Visual Attention to Pictorial Food Stimuli in Individuals with Night Eating Syndrome: An Eye-Tracking Study

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Conflict of Interest Statement

The authors declare no conflicts of interest.

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Abstract

Night eating syndrome (NES) is characterized by excessive evening and/or nocturnal eating episodes. Studies indicate an attentional bias towards food in other eating disorders. For NES, however, evidence of attentional food processing is lacking. Attention towards food and non-food stimuli was compared using eye-tracking in 19 participants with NES and 19 matched controls without eating disorders during a free exploration paradigm and a visual search task. In the free exploration paradigm, groups did not differ in initial fixation position or gaze duration. However, a significant orienting bias to food compared to non-food was found within the NES group, but not in controls. A significant attentional maintenance bias to non-food compared to food was found in both groups. Detection times did not differ between groups in the search task. Only in NES, attention to and faster detection of non-food stimuli were related to higher BMI and more evening eating episodes. The results might indicate an attentional approach-avoidance pattern towards food in NES. However, further studies should clarify the implications of attentional mechanisms for the etiology and maintenance of NES.

Key words: night eating syndrome; eating disorder; attention; visual; eye-tracking.

Highlights

- Participants with night eating syndrome (NES) did not differ from controls in eye-tracking data and detection times.
- An orienting bias to food was found within the NES group, but not in controls.
- Both NES and controls showed an attentional maintenance bias to non-food.
- The results suggest an attentional approach-avoidance pattern towards food in NES.

Introduction

Night eating syndrome (NES) was recently included in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) under the section of Other Specified Feeding or Eating Disorders (OSFED; American Psychiatric Association, 2013). It is characterized by recurrent night eating episodes, which are defined by eating after awakening from sleep and/or excessive food consumption after the evening meal while being aware of and able to recall the episode (American Psychiatric Association, 2013). Clinical utility of NES has been demonstrated in a number of studies (Allison, Grilo, Masheb, & Stunkard, 2005; Runfola, Allison, Hardy, Lock, & Peebles, 2014; Vander Wal, 2012). Specifically, NES was related to overweight and obesity, higher general psychopathology (Cleator, Abbott, Judd, Sutton, & Wilding, 2012; Gallant, Lundgren, & Drapeau, 2012), and non-normative eating behaviors such as emotional eating and food addiction (Baldofski et al., 2015). Research suggests a moderate degree of overlap between NES and binge-eating disorder (BED; Allison et al., 2010; Cleator et al., 2012), while studies indicated higher levels of eating disorder psychopathology and more objective binge-eating episodes (i.e., eating an objectively large amount of food with a sense of loss of control over eating) and objective overeating episodes (i.e., eating an objectively large amount of food without loss of control) in BED than in NES (Adami, Campostano, Marinari, Ravera, & Scopinaro, 2002; Allison, Grilo et al., 2005; Baldofski et al., 2015).

Research on eating disorders suggests that dysfunctional cognitive structures related to eating, weight, and body shape may bias cognitive processes and, more specifically, attentional processes regarding eating disorder-related stimuli such as food cues (Brooks, Prince, Stahl, Campbell, & Treasure, 2011; Giel, Teufel et al., 2011). The relevance of cognitive-motivational mechanisms in attentional processing of food is highlighted in the incentive-sensitization theory of addictive disorders (Robinson & Berridge, 1993, 2001). This model proposes that repeated exposure to salient stimuli, for example food stimuli, elicits changes in the dopamine reward system resulting in a conditioning process. As a consequence, incentive salience is attributed to food stimuli, making them attractive and guiding behavior towards these incentives (Robinson & Berridge, 1993).This process may result in an attentional bias, which refers to the selective attention to disorder-relevant, salient stimuli, i.e. food stimuli, in preference over other, usually neutral stimuli (Giel, Teufel et al., 2011).

Most studies investigating attention to food in eating disorders have used reaction time-based measures such as Stroop and visual dot probe tasks, yielding evidence for an attentional bias towards food in anorexia nervosa (AN), bulimia nervosa (BN), and BED compared to controls (Brooks et al., 2011; Giel, Teufel et al., 2011). Specifically, in BED, findings indicated an early engagement to food stimuli (Schmitz, Naumann, Biehl, & Svaldi, 2015; Schmitz, Naumann, Trentowska, & Svaldi, 2014; Svaldi, Naumann, Biehl, & Schmitz, 2015) as well as delayed disengagement from food stimuli at long stimulus presentation durations (Svaldi, Naumann, Trentowska, & Schmitz, 2014). A limitation to reaction time-based measures is that they assess different components of visual attention as compared to eye-tracking paradigms. Specifically, performance-based approaches are likely to assess earlier attentional stages due to shorter stimulus presentation durations. They measure attention only indirectly and cannot reveal temporal aspects, such as differences in the early automatic initial allocation versus later maintenance or disengagement of attention (Mogg, Bradley, Field, & Houwer, 2003; Wolz, Fagundo, Treasure, & Fernández-Aranda, 2015). Further, reaction time-based measures do not evoke a direct response conflict between attention-competing food and non-food stimuli (Mogg & Bradley, 1998), thus, leaving ambiguity about selective attentional mechanisms.

