with a restrictive subtype reported higher punishment sensitivity than patients with a binge-eating/purging subtype and participants without an eating disorder (Claes et al., 2006). Last, two studies reported that both patients with a restrictive and with a binge-eating/purging subtype reported higher punishment sensitivity than participants without an eating disorder (Matton et al., 2015; Monteleone et al., 2014).

The reward sensitivity findings are inconsistent as well. Results have shown that adolescent and young adult patients with AN did not differ from a non-eating disordered comparison group in their self-reported reward sensitivity (Jappe et al., 2011; Matton et al., 2015; Monteleone et al., 2014), reported lower sensitivity to reward (Claes et al., 2006), or that patients reported higher sensitivity to reward than a comparison group of participants without an eating disorder (Glashouwer et al., 2014; Jappe et al., 2011). Regarding AN subtypes, one study found that patients with a restrictive subtype of AN, but not patients with a binge-eating/purging subtype of AN, reported lower reward sensitivity than a non-eating disordered comparison group (Matton et al., 2015). However other studies reported no differences with regard to self-reported reward sensitivity between patients with restrictive or binge-eating/purging subtypes of AN (Claes et al., 2006; Glashouwer et al., 2014; Matton et al., 2015).

These inconsistencies in findings, especially regarding reward sensitivity, might be due to the differences in questionnaires that were used (e.g., Glashouwer et al., 2014). Specifically, studies reporting higher reward sensitivity in patients with AN used the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia et al., 2001) to index reward sensitivity (Glashouwer et al., 2014; Jappe et al., 2011), whereas studies reporting lower reward sensitivity, or no difference in reward sensitivity used the Behavioral Inhibition Scale/Behavioral Activation Scale (BIS/BAS; Carver & White, 1994) (Claes et al., 2006; Jappe et al., 2011; Matton et al., 2015; Monteleone et al., 2014). Although the BIS/BAS and the SPSRQ are used interchangeably, the BIS/BAS is designed as general measure of reward and punishment sensitivity (Carver & White, 1994), whereas the SPSRQ is designed to measure responses to specific situations reflecting reward or punishment (Torrubia et al., 2001). Previously, it was shown that when excluding items on appearance and social rejection from the SPSRQ score, adolescents with AN scored comparable to the comparison group without an eating disorder on reward sensitivity (Glashouwer et al., 2014). However, this still indicates a different pattern than that of lowered reward sensitivity in patients with AN when reward sensitivity as indexed by the BIS/BAS scale. All in all, the role of reward and punishment sensitivity in AN remains unclear. The aim of the current study was to address these inconsistencies in differences between patients with AN and comparison groups in reward and punishment sensitivity. As a first step the difference in reward and punishment sensitivity was assessed in a large group of adolescent patients with AN and a matched non-eating disordered comparison group using both the BIS/BAS and the SPSRQ to index reward and punishment sensitivity.

By including both the BIS/BAS and the SPSRQ we can limit the chance of instrument specific findings. However, it does not bring us beyond the limitations such as the potential of measurement bias due to the specific content of the questions in these questionnaires. An additional issue of the use of self-report measures is that to answer such questionnaires, participants need self-insight and the ability to linguistically express their own tendencies. Such expression is not easy for everyone (e.g., Gregg et al., 2013), and might be specifically difficult for young adolescents. One way to tackle this limitation is by indexing reward and punishment sensitivity with a performance measure. Recently, a pilot study examined differences between eating disorder patients and non-eating disorder comparisons in reward and punishment sensitivity with the Spatial Orientation Task (SOT) (Derryberry & Reed, 2002; Matton et al., 2017). The SOT measures attention to cues signaling reward and punishment, which is considered as behavioral output of the reward and punishment systems (Gray, 1970; Gray & McNaughton, 2000). More specifically, reward and punishment sensitive individuals have been suggested to be more prone to detect signals of reward and punishment respectively in the environment (Davis & Fox, 2008), making the SOT an appropriate measure to index reward and punishment sensitivity. Furthermore, by manipulating the location of the cue relative to the location of the target, the SOT provides the opportunity to examine the two facets of attention allocation that have been suggested to play a role in behavior – the extent to which attention is drawn by a cue (i.e., attentional engagement), and how long attention is maintained on the cue (most likely due to a difficulty to disengage attention from it; i.e., attentional disengagement) (Grafton & MacLeod, 2014; Posner, 1980; Posner & Petersen, 1990). An additional aspect of the SOT is that there are trials in which the rewarding or punishing cue is shown relatively briefly (250 ms), and trials in which it is shown for a relatively long duration (500 ms). This timing variable provides the opportunity to look at relatively automatic versus more voluntary, controlled attentional processes.

In the study of Matton and colleagues (2017) patients with a restrictive subtype of AN (restrictive group; $n = 20$), and a group combining patients with a binge/purge subtype of AN and patients with bulimia nervosa (binge/purging group; $n = 16$) were compared to non-eating disordered controls on their performance on the SOT. Results showed a non-significant trend that eating disorder patients (restrictive and binge/purge combined) showed attentional engagement towards the cues that signal punishment on the short and long cue delay trials compared to the non-eating disordered comparison group. Additionally, the binge/purging group showed significantly more difficulty in disengaging attention away from cues signaling punishment than the restrictive patients on the long cue delay trials. No differences were found between the eating disorder group and the comparison group on attention to cues signaling reward, although the restrictive group had more difficulty to disengage from cues signaling reward on the long cue delay trials than the binge/purge group. Thus, this study showed some initial evidence for more attention to cues that signal punishment in eating disorder patients, and for differences in this regard between restrictive and binge-purge type of patients. However, by combining the patients with a binge/purge subtype of AN and bulimia patients into one group it might be that differences between the subtypes of eating disorders were carried by the bulimia patients and not the patients with AN per se.

Furthermore, because of the low statistical power of this study due to the small sample sizes, replication is important (Matton et al., 2017). Therefore, the second aim of the current study was to examine differences between patients with AN and a non-eating disordered comparison group in attention to cues that signal reward and punishment as measured with the SOT.

To sum up, the current study examined whether patients with AN differ from a non-eating disordered comparison group in their general sensitivity for reward and punishment. Importantly, this is the first study to use both self-report measures (BIS/BAS and SPSRQ) as well as a performance measure (SOT) to index reward and punishment sensitivity. Since AN mostly develops during adolescence, this study focused on adolescent patients. Following the examination of general differences between AN patients and the comparison group, differences between AN patients with a restrictive and a binge-eating/purging subtype were explored. The following hypotheses were tested: Patients with AN are more sensitive for punishment and as such (1) report higher sensitivity to punishment, and (2) have more attention to punishing cues; and patients with AN are less sensitive for reward and as such (3) report less reward sensitivity, and (4) have less attention to rewarding cues, than a non-eating disordered comparison group. Furthermore, differences between AN patients with a restrictive and a binge-eating/purging subtype were explored.

Method

Participants

Patients between the ages of 12 and 23 who were referred for inpatient and for outpatient treatment to the eating disorder clinic of Accare between June 2015 and June 2017, and whose primary diagnosis was Anorexia Nervosa or atypical Anorexia Nervosa according to DSM-5 criteria, were eligible to participate in the study. There were no additional in- or exclusion criteria. Participants were 69 patients (67 female, $M_{\text{age}} = 15.55$, $SD_{\text{age}} = 1.70$), and a comparison group without an eating disorder ($n = 69$[3], 67 female, $M_{age} = 15.48$, $SD_{\text{age}} = 1.82$). Eating disorder pathology was examined with the child version of the Eating Disorder Examination (EDE) interview (Bryant-Waugh et al., 1996), and based on this, DSM-5 classifications were made. The patient group fulfilled the criteria of 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 ($n = 9$). To examine differences between the AN subtypes, the anorexia and atypical anorexia restrictive subtypes were combined into one anorexia restrictive group (AN-R; $n = 50$). The anorexia and atypical anorexia binge purge subtypes were combined into one purging subtype group (AN-BP; $n = 19$). Although the DSM-5 defines binge purge subtype as patients who can be characterized by both eating binges and purging behavior, in the current sample objective binge eating was rare. Only one participant was known to have eating binges, 15 did not, and

[3] Data of the performance measure of one participant is missing due to a computer crash during the task.

of 3 participants it was unknown[4]. The comparison group (CG) consisted of participants with a healthy weight who were matched on gender, age and educational level to the patient group.

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 (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 normal weight, and smaller than 85% as underweight (Van Winckel & Van Mil, 2001).

Eating disorder symptoms

The Eating Disorder Examination Questionnaire (EDE-Q) (Fairburn & Beglin, 2008), was administered to assess eating disorder pathology within the past 28 days. Adaptations (comparable to adaptations that were made to the previous version of the EDE-Q; Jansen, Mulkens, Hamers, & Jansen, 2007) were made to make it appropriate for children and adolescents. An average score of the 22 items was used as general index of eating disorder pathology (cf., Aardoom et al., 2012). Scores can range from 0 – 6, and reliability of this total EDE-Q score was excellent (Cronbach's alpha of .97).

Symptoms of anxiety and depression

Symptoms of anxiety and depression were assessed with a Dutch version of the Revised Child Anxiety and Depression Scale (RCADS; Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000). The RCADS consists of 47 questions that can be answered on a 4-point scale ranging from *never* (0) to *always* (3). The depression subscale consists of 10 items and had a good internal reliability (Cronbach's alpha of 0.90). Anxiety was assessed by summing the items of the Social Phobia (9 items), Panic Disorder (9 items), Separation Anxiety (7 items) and Generalized Anxiety (6 items) subscales. Internal reliability of this score in the current study was good (Cronbach's alpha of .95). In line with the DSM-5 categorization of anxiety disorders, the obsessive compulsive subscale was not included in the anxiety score of the current study (American Psychiatric Association, 2013).

Self-reported reward and punishment sensitivity

The current study included both the Behavioral Inhibition Scale/Behavioral Activation Scale (BIS/BAS) (Carver & White, 1994) and the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) (Torrubia, Ávila, Moltó, & Caseras, 2001) to measure self-reported reward and punishment sensitivity.

The BIS/BAS contains 24 statements, including 4 distractor items, that are answered on a 4-point scale ranging from *very false for me* (1), to *very true for me* (4). The questionnaire consists of a punishment sensitivity subscale containing 7 items (BIS; e.g., "I worry about

[4] 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.

making mistakes"), and three reward sensitivity subscales; 5 items regarding Reward Responsivity (BAS-RR; e.g., "When good things happen to me, it affects me strongly"), 4 items regarding Reward Drive (BAS-Drive; e.g., "I go out of my way to get things I want"), and 4 items regarding Fun Seeking (BAS-FS; e.g., "I crave excitement and new sensations"). The BAS-FS is not of interest in the current study, yet will be reported for the sake of completeness. Subscale scores are calculated by averaging the respective item scores. Additionally, the total reward sensitivity score (BAS-Total), which is the average of the three subscales will be calculated and the descriptives reported. The internal reliabilities of the BIS, BAS-Total, BAS-RR and BAS-Drive subscales in the current study were good (Cronbach's alpha of .84, .83, .75 and .79, respectively). The internal reliability of the BAS-FS was poor (Cronbach's alpha of .54).

The SPSRQ contains 24 questions about sensitivity to reward (SR; e.g., "Do you often do things to be praised?"), and 24 about sensitivity to punishment (SP; e.g., "Are you often worried by things that you said or did?"). Participants can answer these questions with *yes* (1) or *no* (0). Subscale scores are calculated by summing the items that were answered with yes. Internal reliability of the SR was acceptable (Cronbach's alpha of .67) and of the SP good (Cronbach's alpha of .88).

<u>Attentional bias to general cues of reward and punishment</u>

The Spatial Orientation Task (SOT) (Derryberry & Reed, 2002) was used to measure attention towards cues of general reward and punishment (for a detailed description of the task, see Jonker et al., 2016). The SOT indexes to what extent individuals direct their attention towards cues signaling reward and punishment (i.e., engagement), and to what extent they have difficulty to look away from cues signaling reward and punishment (i.e., disengagement). The SOT differentiates between a more automatic process that happens in a short time period (250 ms), and a more voluntary process that happens over a somewhat longer time period (500 ms). The SOT was completed on a HP Probook 650 G1 running Windows 7 on a 15-inch monitor (1366 x 768 pixels). Screen refresh rate was set at 60 Hz, and the task was programmed in E-prime 2.0 (Schneider et al., 2002). Participants were seated 50 cm away from the screen and responses were collected with a response box with two buttons. The response box was placed in front of the participants with the buttons arranged vertically and participants were told that they only needed to use to button closest to them, although both buttons worked.

The following were displayed throughout the task (see Figure 1 for an example of a trial): the current score in the middle of the screen; and two small black bars, one on the right and one on the left side of the score. Participants were instructed to pay attention to this score during the game. At the start of each trial the score disappeared from the screen for 200 ms; 250 ms after the score reappeared, a cue replaced one of the two black bars. This cue was either a blue arrow pointing upward, or a red arrow pointing downward. After either 250 ms (short delay) or 500 ms (long delay), a small grey rectangle (the target) appeared within the cue (cued trial), or within the remaining black bar (uncued trial). Participants were instructed to respond with a button press on the response box as soon as they saw the target. Two thirds of the targets appeared in the cued location. The blue cue signaled that responding to the cued target would be easy and it results in a fast enough response 75% of the time (see Table 1). Responding to the uncued target in a blue cue trial would be hard and results in an insufficiently fast response 75% of the time. For the red cue it is the opposite, responding to the cued target would be hard and it results in an insufficiently fast response 75% of the time. Responding to an uncued target in a red cue trial would be easy and results in a fast enough response 75% of the time. Thus, in general the blue cue was a signal for a high chance of a fast enough response, and the red cue a signal for a high chance of a too slow response. Participants were informed about this difference between the cues in the instructions. In some trials no target appeared (catch trials), and for those trials, participants were instructed to not press the button. At the end of each trial a feedback signal was presented in the middle of the screen directly below the score. Here again a blue or red arrow was used. The blue arrow pointing upwards signaled a fast enough response on targeted trials or a correct nonresponse on catch trials. The red arrow pointing downward signaled a too slow response on targeted trials, a response before the target appeared on targeted trials, or an inappropriate response on catch trials. 250 ms after the feedback signal appeared, the score in the middle of the screen was changed. There was a random inter trial interval of either 500 or 1000 ms.