Eye-tracking represents an ecologically valid and directly observable measure of overt visual attention by continuously recording participants’ eye movements (Mogg et al., 2003). Eye-tracking paradigms are often applied in combination with indirect attentional measures.

Regarding initial engagement processes, prior studies have yielded mixed evidence for an early attentional bias to food in BED. While one study reported an early attentional engagement to food stimuli in participants with binge eating compared to controls (Popien, Frayn, Ranson, & Sears, 2015), other studies found that individuals with BED did not differ from controls in their initial attentional orientation towards food stimuli (Schag et al., 2013; Schmidt, Lüthold, Kittel, Tetzlaff, & Hilbert, 2016). However, a number of studies comparing individuals with overweight and obesity to normal weight participants yielded an early attentional bias towards food in overweight and obesity (Castellanos et al., 2009; Werthmann et al., 2011). Another study found an early attentional bias for high calorie relative to low calorie food in participants with normal weight compared to participants with overweight and obesity (Graham, Hoover, Ceballos, & Komogortsev, 2011), while other studies did not yield group differences in early attentional engagement between individuals with normal weight and overweight and obesity, respectively (Doolan, Breslin, Hanna, Murphy, & Gallagher, 2014; Nijs, Muris, Euser, & Franken, 2010).

Regarding attentional maintenance or disengagement processes, participants with BED or binge eating exhibited longer gaze duration on food stimuli compared to controls in a free exploration task (Popien et al., 2015; Schag et al., 2013; Schmidt et al., 2016) and faster detection of food compared to non-food stimuli in a visual search task (Schmidt et al., 2016). The latter effect was more pronounced for food stimuli with a high personal pleasantness compared to unattractive food stimuli in adolescents with BED (Schmidt et al., 2016). In obesity, a longer gaze duration on food compared to controls (Castellanos et al., 2009), but no reaction time differences between groups in a dot probe task were found (Castellanos et al., 2009; Werthmann et al., 2011). In another study, participants with overweight and obesity versus normal weight did not differ in gaze duration (Graham et al., 2011). Finally, while one study yielded a greater gaze duration towards high energy density food in males with overweight and obesity compared to normal weight males (Doolan et al., 2014), findings from another study yielded no group differences in a free exploration task between women with normal weight and with overweight and obesity, respectively (Nijs et al., 2010). The aforementioned divergent results might be explained by methodological differences across these studies. Specifically, heterogeneous sample characteristics (e.g., clinical vs. non-clinical samples, different weight ranges) might have influenced the results. Further, the use of different experimental tasks (e.g., free exploration paradigms vs. visual search tasks) including varying stimulus presentation durations and different stimulus sets could have also affected attentional processing results (Werthmann, Jansen, & Roefs, 2015).

Overall, while previous evidence is conflicting (Werthmann et al., 2015), prior research largely points to biased attentional processing of food in eating disorders (Brooks et al., 2011; Giel, Teufel et al., 2011) and obesity (Hendrikse et al., 2015) compared to controls. Specifically, studies suggest an attentional approach-approach pattern in BED and obesity, i.e. rapid orienting to and delayed disengagement from food stimuli. In NES, however, evidence for attentional food processing is lacking. As NES is associated with obesity (Cleator et al., 2012) and shows comorbidity with BED (Cleator et al., 2012; Striegel-Moore, Franko, & Garcia, 2009), we hypothesized an attentional approach-approach pattern in NES.

This study sought to comprehensively investigate visual attentional orienting and disengagement processes in NES using eye-tracking and reaction time-based paradigms. To this end, a free exploration paradigm was used to assess initial gaze direction and overall gaze duration on food and non-food stimuli. A visual search task including multiple attention-competing stimuli was used to examine detection processes. We hypothesized a greater attentional bias towards food compared to non-food stimuli in individuals meeting DSM-5 NES criteria compared to a control group (CG) without eating disorder symptoms. Specifically, we expected an attentional approach-approach pattern in NES, as reflected by a) a facilitated initial orientation to and longer overall gaze duration on food stimuli during a free exploration paradigm (Task 1) and b) faster detection of a food target among non-food distractors than vice versa in a visual search task (Task 2) in NES compared to controls. An exploratory analysis investigated whether attentional food processing was associated with eating disorder psychopathology, body mass index (BMI), and hunger.