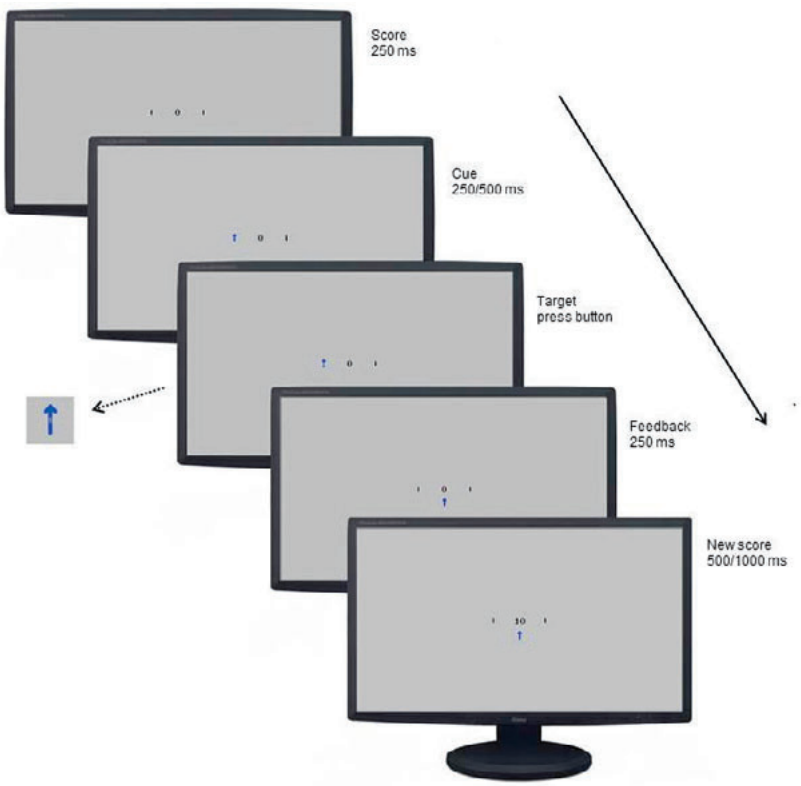

Figure 1. Example of a blue cue, cued trial with a sufficiently fast response in a winning game.

The task consisted of two different types of blocks (games). During winning games, participants would win 10 points on each trial that they responded sufficiently fast on, and would not win points when they responded too slowly. During losing games, participants would lose 10 points when they responded too slowly and would not lose points when they responded sufficiently fast on a trial. Regardless of the block, participants would lose 10 points if they responded inaccurately (i.e., before the target was shown or on catch trials). The task started with an instruction block, with 7 cued, 6 uncued and 1 catch trial, all trials with a long delay after the cue. This instruction block was followed by two practice blocks – a winning and a losing – each consisting of 6 cued, 6 uncued, and 2 catch trials. After the practice blocks, all participants started the test with two winning games, continued with two losing games followed by another two winning and two losing games. Each game consisted of 32 cued trials (57%), 16 uncued trials (29%) and 8 catch trials (14%) in random order.

At the end of each game the participant's median reaction time and standard deviation were calculated to compute cutoffs for fast and slow responses in the following game of the same type. For the three practice blocks, a fixed cutoff of 350 ms was used since no personalized cutoffs were available for these blocks. During easy trials (cued blue or uncued red) responses were labeled sufficiently fast when they were faster than participant's median reaction time plus 0.55 times the standard deviation. During hard trials (uncued blue or cued red) responses were labeled sufficiently fast when they were faster than participant's median reaction time minus 0.55 times the standard deviation. Further, since reaction times tend to be about 25 ms slower after a short cue delay time then after a long cue delay time (Derryberry & Reed, 2002), 12 ms were added to the median reaction time for short-delay trials and 12 ms were subtracted from the median reaction time for long-delay trials (see Table 1 for an overview).

In order to emphasize the rewarding and punishing aspects of the task, participants were told that if they performed well on the winning games they could win a prize (i.e., reward). Additionally, they were told that if they did not perform well enough on the losing games they would have to redo the task (i.e., punishment). In order to give the impression that this was checked at the end participants had to write their obtained score of each game on a paper. All participants were told that they performed well enough to not have to redo the task, and they all won a prize (gift bag with a mug, notebook, and pencil).

Following the task, after they were informed that they won the prize and did not have to redo the task, participants answered some questions about the task. To examine whether the reward (winning a prize) and the punishment (redoing the task) were comparable in strength, participants were asked how much they liked that they could win a prize, and how much they disliked that they might had to redo the task. These two questions were answered on a VAS ranging from *Not at all* (0) to *A lot* (100). To examine whether the blue cue becomes a signal of reward, and the red cue a signal of punishment, they were asked how they felt about the blue and the red arrow. These two questions were answered on a VAS ranging from *Very negative* (0) to *Very positive* (100). To examine whether the blue trials are experienced as more easy than the red trials, they were asked whether it was easy to respond fast enough in blue arrow trials, and red arrow trials. These two questions were answer on a VAS ranging from *Completely disagree* (0) to *Completely agree* (100).

Table 1. *Overview of trials of the spatial orientation task*

Cue	Target	Odds	Cue delay time	Cutoff for fast response[1]	Correction for cue delay time	Anticipated outcome
Blue	Cued	2/3	250 ms	Median RT + 0.55 SD	+ 12 ms	75% chance of **positive** outcome
	Cued	2/3	500 ms	Median RT + 0.55 SD	– 12 ms	75% chance of **positive** outcome
	Uncued	1/3	250 ms	Median RT – 0.55 SD	+ 12 ms	75% chance of **negative** outcome
	Uncued	1/3	500 ms	Median RT – 0.55 SD	– 12 ms	75% chance of **negative** outcome
Red	Cued	2/3	250 ms	Median RT – 0.55 SD	+ 12 ms	75% chance of **negative** outcome
	Cued	2/3	500 ms	Median RT – 0.55 SD	– 12 ms	75% chance of **negative** outcome
	Uncued	1/3	250 ms	Median RT + 0.55 SD	+ 12 ms	75% chance of **positive** outcome
	Uncued	1/3	500 ms	Median RT + 0.55 SD	– 12 ms	75% chance of **positive** outcome

Note. RT = reaction time. Since the cutoff score is calculated relative to performance, this is not expected to influence performance of some individuals differently than performance of others.

The SOT data were analyzed following Jonker et al., (2016). Facilitated engagement to reward was inferred when participants attend more to rewarding than to non-rewarding cues during the winning games. In other words, when during winning games, they responded faster to targets that appeared in the location preceded by the blue cue than in the location preceded by the red cue. Higher scores reflect more attentional engagement with reward. Facilitated engagement to punishment was inferred when participants attended more to punishing than to non-punishing cues. Thus, when during losing games, they responded faster to targets that appeared in a location preceded by a red cue, than to targets that appeared in a location preceded by a blue cue. Higher scores reflect more attentional engagement with punishment. Difficulty to disengage from reward was inferred when participants had more difficulty to look away from rewarding cues than from non-rewarding cues during winning games. Thus, when they responded slower on uncued blue cue trials, than on uncued red cue trials. Higher scores reflect more difficulty to disengage from reward. Analogously, difficulty to disengage from punishment was inferred when participants had more difficulty to look away from punishing cues than from non-punishing cues during losing games. Thus, when they responded slower on uncued red trials, than on uncued blue trails. Higher scores reflect more difficulty to disengage from punishment (see Appendix Table A).

As an estimate of the reliability of the SOT, Spearman-Brown coefficients were computed between the outcome measures for the first and the second half of the task. The relationship between these halves for all outcome measures were low with Spearman-Brown coefficients ranging from .02 to .26.

Procedure

This study was approved by the medical ethical committee of the University Medical Center in Groningen, the Netherlands (NL.51694042.14). 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 at the Center for Eating Disorders, and permission was asked to use this information for the current study. Participants for the comparison group were recruited at schools. For every patient an individually matched comparison participant with a healthy weight was selected based on age and educational level. Educational level was summarized into two categories[5] – low and high – yet the matching was done on the fine-grained level. For patients the study took place at the treatment center and for the comparison group at their school. Participants performed the SOT after which they answered the EDE-Q, BIS/BAS and SPSRQ. The procedure for the matched controls was comparable, although they did not participate in the EDE interview. The current paper reports data from a larger study on reward and punishment sensitivity (See also Jonker, Glashouwer, Hoekzema, Ostafin, & De Jong, 2019), and the SOT was the last of five computer tasks in this study.

Analyses

Group differences on age, adjusted BMI, EDE-Q score, and symptoms of anxiety and depression were assessed with independent samples *t*-tests. Differences in educational level was assessed with the Chi-square test. Next, the general response pattern of the SOT and the answers to the task assumption questions were checked. After calculation of the attentional bias scores, bivariate correlations were performed to examine the relation between the attentional bias measures and the self-report measures.

To examine whether patients with anorexia nervosa are more sensitive to punishment than the comparison group, two Multivariate Analysis of Variance (MANOVA) were performed with (1) the BIS and SP scores, and (2) the four attentional bias scores – engagement to cues signaling punishment on the short and long cue delay and disengagement from cues signaling punishment on the short and long cue delay – as dependent variables and Group (AN or comparison) as fixed factor. Univariate ANOVAs were used to examine on which variable(s) differences were found between the groups. These between subject tests had a power of 83% to find medium effects. To correct for familywise error rate a Bonferroni-Holm correction was applied. This means that for the self-report analyses the smallest p-value will be tested against an alpha of .025 and the largest against an alpha of .05. For the attentional bias analyses the smallest p-value will be tested against an alpha of .0125, the p-values following against .016 and .025, respectively, and the largest against .05.

To examine whether patients with anorexia are less sensitive for reward than the comparison group, two MANOVAs were performed with (1) the BAS-RR, BAS-Drive, BAS-Fun Seeking, and SR scores, and (2) the four attentional bias scores– engagement to cues signaling reward on the short and long cue delay and disengagement from cues signaling reward on the short and long cue delay – as dependent variables, and Group (AN or comparison) as fixed factor. Univariate ANOVAs were used to examine on which variable(s) differences were found between the groups. BAS-Total will not be included in these analyses since the three subscales already represent this score in the MANOVA. To correct for familywise error rate a Bonferroni-Holm correction was applied. This means that for both analyses, the smallest p-value will be tested against an alpha of .0125, the ones following against .016 and .025, respectively, and the last against .05.

To explore differences between AN-R and AN-BP patients four separate MANOVAs (self-reported punishment sensitivity, attention to cues signaling punishment, self-reported reward

[5] Since the International Standard Classification of Education depends highly on the number of years of education an individual has had, this classification does not seem appropriate in a sample with such a large age range as in the current sample.

sensitivity, and attention to cues signaling reward) were performed with diagnosis (AN-R, AN-BP or comparison) as fixed factor. This was analyzed separately from the main analyses, because the AN-BP group was relatively small reducing the power of the between subject test on the three groups to 74%, and that between AN-R and AN-BP specifically to 52% to find medium effects.

Classical statistical analyses were complemented with results following the Bayesian approach to increase the confidence in our results and test the evidence for the null-hypotheses in the case of non-significant findings. Bayesian analyses were conducted with JASP (JASP Team, 2018). Only *t*-tests were performed, since there is no option for a Bayesian MANOVA. Cauchy prior was set at the recommended default r = .707 (Wagenmakers et al., 2017). To facilitate interpretation of the outcomes, Bayes factors of 1 or higher were reported. That means that BF_{01}, which quantifies the evidence for the null hypotheses over the alternative hypotheses (patients with anorexia do not differ from the comparison group without an eating disorder in their sensitivity to reward) was reported when it is 1 or higher. If the BF_{01} is not higher than 1 its inverse BF_{10}, which quantifies the evidence for the alternative hypotheses over the null hypotheses (patients with anorexia are less sensitive for punishment) was reported. 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 educational level, and the mean age, BMI, EDE-Q, anxiety and depression scores of the patients with AN and the comparison group without eating disorder. As expected due to the individual matching, no difference in age and educational level was found between patients with AN and the comparison group. Patients with AN did have a significantly lower BMI, higher scores on the EDE-Q, and higher scores on the depression and anxiety subscales of the RCADS.

Table 2. *Group characteristics*

	CG (*n* = 69)		**AN (*n* = 69)**		**Between-groups test**
Educational level	Low	26	Low	26	χ^2 = 0.00,
	High	43	High	43	*p* = .57
	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)
Anxiety	23.22	12.35	40.59	15.10	7.40 (< .001)
Depression	7.58	4.73	15.55	4.56	10.08 (< .001)

Note. CG= comparison group, AN = patients with anorexia nervosa, BMI = Adjusted Body Mass Index, EDE-Q = total score on the Eating Disorder Examination Questionnaire, Anxiety = symptoms of anxiety as measured with the Revised Child Anxiety and Depression Scale, depression = symptoms of depression as measured with the Revised Child Anxiety and Depression Scale.

Data reduction

Before calculating the attentional bias measures of the SOT, outliers and errors were removed, following van Hemel-Ruiter et al. (2013). First, trials on which participants responded before the target appeared were deleted. For the anorexia patients this resulted in the deletion of 7.9% of the trials, and for the healthy controls this was 9.3%. Trials during which participants did not respond whereas they should have responded were also excluded from further analyses. This were 6.9% of the trials in the AN group and 6.3% of the trials in the HC group. Lastly, trials with reaction times below 125 ms (anticipation errors) were deleted. In the AN group this were 7.4% of the trials, and in the HC group 7.9%. No trials with reaction times above 1000 ms (probable distractions) were identified. Mean reaction times and standard deviations per trial type per group can be found in Table B in the appendix.

SOT response pattern

The general response pattern of the participants was examined (See Table 3). Paired samples t-tests showed a general engagement effect, both on the short and long cue delay trials. Participants were faster on cued blue trials than on cued red trials. On the short cue delay trials a disengagement effect was found, participants had more difficulty to direct their attention away from the blue cues than from the red cues. However, this disengagement effect was not found on the long cue delay trials.

Table 3. *Overall differences between blue and red cue trails, separately for different trial types*

				95 % CI of the difference		
		Calculation	**Cue delay**	**Lower bound**	**Upper bound**	***p***
WG	**Engagement**	Cued red – Cued blue	Short	31.66	48.59	< .001
			Long	22.46	41.94	< .001
	Difficulty to disengage	Uncued blue – Uncued red	Short	-26.59	-1.79	< .05
			Long	-12.32	10.67	.89
LG	**Engagement**	Cued blue – Cued red	Short	-44.90	-32.00	< .001
			Long	-31.67	-10.39	< .001
	Difficulty to disengage	Uncued red – Uncued blue	Short	15.77	44.58	< .001
			Long	-12.31	14.52	.87

Note. N = 137, WG = winning game, LG = losing game.

SOT task assumptions

Further, we examined the task assumption questions (see Table 4). In general participants were as positive about that they could win a prize, as they were negative about that they might have to redo the task ($t(136) = 1.10$, $p = .28$). Further, the blue arrow was rated as more positive than the red arrow ($t(136) = 26.98$, $p < .001$), and blue cue trials were rated as more easy than red cue trials ($t(136) = 11.60$, $p < .001$). Since the evaluation of these task aspects might be influenced by individuals' reward and punishment sensitivity, and we expect group differences on sensitivity to reward and punishment, it was examined whether the AN and CG groups differed in their answers on these questions. This was however not the case.

Table 4. *Checking task assumption questions*

	All (N = 137)	CG (n = 68)	AN (n = 69)	Between-groups test
	M (SD)	*M (SD)*	*M (SD)*	*t (p)*
How much did you like that you could win a prize	73.58 (21.86)	74.21 (22.18)	72.97 (21.68)	-0.33 (.74)
How much did you mind that you might had to redo the task	70.11 (28.33)	73.03 (26.75)	67.23 (29.72)	-1.20 (.23)
I think the blue arrow was..	76.23 (18.35)	78.34 (18.21)	74.16 (18.38)	-1.34 (.18)
I think the red arrow was...	17.00 (13.64)	17.07 (14.07)	16.93 (13.31)	-0.06 (.95)
It was easy to respond on blue arrow trials	61.82 (26.54)	63.50 (28.06)	60.16 (25.04)	-0.74 (.46)
It was easy to respond on red arrow trials	24.58 (23.03)	24.13 (22.19)	25.04 (24.00)	-0.23 (.82)

Descriptives

Table 5 shows the attentional bias scores and the mean scores on the self-report measures of the patient group and the comparison group (CG). Mean reaction times per group, per trial, can be found in Table B in the appendix. Bivariate correlations between the measures of reward and punishment sensitivity can be found in Table C in the appendix. Importantly, age and educational level were related to some of the reward and punishment sensitivity measures, and were therefore included as covariates in the analyses. Age was related to BAS-Drive (r = .18, p = .033), RS (r = .22, p = .010), and reward engagement short (r = .20, p = .019). Educational level was related to BIS (r_s = .17, p = .045), punishment disengagement short (r_s = -.23, p = .008), engagement reward short (r = -.18, p = .039), and reward disengagement long (r_s = .20, p = .020). Anxiety and depression were not included as covariates, since anxiety and depression are known characteristics of patients with AN (cf., Miller & Chapman, 2001).