Methods

Ethics Statement

This study was approved by the Ethics Committee of the Medical Faculty of the University of Leipzig. Written informed consent was obtained from all participants prior to participation.

Participants

Participants aged ≥ 18 years were recruited from the community via internet-based advertisements. They were naive to the purpose of the experiment and were informed that they would be participating in a study on eye movements. All participants received financial compensation. Participants in the NES group (*n* = 19) were diagnosed with current full-syndrome NES (*n* = 12; 63.16%) according to the DSM-5 (American Psychiatric Association, 2013) or subsyndromal NES (*n* = 7; 36.84%). The control group (CG; *n* = 19) comprised participants without eating disorder symptoms individually matched according to sex, age, and BMI (kg/m^2). The DSM-5 criteria for NES do not specify frequency and duration of night eating episodes (NEEs), however, based on previous recommendations, full-syndrome NES comprised at least two NEEs per week within the last three months (Allison et al., 2010). Further, subsyndromal NES was defined according to recommended criteria for subsyndromal BED (de Zwaan et al., 2012), including NEEs that occurred only once per week or were not associated with significant distress.

Telephone interviews were carried out to determine participant eligibility. To minimize the potential effects of hunger or recent food consumption on attentional food processing (Castellanos et al., 2009; Piech, Pastorino, & Zald, 2010), eligible participants were instructed to be satiated at the appointment, but to avoid consumption of food and caloric drinks one hour beforehand. At the appointment, the diagnostic version (i.e., including diagnostic items only) of the semistructured Eating Disorder Examination (EDE) interview (Fairburn & Cooper, 1993; Hilbert & Tuschen-Caffier, 2016a) was completed after the experimental tasks and was used to assess diagnostic criteria and confirm inclusion. Additional items for NES according to the DSM-5 were developed based on the structure of EDE items by the first author (SB; Baldofski et al., 2015). Exclusion criteria comprised non-corrected vision impairment, current intake of psychotropic or weight-affecting medication, current substance abuse/addiction, psychotic disorder, bipolar disorder, neurological diseases, pregnancy or lactation, as well as objective binge-eating episodes and inappropriate compensatory behavior within the last three months. Further, in the CG, NEEs within the last three months were an exclusion criterion.

Eye-Tracking and Experimental Design

Free exploration paradigm (Task 1). All experimental procedures have been previously used in adolescents with BED (see Schmidt et al., 2016). In Task 1, 30 pairs of matched food and non-food stimuli were randomly presented, resulting in a total of 30 trials (see Figure 1). While eye movements were recorded, participants were instructed to freely explore the stimuli as if watching TV. All images were scaled to a width of 150 pixels and presented on an imaginary diagonal. The food and non-food stimuli positions (left/right, top/bottom) were randomized for each trial.

Visual search task (Task 2). Stimuli were presented in a circular search array, with the number of stimuli varying randomly between three or six (see Figure 2). All images were scaled to a width of 100 pixels and were arranged on an imaginary circle in the screen's center. Participants were instructed to indicate as quickly and accurately as possible whether the array contained only stimuli of the same category or whether one stimulus (target) was different from the others (distractors) by pressing one of two keys. The task consisted of four trial types (see Figure 2). For hypothesis testing, only food and non-food target trials were analyzed. The task comprised seven blocks with 30 trials each, of which the first block served as a practice block and therefore was not included in the analyses.

Stimuli. The same stimulus materials were used for both tasks and consisted of 30 food stimuli depicting low to high calorie foods and 30 non-food stimuli depicting everyday objects not related to eating or food (for examples see Figures 1 and 2). Each food stimulus was closely matched with a non-food stimulus for color, shape, size, and complexity. The stimulus set was pre-tested with ten participants to ascertain recognizability and rapid distinguishability of stimulus categories. Using the ratings obtained from clinical psychologists, it was ascertained that each stimulus could be clearly assigned to one of the two categories of food and non-food stimuli, respectively, and that stimuli of each matched stimulus pair showed sufficient similarity regarding their color, shape, size, and visual complexity. Stimuli with ambiguous results regarding these criteria were removed from the stimulus set. The stimulus set has been previously used to examine attentional processing in BED (Schmidt et al., 2016).