Table 5. *Mean scores of reward and punishment sensitivity per group*

	CG (n = 69[1])		AN (n = 69)	
	M	*SD*	*M*	*SD*
Punishment sensitivity				
BIS	2.83	0.57	3.30	0.53
PS	10.90	5.40	15.87	5.02
Punishment engagement 250ms	-43.72	38.21	-33.26	37.66
Punishment engagement 500 ms	-33.92	58.24	-8.62	67.04
Punishment disengagement 250 ms	35.54	90.99	24.89	79.50
Punishment disengagement 500 ms	4.96	88.06	-2.70	70.31
Reward sensitivity				
BAS-RR	3.22	0.37	3.07	0.58
BAS-Drive	2.63	0.58	2.51	0.68
BAS-FS	2.85	0.52	2.62	0.52
BAS-Total	2.92	0.38	2.76	0.48
RS	11.52	3.39	10.48	3.71
Reward engagement 250 ms	40.84	38.59	39.42	59.61
Reward engagement 500 ms	33.73	58.43	30.69	57.28
Reward disengagement 250 ms	-4.74	73.32	-23.50	72.80
Reward disengagement 500 ms	-12.99	66.32	11.17	68.07

Note. [1] Attention to reward and punishment sensitivity is reported of 68 participants, CG = comparison group, AN = patients with anorexia nervosa, BIS = punishment sensitivity of the BIS/BAS, PS = punishment Sensitivity of the SPSRQ, BAS-RR = reward responsivity of the BIS/BAS, BAS-Dr = reward drive of the BIS/BAS, BAS-FS = fun seeking of the BIS/BAS, RS = Reward Sensitivity of the SPSRQ.

Are patients with AN more sensitive to punishment than the comparison group?

Self-report

A significant difference was found between patients with AN and the comparison group on self-reported punishment sensitivity (Λ = .79, $F(2,133) = 17.65$, $p < .001$, $\eta^2_p = .21$, CI [.11, .30]). Between subjects test showed that patients with AN scored higher than the comparison group on both the BIS ($\alpha = .05$, $F(1,134) = 26.12$, $p < .001$, $\eta^2_p = .16$, CI [.08, .26]), and the PS ($\alpha = .025$, $F(1,134) = 32.16$, $p < .001$, $\eta^2_p = .19$, CI [.11, .29]). Bayesian independent *t*-tests showed extreme evidence that the observed data are more likely under the hypotheses that patients with AN are more sensitive for punishment than adolescents without an eating disorder (BF_{10} BIS = 17615, and BF_{10} PS = 210447, respectively).

Attentional bias

Patients with AN did not differ from the non-eating disorder comparison group in their attentional bias for cues signaling punishment (Λ = .94, $F(4,130) = 2.11$, $p = .08$, $\eta^2_p = .06$, CI [.00, .11]). Bayesian independent samples t-tests showed moderate evidence that the observed data on disengagement from cues signaling punishment on the short (BF_{01} = 8.80) and long (BF_{01} = 7.99) cue delay trials are more likely under the null hypothesis. The analyses shows anecdotal evidence that the observed data on engagement to cues signaling punishment on the short cue delay trials (BF_{10} = 1.12) is more likely under the alternative hypothesis, and moderate evidence that the observed data on the long cue delay trials (BF_{10} = 4.43) is more likely under the alternative hypothesis.

Are patients with AN less sensitive to reward than the comparison group?

Self-report

Patients with AN did not differ from the comparison group on self-reported sensitivity to reward (Λ = .95, $F(4,131) = 1.82$, $p = .13$, $\eta^2_p = .05$, CI [.00, .10]). Bayesian independent samples t-tests showed anecdotal evidence that the observed data on BAS-Drive (BF_{01} = 1.83) are more likely under the null hypothesis. The analyses showed anecdotal to moderate that the observed data on BAS-RR (BF_{10} = 1.39), BAS-FS (BF_{01} = 0.15 which translates to BF_{10} = 6.87), and RS (BF_{10} = 1.34) are more likely under the alternative hypothesis.

Attentional bias

Patients with AN did not differ from the comparison group in their attentional bias for cues signaling reward (Λ = .95, $F(4,130) = 1.72$, $p = .15$, $\eta^2_p = .05$, CI [.00, .10]). Bayesian independent samples *t*-tests showed evidence that the observed data on engagement to cues signaling reward on the short (BF_{01} = 4.79) and long (BF_{01} = 4.25) cue delay trials, and disengagement from cues signaling reward on the short (BF_{01} = 1.06) and long cue delay time trials (BF_{01} = 16.04) are more likely under the null hypothesis.

Post-hoc analyses

The analyses on differences between patients with AN and non-eating disordered comparisons were also performed excluding healthy controls who scored relatively high on the eating disorder examination questionnaire (2.3 or higher; Mond, Hay, Rodgers, Owen, &

Beumont, 2004) from the comparison group (n = 17). Although these adolescents in the comparison group were not in treatment for an eating disorder and they had a healthy weight, they could be considered symptomatic. However, outcomes of the four MANOVAs were comparable with the analyses including all participants, and resulted in the same conclusions: self-reported punishment sensitivity ($\Lambda = .75$, $F(2,119) = 19.48$, $p < .001$, $\eta^2_p = .25$, CI [.13, .34]); attention to cues signaling punishment ($\Lambda = .94$, $F(4,117) = 1.76$, $p = .141$, $\eta^2_p = .06$, CI [.00, .11]); self-reported reward sensitivity ($\Lambda = .95$, $F(4,117) = 1.43$, $p = .228$, $\eta^2_p = .05$, CI [.00, .09]); and attention to cues signaling punishment and cues signaling reward sensitivity ($\Lambda = .95$, $F(4,117) = 1.63$, $p = .170$, $\eta^2_p = .05$, CI [.00, .10]).

As suggested by an anonymous reviewer, we performed post-hoc analyses excluding patients with atypical anorexia nervosa (n = 20) from the patient group. Outcomes of the MANOVA on self-reported punishment sensitivity ($\Lambda = .75$, $F(2,113) = 19.28$, $p < .001$, η^2_p = .25, CI [.14, .35]) and self-reported reward sensitivity ($\Lambda = .79$, $F(4,111) = 1.16$, $p = .331$, η^2_p = .04, CI [.00, .08]) did not change. However, patients with AN now did differ from the non-eating disordered comparison group on attention to cues signaling punishment ($\Lambda = .88$, $F(4,110) = 3.67$, $p = .008$, $\eta^2_p = .12$, CI [.02, .19]). Specifically, patients with AN showed more engagement to cues predicting punishment on the long time trials ($\alpha = .0125$, $F(1,113)$ = 8.98, $p = .003$, $\eta^2_p = .07$, CI [.01, .16]). Bayesian independent t-test showed strong evidence that the current data are more likely under the alternative hypotheses that patients with AN show a stronger AB to cues signaling punishment than adolescents without an eating disorder ($BF_{10} = 21.29$). The differences on engagement to cues signaling punishment on the short time trials ($\alpha = .016$, $F(1,113) = 4.09$, $p = .045$, $\eta^2_p = .04$, CI [.00, .11], $BF_{01} = 0.37$; $BF_{10} = 2.72$), disengagement from cues signaling punishment on the short time trials ($\alpha = .025$, $F(1,113)$ = 1.07, $p = .303$, $\eta^2_p = .01$, CI [.00, .06], $BF_{01} = 10.40$), and disengagement from cues signaling punishment on the long time trials ($\alpha = .05$, $F(1,113) = 0.00$, $p = .963$, $\eta^2_p = .00$, CI [.00, .00], $BF_{01} = 4.86$) were not significant.