Apparatus. A desktop-mounted, video-based infrared eye-tracking system (Eyelink I, SR Research) with a spatial resolution of 0.1° and a temporal resolution of 500 Hz was used. Participants could move their head freely, but were instructed to keep it as still as possible at a distance of 60 cm of the display. Before each experiment, participants underwent a 10-point calibration of the eye-tracker and a drift correction was applied. All experiments were written in MATLAB and were run on an Intel® CoreTM i3-2120 CPU 3.30 GHz PC running Windows 7 and MATLAB (R2008b) with a 19-in monitor (resolution: 1280×1024).

Data preparation. Raw data for each participant were analyzed using MATLAB. Afterwards, data were reduced and aggregated across participants. Trials were valid if (a) participants directed their gaze at the fixation cross at trial onset; b) saccades occurred at least 150 ms after image onset; and (c) fixations were directed at images and remained stable within 1° for at least 100 ms. For Task 1, participants with a total gaze duration 3 SD below the group's mean and invalid trials 3 SD above the group's mean were excluded due to lowered data quality (Schmidt et al., 2016). Following these criteria, no participant had to be excluded. For Task 2, trials with incorrect responses and reaction times of 3 SD below or above the group's mean across all trials were excluded (Schmidt et al., 2016). One participant in each group (NES, CG) was excluded as data were not recorded due to technical problems. The individually matched counterpart of each participant was excluded from the analyses as well, resulting in a sample size of n = 17 for each group for Task 2.

Measures and Variables

Attentional Bias Scores

Free exploration paradigm. Reflecting an initial attentional orientation, a gaze direction bias score (in %) indicated the number of first fixations on the food stimulus as a proportion of all first fixations made to either stimulus (Schmidt et al., 2016; Werthmann et al., 2011). Scores greater and less than 50% indicate an orienting bias to food or non-food stimuli, respectively, while a score of 50% indicates no gaze direction bias. Further, a gaze duration bias score (in ms; Δ gaze duration on food stimuli – gaze duration on non-food stimuli) reflects attentional maintenance (Schmidt et al., 2016; Werthmann et al., 2011). Positive scores indicate a longer attentional maintenance on food than on non-food stimuli.

Visual search task. A food detection bias score (in ms) was computed by subtracting the mean reaction time on food target trials from the mean reaction time on non-food target trials (Schmidt et al., 2016; Veenstra, de Jong, Koster, & Roefs, 2010). Positive scores indicate faster detection for food stimuli and/or delayed disengagement from food distractor stimuli.

Variables for Clinical Associations

Patient Health Questionnaire – Depression (PHQ-D). Using the German version of the 9-item PHQ short version for depression (Löwe, Spitzer, Zipfel, & Herzog, 2002; Spitzer, Kroenke, & Williams, 1999), depressive symptoms within the past two weeks were assessed

(0 = *not at all* to 3 = *nearly every day*). Higher sum scores indicate more depressive symptoms. Internal consistency in the current sample was α = 0.79.

Eating Disorder Examination-Questionnaire (EDE-Q). The EDE-Q (Fairburn & Beglin, 1994; Hilbert & Tuschen-Caffier, 2016b) is the self-report version of the EDE interview. To assess eating disorder psychopathology within the past 28 days (0 = *not at all* to 6 = *markedly*), 22 items assigned to four subscales (restraint; eating, weight, and shape concern) were administered. Higher global mean scores indicate higher eating disorder psychopathology. In this study, internal consistency was α = 0.89.

Dutch Eating Behavior Questionnaire – Emotional Eating (DEBQ). Emotional eating was assessed using the 10-item emotional eating subscale (1 = *never* to 5 = *very often*) of the revised German version of the DEBQ (Grunert, 1989; van Strien, Frijters, Bergers, & Defares, 1986). A higher mean score indicates higher levels of emotional eating. Internal consistency in this sample was α = 0.90.

All study measures demonstrated good reliability and validity (Grunert, 1989; Hilbert & Tuschen-Caffier, 2016b; Löwe et al., 2002). Self-report questionnaires were completed after the experimental tasks in order to minimize any priming effects regarding eating or food.

Hunger rating. Participants rated their hunger prior to eye-tracking using a Likert scale ranging from 0 = *not at all hungry* to 6 = *very hungry*.

Valence rating of food stimuli. After the tasks, all food stimuli were presented randomly on the screen and participants rated their pleasantness on a visual analogue scale, resulting in a valence rating score ranging from 0 = *not at all pleasant* to 400 = *very pleasant*.

Body mass index (BMI). BMI (kg/m^2) was calculated from measured weight and height.