When excluding patients with atypical anorexia nervosa (n = 20), patients with AN also differed from the comparison group on attention to cues signaling reward ($\Lambda = .88$, $F(4,110)$ = 3.65, $p = .008$, $\eta^2_p = .12$, CI [.02, .19]). However, although in the expected direction – we found less engagement to cues signaling reward and less difficulty to disengage from cues signaling reward in patients with AN – none of the follow-up ANOVAs reached statistical significance; engagement to cues signaling reward on the short time trials ($\alpha = .025$, $F(1,113)$ = 1.71, $p = .193$, $\eta^2_p = .02$, CI [.00, .07], $BF_{01} = 1.12$), engagement to reward cues signaling reward on the long time trials ($\alpha = .05$, $F(1,113) = 0.40$, $p = .530$, $\eta^2_p = .00$, CI [.00, .04], BF_{01} = 2.86), disengagement from cues signaling reward on the short time trials ($\alpha = .016$, $F(1,113)$ = 4.16, $p = .044$, $\eta^2_p = .04$, CI [.00, .11], $BF_{10} = 1.74$), and disengagement from cues signaling reward on the long time trials ($\alpha = .0125$, $F(1,113) = 5.64$, $p = .019$, $\eta^2_p = .05$, CI [.00, .12], $BF_{01} = 16.62$). The Bayesian independent t-tests showed strong evidence that the current data are more likely under the null hypotheses of no difference between the groups in disengagement from cues signaling reward on the long time trials. The evidence for the engagement on the short and long time trials, and difficulty to disengage from cues signaling reward on the short time trials was inconclusive.

Do patients with AN-R and AN-BP differ in their reward and punishment sensitivity?

Table 6 provides the means for the AN-R and AN-BP groups. AN-R patients had a lower educational level, a lower BMI and less symptoms of depression than AN-BP patients. Additionally, AN-R patients had marginally lower EDE-Q scores than AN-BP patients.

Table 6. *Group characteristics of patients with AN-R and AN-BP*

	AN-R (*n* = 50)		**AN-BP (*n* = 19)**		**Between-diagnosis test**	
Educational level	Low	14	Low	12	$X^2 = 7.25$,	
	High	36	High	7	$p < .01$	
	M	***SD***	***M***	***SD***	***t***	***p***
Age	15.42	1.55	15.89	2.05	-1.04	.304
BMI	82.72	10.86	89.87	14.10	-2.24	.028
EDE-Q	4.01	1.14	4.57	0.96	-1.90	.062
Anxiety	40.96	14.67	39.63	16.57	0.32	.747
Depression	14.84	4.55	17.42	4.14	-2.16	.035
Punishment sensitivity						
BIS	3.41	0.47	3.00	0.59		
PS	16.82	4.29	13.37	5.98		
Punishment engagement 250ms	-33.02	37.56	-33.89	38.94		
Punishment engagement 500 ms	-6.15	62.02	-15.11	80.30		
Punishment disengagement 250 ms	14.99	70.95	50.95	95.85		
Punishment disengagement 500 ms	-11.44	64.47	20.33	81.18		
Reward sensitivity						
BAS-RR	3.15	0.55	2.89	0.62		
BAS-Drive	2.52	0.69	2.50	0.68		
BAS-FS	2.60	0.51	2.70	0.54		
BAS-Total	2.78	0.46	2.71	0.55		
RS	10.20	3.76	11.21	3.58		
Reward engagement 250 ms	31.68	35.33	59.78	97.05		
Reward engagement 500 ms	26.55	55.61	41.57	61.69		
Reward disengagement 250 ms	-15.53	69.48	-44.46	78.99		
Reward disengagement 500 ms	13.88	75.10	4.03	45.57		

Note. BMI = Adjusted Body Mass Index, EDE-Q = total score on the Eating Disorder Examination Questionnaire, Anxiety = symptoms of anxiety as measured with the Revised Child Anxiety and Depression Scale, Depression = symptoms of depression as measured with the Revised Child Anxiety and Depression Scale, AN-R = patients with AN restrictive subtype, AN-BP = patients with AN binge purging subtype, BIS = punishment sensitivity of the BIS/BAS, PS = punishment Sensitivity of the SPSRQ, BAS-RR = reward responsivity of the BIS/BAS, BAS-Dr = reward drive of the BIS/BAS, BAS-FS = fun seeking of the BIS/BAS, RS = reward sensitivity of the SPSRQ.

Our explorative analyses on differences between the subtypes of AN showed a significant difference between AN-R and AN-BP patients on self-reported punishment sensitivity (Λ = .87, $F(2,66) = 5.11$, $p = .009$, $\eta^2_p = .13$, *CI* [.20, .25]). Between subjects tests showed that the AN-R group scored higher on both BIS ($F(1,67) = 9.39$, $p = .003$, $\eta^2_p = .12$, *CI* [.03, .25], $BF_{10} = 11.87$) and PS ($F(1,67) = 7.10$, $p = .01$, $\eta^2_p = .10$, *CI* [.01, .21], $BF_{10} = 4.85$) than the AN-BP group. There was no evidence for a difference in attention to cues signaling punishment between patients with AN-R and AN-BP in this respect ($\Lambda = 0.91$, $F(4,64) = 1.55$, $p = .20$, $\eta^2_p = .09$, *CI* [.00, .16]). Bayesian independent samples *t*-tests showed anecdotal to moderate evidence that the observed data on engagement to cues signaling punishment on the short ($BF_{01} = 3.67$) and long ($BF_{01} = 3.33$), and disengagement from cues signaling punishment on the short (BF_{01} = 1.12) and long (BF_{01} = 1.12) cue delay trials are more likely under the null hypothesis.

The explorative analyses showed no significant difference between AN-R and AN-BP patients in their self-reported reward sensitivity (Λ = .88, F(4,64) = 2.26, p = .08, η^2_p = .12, *CI* [.00, .21]). Bayesian independent samples t-tests showed anecdotal to moderate evidence that the observed data on BAS-RR (BF_{01} = 1.30), BAS-Drive (BF_{01} = 3.67), BAS-FS (BF_{01} = 2.94), and RS (BF_{01} = 2.41) are more likely under the null hypothesis. Additionally, no differences between patients with AN-R and AN-BP were found on attentional bias to cues signaling reward (Λ = .93, F(4,64) = 1.16, p = .34, η^2_p = .07, *CI* [.00, .13]). Bayesian independent samples *t*-tests showed anecdotal to moderate evidence that the observed data on engagement to cues signaling reward on the short (BF_{01} = 1.00) and long (BF_{01} = 2.49), and disengagement from cues signaling reward on the short (BF_{01} = 1.48) and long (BF_{01} = 3.27) cue delay trials are more likely under the null hypothesis.

Discussion

The current study set out to examine whether patients with AN differed from adolescents without an eating disorder in their general sensitivity to reward and punishment. This is the first study to use both self-report as well as a performance measure to index reward and punishment sensitivity in AN. The main findings can be summarized as follows: Patients with AN (1) reported higher sensitivity to punishment as measured with both the BIS/BAS and SPSRQ; (2) did not show more attention to cues signaling punishment; (3) did not report lower sensitivity to reward as measured with the BIS/BAS and SPSRQ; and (4) did not show less attention to cues signaling rewarding, than adolescents without an eating disorder. Additionally, exploratory analyses showed that patients with a restrictive subtype of AN reported higher sensitivity to punishment than patients with a binge-purging subtype of AN.