Data Analytic Plan

Statistical analyses were performed using IBM SPSS Statistics version 20.0. Differences in sample characteristics were examined using repeated measures General Linear

Model Analyses for continuous variables (age, BMI, psychopathology, hunger, and valence ratings) and χ^2 tests for categorical variables (sex and educational level). To account for the individually matched design, group differences in bias scores were analyzed using repeated measures General Linear Model Analyses with Group (NES, CG) as within subject factor. All dependent variables were normally distributed, as indicated by the Shapiro-Wilks test (all $p >$ .05). In addition, for each group separately, one sample *t* tests were used for testing attentional bias scores against 50% (gaze direction bias) and zero (gaze duration and food detection bias), respectively. Further, Pearson's *r* correlations between bias scores and study measures were computed separately for each group. All analyses were performed in the total sample and an additional exploratory analysis included a subgroup of participants with full-syndrome NES (n = 12) compared to their matched counterparts. Results of this exploratory analysis were only reported if they differed from the analyses in the total sample.

Based on the reported results of one primary outcome measure (i.e., gaze direction bias), a post-hoc power analysis was computed, indicating that n = 19 participants in each group were sufficient to obtain 78.6% power to detect differences in gaze direction bias scores when employing a two-tailed α = .05 (Rosner, 2011). For effect size estimation, φ was reported for the χ^2 tests (small: φ = 0.1, medium: φ = 0.3, large: φ = 0.5), partial η^2 was reported for the repeated measures General Linear Model Analyses (small: η^2 = 0.01, medium: η^2 = 0.06, large: η^2 = 0.14), and Cohen's *d* for the one sample *t* tests (small: d = 0.20, medium: d = 0.50, large: d = 0.80; Cohen, 1988). A two-tailed α = 0.05 was applied to all statistical testing.

Results

Sample Characteristics

While the NES group reported significantly more NEEs than the CG (p = .006, large effect; see Table 1), the two groups did not differ regarding sex, age, BMI, and educational level (all $p >$ .05, small effects). Further, no group differences were found in depressive symptoms (medium effect), eating disorder psychopathology (small effect), emotional eating, hunger ratings (medium effects), and valence ratings of food stimuli (small effect; all $p > .05$).

Free Exploration Paradigm

Gaze direction bias. The NES group did not differ from the CG in gaze direction bias scores ($p = .346$, small effect; see Table 2). One-sample *t* tests showed that the gaze direction bias score in the NES group significantly differed from 50% ($p = <.001$, large effect; see Table 3), indicating an initial orienting bias towards food, while scores in the CG were not different from 50% ($p = .319$, small effect).

Gaze duration bias. No significant group differences emerged between the NES group and the CG in gaze duration bias scores ($p = .162$, medium effect; see Table 2). Within each group, the gaze duration bias scores differed significantly from zero (NES: $p = .049$, medium effect; CG: $p = <.001$, large effect; see Table 3), indicating that overall, non-food stimuli were fixated longer than food stimuli in both groups.

Visual Search Task

Food detection bias. The negative food detection bias scores did not differ between the NES group and the CG ($p = .554$, small effect; see Table 2).One-sample *t* tests showed that the food detection bias score in the NES group did not significantly differ from zero ($p = .331$, small effect; see Table 3), while scores in the CG were marginally significantly different from zero ($p = .056$, medium effect). The exploratory analysis in the subgroup with full-syndrome NES revealed that the food detection bias score differed marginally significantly from zero in the NES group, $t(9) = -2.18$, 95% confidence interval[-47.26, 0.86], $p = .057$, $d = 0.69$ (medium effect), and were not different from zero in the respective CG, $t(9) = -1.13$, 95% confidence interval [-40.32, 13.52], $p = .289$, $d = 0.36$ (medium effect).

Clinical Associations

The gaze direction bias was not significantly associated with any of the variables in the NES group or the CG, respectively (*p*s > .05). The gaze duration bias was negatively associated with BMI in the NES group (r = -.50, p = .029) and subgroup with full-syndrome NES (r = -.63, p = .027), respectively, but not in the CG (total sample: r = -.05, p = .831; subgroup: r = .17, p = .601). The food detection bias showed a negative association with excessive evening eating episodes in the NES group (r = -.49, p = .047) and subgroup (r = -.80, p = .006), respectively. Further, the food valence rating was negatively correlated with BMI in the NES group (r = -.55, p = .022), but not in the CG (r = -.05, p = .836). No other significant associations were found (ps > .05).