In line with previous findings, patients with AN in the current study reported higher sensitivity for punishment than adolescents without an eating disorder (Claes et al., 2006; Glashouwer et al., 2014; Jappe et al., 2011; Matton et al., 2015; Monteleone et al., 2014). This difference was found when assessing punishment sensitivity with the BIS/BAS as well as with the SPSRQ. In the current study, evidence for a difference between the groups was extremely high (BF_{10} > 100) for both questionnaires. All in all, the finding that patients with AN report a higher sensitivity to punishment than non-eating disordered comparisons seems robust. Future studies should further examine whether this relatively high punishment sensitivity plays a role in the development and/or maintenance of the disorder, whether it is a personality characteristic that fluctuates together with the symptoms of AN – both eating disorder symptoms and anxiety – or whether high reports of punishment sensitivity are a consequence of the disorder. Previously, punishment sensitivity was not found to relate to symptoms persistence (Glashouwer et al., 2014), and treatment of AN was not found to result in a decrease in punishment sensitivity (Harrison et al., 2016). However, the change in punishment sensitivity was not examined in relationship to change in symptoms, and the relationship with symptoms of anxiety was not examined.

Although patients with AN reported higher punishment sensitivity than the comparison group, there was no evidence for a difference in attention to cues signaling punishment between the two groups. This finding seems to be consistent with a previous study showing no difference in patients with AN and a comparison group on attention to general threat words, which could be considered cues signaling punishment (Schober et al., 2014). However, when excluding patients with atypical AN from the patient group there was strong evidence for more attentional engagement to cues signaling punishment on the long cue delay trials in patients with AN. Thus specifically on the trials which index more voluntary attentional allocation, patients with AN had a tendency to engage their attention on cues signaling punishment. This is in line with previous findings of a non-significant trend showing that eating disorder patients (restrictive and binge/purge combined) show more attentional engagement with cues that signal punishment than non-eating disordered comparisons (Matton et al., 2017). Since atypical and full-threshold AN do not seem to differ in psychological and physical severity (Sawyer, Whitelaw, Le Grange, Yeo, & Hughes, 2016)[6], this implies that there might be different characteristics that play a role in full-threshold AN compared to atypical AN. Potentially, sensitivity to punishment might play a role in the development of full-threshold AN, but not in the development of atypical AN. This might relate to the finding that adolescents with atypical AN are more often premorbidly overweight or obese than patients with full-threshold AN (Sawyer et al., 2016), and overweight and obesity have been related to lower punishment sensitivity (Danner et al., 2012, however also see Nederkoorn et al., 2006).

Nevertheless, in the full sample of patients with AN we did not find a parallel between the results from self-reported punishment sensitivity and the results of the attentional measure of punishment sensitivity. It might be that the relatively high sensitivity to punishment as reported by patients with AN is limited to their own experience, but is not reflected in their actual behavior. However, it might also be that attention is not the most relevant behavior related to punishment sensitivity in the context of AN. It has been suggested that individuals who are sensitive to punishment respond more negatively to punishment, have more attention to punishment, and show more avoidance behavior in response to punishment in the environment (Gray, 1970; Gray & McNaughton, 2000). The self-report measures of punishment sensitivity, the BIS/BAS and the SPSRQ, on which individuals with AN score relatively high mainly seem to index punishment responsivity (e.g., BIS/BAS: “Criticism or scolding hurts me quite a bit”), and avoidance components (e.g., SPSRQ: “Do you often refrain from doing something you like in order not to be rejected or disapproved of by others?”). It might thus be that patients with AN do not differ in attention to punishment, but would differ on behavioral measures that index responsivity or avoidance behavior.

The current study did not find a difference between patients with AN and a non-eating disordered comparison group in self-reported reward sensitivity as measured with the BIS/BAS and the SPSRQ. Not finding a difference between patients with AN and a comparison group in self-reported reward sensitivity as measured with the BIS/BAS is in line

[6] In this study, patients with full-threshold AN scored lower on the EDE ($t(65) = -2.06$, $p = .044$), had lower BMI ($t(67) = -9.45$, $p < .001$), scored lower on symptoms of depression ($t(67) = -3.02$, $p = .004$), yet did not differ in symptoms of anxiety ($t(67) = -0.86$, $p = .392$) from patients with atypical AN.

with most studies (Jappe et al., 2011; Matton et al., 2015; Monteleone et al., 2014), yet inconsistent with one study (Claes et al., 2006). However, when examining the latter study more closely, it appears that in that study, the lower reward sensitivity in patients with AN is due to lower reports on BAS fun seeking specifically. Indeed, in the current study the Bayesian analysis showed moderate evidence for lower BAS fun seeking in patients with AN. However, since this subscale has been suggested to measure impulsivity or sensation seeking rather than reward sensitivity (Scheres & Sanfey, 2006), it seems reasonable to conclude that the studies using the BIS/BAS consistently find no differences between patients with AN and a comparison group in self-reported reward sensitivity. The absence of a difference between patients with AN and a comparison group in self-reported reward sensitivity as measured with the SPSRQ is inconsistent with previous findings (Glashouwer et al., 2014; Jappe et al., 2011). Interestingly, the difference in findings seems to result from differences in reported reward sensitivity in the comparison group (mean of 8.05 in Glashouwer et al. (2014) vs. 11.52 in the current study), while reward sensitivity as reported by the patients with AN seems comparable (mean of 10.48 in this study vs. 9.70 in the study of Glashouwer et al., 2014). Unfortunately the scores of the study of Jappe et al. (2011) cannot be compared since they used an adapted subscale. Nevertheless, findings on reward sensitivity as measured with the SPSRQ should be interpreted with caution since they might not reflect general reward sensitivity, but a sensitivity to the specific situations that are asked about in the questionnaire (Glashouwer et al., 2014). The current study also failed to find differences in attention to cues signaling reward between patients with AN and the comparison group. This is in line with a pilot study that showed no differences between eating disorder patients and a comparison group on attention to reward as measured with the same task (Matton et al., 2017). Findings of the current study are also in line with an fMRI study showing no difference in brain activation in response to reward anticipation between patients with AN and healthy women (Murao et al., 2017). All in all, findings mostly seem to indicate that there is no difference between patients with AN and non-eating disordered comparisons in reward sensitivity.

In the current study we explored differences in reward and punishment sensitivity between patients with a restrictive subtype of AN and patients with a purging subtype of AN. No differences were found between the subtypes in sensitivity to reward, which is in line with most previous self-report studies (Claes et al., 2006; Glashouwer et al., 2014; Matton et al., 2015). Further, AN-R patients in the current study reported higher sensitivity to punishment than AN-BP patients as measured with both the BIS/BAS and the SPSRQ. This is in line with one previous study (Claes et al., 2006), but in contrast with most other prior studies (Glashouwer et al., 2014; Matton et al., 2015; Monteleone et al., 2014). There was no significant difference between patients with AN-R and AN-BP in their attention to cues signaling punishment. This seems to be in contrast with findings from an fMRI study in which patients with AN-BP were found to have increased brain activation in response to loss anticipation compared to patients with AN-R or a comparison group (Murao et al., 2017). In the present study the AN-BP group consisted mainly of patients who only used purging behaviors but did not report objective binge eating episodes. Since prior studies did not report about objective binge eating of the AN-BP groups, it is unclear whether our sample differs from other samples. Consequently, it might thus be that inconsistencies in findings are due to differences in subsamples. Future studies should further explore this by keeping in mind that there might be differences in binge and purge behavior between patients that receive the same diagnostic label.

The current study has several strengths, such as the large group of patients and the individually matched comparison group. Additionally, a behavioral measure of reward and punishment sensitivity that assesses attentional bias to cues that signal reward and punishment was included. Attesting to the validity of the task, previous studies have shown that it has predictive validity with regard to anxiety and substance use (Derryberry & Reed, 2002; Van Hemel-Ruiter et al., 2013). Further, subjective reports of participants showed that the evaluation of the cues in the task, red as punishing and blue as rewarding, are in line with the design of the task. Additionally, the pattern of RTs to cued and uncued trials are conform expectation, which has also been shown in large scale studies (Jonker et al., 2016; van Hemel-Ruiter et al., 2013) and a study in patients with eating disorders (Matton et al., 2017). As a last step to examine the validity of the SOT future studies might consider complementing the RTs with EEG measures in order to provide more direct measures of covert attention.

Nevertheless, the current study also has some limitations that should be taken into account when interpreting the results. First, estimates of reliability in terms of spilt-half reliability coefficients for the SOT were low. Yet, this should be interpreted with some caution since the indices used in the split-half reliability analyses are calculated from less trials than are expected to be necessary for an acceptable signal to noise ratio. That means that two a priori unreliable indices are compared in the split-half reliability analyses (Elgersma et al., 2019). Furthermore, it has recently been questioned whether internal consistency and test-retest reliability are relevant estimates of true reliability, especially in the case of performance measures such as the SOT (e.g., De Schryver, Hughes, De Houwer, & Rosseel, 2018). Second, the questionnaires used to assess punishment sensitivity show some conceptual overlap with symptoms of anxiety. It can therefore not be ruled out that the heightened PS scores in AN at least partly reflect heightened anxiety in AN. It would therefore be important for future studies to examine whether patients with AN also score higher on punishment sensitivity when assessed with a measure that does not show such conceptual overlap with anxiety symptoms. Third, the cross-sectional design constrains the interpretation of the findings. Longitudinal and experimental research is needed to examine the direction of effects found in the current study. Fourth, the findings on the differences between the subtypes of AN should be interpreted with caution since the group of AN-BP patients was small and might not reflect the full group of patients with a binge/purge subtype of AN. Last, even though we specifically recruited adolescents without eating problems for the comparison group, this was not checked with a diagnostic interview. However, the EDE-Q was used to assess eating disorder symptoms and a healthy BMI was required. It is therefore very unlikely that participants in the comparison group had (substantial) eating problems.

To conclude, the current study did not find any evidence for a difference in reward sensitivity between patients with AN and a non-eating disordered comparison group. However, the current study did show that patients with AN reported higher sensitivity to punishment than adolescents without an eating disorder. This finding seems robust since it is consistently found also in previous studies, and occurred regardless of the questionnaire that was used to assess punishment sensitivity. Additionally, when excluding patients with atypical AN, we found more attentional engagement to cues signaling punishment in full-threshold patients with AN. It would be important for future studies to examine the specific role of heightened punishment sensitivity in the development and persistence of AN. When high punishment sensitivity is related to symptom persistence, treatment might benefit from addressing this general sensitivity to punishment.

Appendix

Table A. *Calculation of attentional biases to reward and punishment*

Game	Bias	Calculation	Interpretation	Cue delay time	
WG	Engagement	mean RT cued red trials –mean RT cued blue trials	high score = high AB to reward	250 ms 500 ms	Automatic Voluntary
	Difficulty to disengage	mean RT uncued blue trials – mean RT uncued red trials	high score = high AB to reward	250 ms 500 ms	Automatic Voluntary
LG	Engagement	mean RT cued blue trials – mean RT cued red trials	high score = high AB to punishment	250 ms 500 ms	Automatic Voluntary
	Difficulty to disengage	mean RT uncued red trials – mean RT uncued blue trials	high score = high AB to punishment	250 ms 500 ms	Automatic Voluntary

From ″ Attentional bias for reward and punishment in overweight and obesity: The TRAILS study ", by N.C. Jonker, K.A. Glashouwer, B.D. Ostafin, M.E. Van Hemel-Ruiter, F.R.E. Smink, H.W. Hoek and P.J. De Jong, 2016, PLOS ONE, Supplemental Material. Reprinted with permission.
Note. WG = *winning* game, LG = *losing* game, RT = reaction time, AB = attentional bias.

Table B. *Mean reaction times and standard deviations of the Spatial Orientation Task*

	AN (*n* = 69)				**CG (*n* = 68)**			
	Cued		**Uncued**		**Cued**		**Uncued**	
	Blue	**Red**	**Blue**	**Red**	**Blue**	**Red**	**Blue**	**Red**
Short cue delay time (250 ms)								
WG	334 (46)	374 (77)	499 (94)	522 (81)	318 (42)	359 (51)	498 (83)	502 (87)
LG	327 (39)	360 (54)	488 (98)	513 (98)	321 (35)	364 (49)	472 (84)	507 (98)
Long cue delay time (500 ms)								
WG	364 (73)	394 (75)	429 (90)	418 (83)	351 (67)	385 (74)	407 (82)	420 (85)
LG	368 (82)	376 (70)	429 (103)	426 (95)	338 (65)	371 (64)	407 (95)	412 (88)

Note. AN = patients with anorexia nervosa, CG = comparison group, WG = *winning* game, LG = *losing* game.

Table C. *Bivariate correlations between measures of reward and punishment sensitivity*

		Punishment						Reward							
		1.	**2.**	**3.**	**4.**	**5,**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**	**14.**
Punishment	**1. BIS**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2. PS	.72**	-	-	-	-	-	-	-	-	-	-	-	-	-
	3. Punishment engagement 250 ms	.10	.05	-	-	-	-	-	-	-	-	-	-	-	-
	4. Punishment engagement 500 ms	.27**	-.19*	.08	-	-	-	-	-	-	-	-	-	-	-
	5. Punishment disengagement 250 ms	-.14	-.11	-.28**	.07	-	-	-	-	-	-	-	-	-	-
	6. Punishment disengagement 500 ms	-.14	-.13	-.10	.11	-.01	-	-	-	-	-	-	-	-	-
Reward	**7. BAS-RR**	.01	-.13	.05	.07	.01	-.02	-	-	-	-	-	-	-	-
	8. BAS-Drive	-.20*	-.18*	.00	.01	.06	.05	.47**	-	-	-	-	-	-	-
	9. BAS-FS	-.21*	-.30**	.03	.02	-.04	.05	.55**	.37**	-	-	-	-	-	-
	10. BAS-Total	-.16	-.25**	.03	.04	.02	.03	.85**	.79**	.77**	-	-	-	-	-
	11. RS	-.13	-.15	-.02	.00	.01	.11	.45**	.46**	.40**	.55*	-	-	-	-
	12. Reward engagement 250 ms	-.14	-.03	-.41**	-.12	.36**	.17*	-.16	.10	-.10	-.06	-.02	-	-	-
	13. Reward engagement 500 ms	-.02	.05	-.03	-.08	-.12	-.04	-.20*	-.05	-.11	-.15	-.09	.13	-	-
	14. Reward disengagement 250 ms	-.11	-.08	.14	-.02	-.12	-.19	.07	-.04	-.02	.01	.02	-.26**	-.01	-
	15. Reward disengagement 500 ms	.13	.22**	-.05	.14	-.05	-.19	.07	-.02	-.04	.01	-.02	-.06	.04	-.04

Note. Note. * $p < .05$, ** $p < .01$. BIS = punishment sensitivity of the BIS/BAS, PS = punishment sensitivity of the SPSRQ, BAS-RR = reward responsivity of the BIS/BAS, BAS-Dr= reward drive of the BIS/BAS, BAS-FS = fun seeking of the BIS/BAS, RS = reward sensitivity of the SPSRQ.