Discussion

This study was the first to examine visual attentional food processing in NES using eye-tracking and reaction time-based paradigms. Contrary to our hypotheses, the NES and control groups did not significantly differ in attentional bias scores. However, eye-tracking data indicated a significant initial orienting bias to food within participants with NES, but not in controls. Contrary to our hypothesis, a significant attentional maintenance bias to non-food was found in both groups. Further, a marginally significant detection bias for non-food was found in full-syndrome NES, but not in controls. In the NES group only, attention to and faster detection of non-food stimuli were related to higher BMI and more excessive evening eating episodes, respectively.

Our finding of an initial orienting bias to food compared to non-food in NES is in line with eye-tracking studies in overweight and obesity (Castellanos et al., 2009; Werthmann et al., 2011). However, this result is not consistent with studies in AN (Giel, Friederich et al., 2011) and BED (Schag et al., 2013; Schmidt et al., 2016), reporting an orienting bias to food in both experimental and control groups or no preference in initial orientation in either group, respectively. Our results indicate that food stimuli have acquired high motivational salience in participants with NES and are in line with incentive-sensitization theories proposing changes in the dopaminergic system due to repeated exposure to salient stimuli (e.g. food; Robinson

& Berridge, 1993), resulting in an increased awareness of food-related stimuli in the current environment (Doolan et al., 2014).

The initial orienting to food stimuli was followed by an attentional maintenance to non-food stimuli in both the NES group and the CG. For NES, this result seems unexpected as previous studies have reported an increased attentional maintenance to food in BED (Popien et al., 2015; Schag et al., 2013; Schmidt et al., 2016) and overweight and obesity (Castellanos et al., 2009; Doolan et al., 2014; Hendrikse et al., 2015). For the CG, this finding seems to contradict studies reporting food biases in healthy controls (e.g., Nummenmaa, Hietanen, Calvo, & Hyönä, 2011). However, it is possible that low hunger levels in the CG affected gaze patterns, as attentional biases towards food are more likely to occur in hungry than in satiated individuals (Piech et al., 2010). For NES, our findings suggest an attentional shift away from food and attentional engagement to non-food at longer stimulus presentations, which may reflect an avoidance strategy regarding food.

When confronted with multiple attention-competing stimuli in the visual search task, participants with full-syndrome NES showed a detection bias for non-food compared to food stimuli. This finding contradicts results of a visual search task (Schmidt et al., 2016) and studies using other reaction time-based measures in BED (Schmitz et al., 2014; Schmitz et al., 2015), reporting an attentional bias for food in BED. However, the detection bias for non-food stimuli is in line with our results from the free exploration paradigm, showing an overall increased attention to non-food stimuli in NES. The detection advantage may reflect a speeded detection of non-food targets among food distractors, but it is also possible that delayed disengagement from non-food distractors has contributed to slower detection of food targets. To clarify these mechanisms, future research could include additional trial types such as trials with non-food targets among other non-food distractors (Smeets, Roefs, van Furth, & Jansen, 2008).

Overall, although no group differences in visual attentional processing between participants with NES and controls were found, a possible explanation for the attentional pattern found in this study might be an underlying approach-avoidance strategy towards food in NES. While the approach component possibly reflects a greater salience and motivational value of food (Robinson & Berridge, 1993) compared to non-food in NES, the avoidance component might indicate negative associations related to food and food consumption, such as feelings of guilt and shame, unhealthy nutritional properties, and weight gain (Macht, Gerer, & Ellgring, 2003). In line with this view, addiction theories propose that an approach-avoidance pattern may result when salient stimuli are associated with positive reinforcement while at the same time negative associations related to consequences of consumption are activated (Breiner, Stritzke, & Lang, 1999). Possible explanations for the lack of significant group differences between the NES and control group in our study might be the inclusion of individuals with subsyndromal NES, who reported lower symptom severity than participants with full-syndrome NES, and the use of a small study sample.

Correlational analyses provided insight into differential associations of attentional processes in NES and controls. Specifically, greater BMI was significantly related to lower food pleasantness and to an increased attention to non-food stimuli in the free exploration paradigm in NES, but not in controls. The latter finding is consistent with results in adolescents with BED (Schmidt et al., 2016) and adults with overweight and obesity (Gearhardt, Treat, Hollingworth, & Corbin, 2012). Additionally, a detection advantage for non-food stimuli was significantly associated with higher NES symptomatology, namely more excessive evening eating episodes. These results suggest that avoidant attentional strategies may be dysfunctional as they are likely to interfere with habituation to food stimuli (Epstein, Leddy, Temple, & Faith, 2007), and could thus result in predisposition to night eating, an increased food intake (Epstein et al., 2007), and associated weight gain in the long-term (Epstein, Robinson, Roemmich, & Marusewski, 2011).

Strengths of this study include the use of a non-treatment seeking sample with NES and the use of diagnostic interviews for NES diagnosis. A limitation is the use of a small study sample. The lack of normal weight control groups with and without NES is a further limitation, as the results suggest potential effects of weight status on attentional processing in NES. Further, a valence rating of non-food stimuli as an additional control variable was not assessed, which would have allowed the investigation of potential effects of the pleasantness of non-food stimuli on attentional patterns, i.e., the possibility that attention could be drawn to a stimulus due to differences in valence compared to its matched stimulus. In addition, potential differences between food and non-food stimuli regarding their complexity might have contributed to the salience of the non-food stimuli. Moreover, to specify attentional mechanisms during the visual search task, future studies could include more trial types and could also investigate attention to more than two attention-competing stimuli at the same time, which may be more reflective of the attentional choices in the everyday environment.

Altogether, this study provided evidence for a visual attentional bias in NES, specifically an initial orienting bias to food compared to non-food and an attentional maintenance bias to non-food compared to food stimuli at longer stimulus presentation durations. Further, a detection bias for non-food stimuli when confronted with multiple attention-competing stimuli was found. However, no significant group differences between participants with NES and controls were found. Our results highlight the importance of further clarifying the role of attentional food processing on the etiology and maintenance of NES, possibly by investigating a larger sample with full-syndrome NES in future research. As opposed to other eating disorders, eating episodes in NES are by definition limited exclusively to a specific time of day. Studies suggest that an underlying mechanism of NES symptomatology might be a delayed circadian rhythm of neuroendocrine function resulting in a delayed food intake pattern (Birketvedt et al., 1999; Pinto, da Silva, de Bruin, & de Bruin, 2016; Stunkard, Allison, Lundgren, & O'Reardon, 2009). A biobehavioral model of NES proposes that elevated serotonin transporter levels in the midbrain lead to an increased serotonin reuptake and thus, to a decrease in postsynaptic serotonin (Stunkard et al., 2009). As a consequence, the circadian rhythm is dysregulated and satiety is increased. In behavioral studies, participants with NES consumed more calories during the evening and nighttime than controls, while total daily caloric intake did not differ between groups (Allison, Ahima et al., 2005; Birketvedt et al., 1999; O'Reardon et al., 2004). Thus, NES seems to be characterized by a phase delay in energy consumption rather than an increase in caloric intake (Allison, Ahima et al., 2005; Birketvedt et al., 1999; O'Reardon et al., 2004).

Relatedly, ecological validity in future research might be increased by investigating attentional processes when NES symptomatology is most likely to occur, which is during the evening and nighttime when participants are hungrier than during the day. Moreover, to clarify the role of food pleasantness on attentional processing, future studies might include foods which are preferentially consumed during night eating episodes (Allison, Ahima et al., 2005; Birketvedt et al., 1999). Behavioral studies showed that foods preferably consumed during these episodes were characterized by a high carbohydrate (Birketvedt et al., 1999) and fat (Allison, Ahima et al., 2005) content. Thus, future studies could investigate whether attentional processing in NES may be driven by the caloric content of food by examining visual attention to high and low calorie food stimuli as compared to non-food stimuli. Longitudinal studies would allow to evaluate the need for interventions aiming at attentional bias modification (Kemps, Tiggemann, & Hollitt, 2014) and could clarify the course and interactions between attentional processing and NES symptomatology. Finally, as found in addictive disorders (Field & Cox, 2008), future research might clarify whether attentional biases to food in NES may serve as an indicator for eating disorder severity.

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Tables

Table 1

Sample Characteristics and Group Differences in Psychopathology, Hunger, and Valence Ratings of Food Stimuli

	NES (n = 19)	CG (n = 19)	Test	p	Effect size
Sex (N female, %)	11 (57.89)	11 (57.89)	$\chi^2(1) = 0.00$	<1.000	$\varphi = 0.00$
Education (≥ 12 years N, %)	12 (63.16)	9 (47.37)	$\chi^2(1) = 0.96$	.515	$\varphi = 0.16$
	M (SD)	*M (SD)*	$F(1, 18)$		η^2
Age	44.42 (13.15)	44.68 (14.01)	0.16	.692	0.01
Body mass index (kg/m^2)	35.12 (9.28)	35.54 (10.33)	0.57	.462	0.03
EDE Night eating episodes	5.89 (8.27)	0.00 (0.00)	9.63	.006	0.35
PHQ-D Depression (0 – 27)	6.68 (3.54)	4.64 (4.43)	2.50	.131	0.12
EDE-Q Global score (0 – 6)	1.67 (0.71)	1.66 (1.10)	0.00	.951	0.00
DEBQ Emotional eating (1 – 5)	2.05 (0.74)	1.70 (0.86)	1.81	.195	0.09
Hunger rating (0 – 6)	0.58 (1.35)	0.11 (0.32)	2.50	.132	0.12
Valence rating food (0 – 400)	213.70 (52.85)	208.16 (67.75)	0.15	.702	0.01

Note. NES = night eating syndrome (including full-syndrome and subsyndromal diagnosis); CG = control group without eating disorder symptoms (i.e., no objective binge-eating episodes, no night eating episodes, no inappropriate compensatory behavior); *M* = mean; *SD* = standard deviation; EDE = Eating Disorder Examination; PHQ-D = Patient Health Questionnaire; EDE-Q = Eating Disorder Examination-Questionnaire; DEBQ = Dutch Eating Behavior Questionnaire. For all measures, higher scores indicate higher levels of psychopathology, hunger, and valence, respectively. Night eating episodes were defined as eating after awakening from sleep and/or excessive eating after the evening meal and include mean episodes per week over the last three months.

Table 2

Attentional Bias Scores as a Function of Group Status

	NES	CG	Test for group differences		
	M (SD)	*M (SD)*	*F*(df)	*p*	η^2
Free exploration paradigm					
Gaze direction bias (%)	56.62 (7.01)	53.65 (15.51)	$F(1, 18) = 0.94$	.346	0.05
Gaze duration bias (ms)	-149.70 (309.77)	-325.13 (300.01)	$F(1, 18) = 2.13$	.162	0.11
Visual search task[a]					
Food detection bias (ms)	-9.12 (37.49)	-17.53 (35.08)	$F(1, 16) = 0.37$	.554	0.02

Note. NES = night eating syndrome (including full-syndrome and subsyndromal diagnosis); CG = control group without eating disorder symptoms (i.e., no objective binge-eating episodes, no night eating episodes, no inappropriate compensatory behavior); *M* = mean; *SD* = standard deviation.

[a]Reduced sample size due to missing data.

Table 3

Attentional Bias Scores Within Each Experimental Group

	Test against 50%/zero (NES)				Test against 50%/zero (CG)			
	t(df)	95% CI	*p*	*d*	*t*(df)	95% CI	*p*	*d*
Free exploration paradigm								
Gaze direction bias (%)	*t*(18) = 4.12	[3.25, 10.00]	<.001	0.94	*t*(18) = 1.02	[-3.83, 11.12]	.319	0.23
Gaze duration bias (ms)	*t*(18) = -2.11	[-299.00, -0.39]	.049	0.48	*t*(18) = -4.72	[-469.72, -180.53]	<.001	<1.00
Visual search task[a]								
Food detection bias (ms)	*t*(16) = -1.00	[-28.39, 10.16]	.331	0.24	*t*(16) = -2.06	[-35.57, 0.51]	.056	0.50

Note. NES = night eating syndrome (including full-syndrome and subsyndromal diagnosis); CG = control group without eating disorder symptoms (i.e., no objective binge-eating episodes, no night eating episodes, no inappropriate compensatory behavior); CI = confidence interval. Attentional bias scores were tested against 50% (gaze direction bias score) and zero (gaze duration and food detection bias scores), respectively, for each group separately.

[a]Reduced sample size due to missing data.

Figures

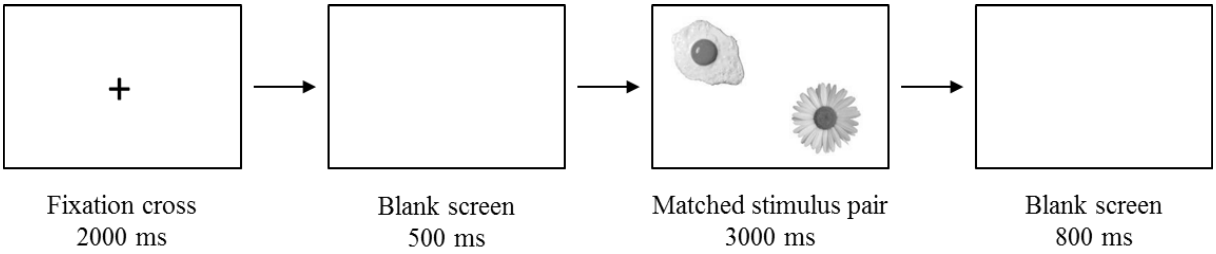

Figure 1. Experimental procedure of the free exploration paradigm (Task 1). Each trial started with a fixation cross followed by a blank screen and the stimulus pair. After that, a blank screen was displayed and the next trial was initiated.

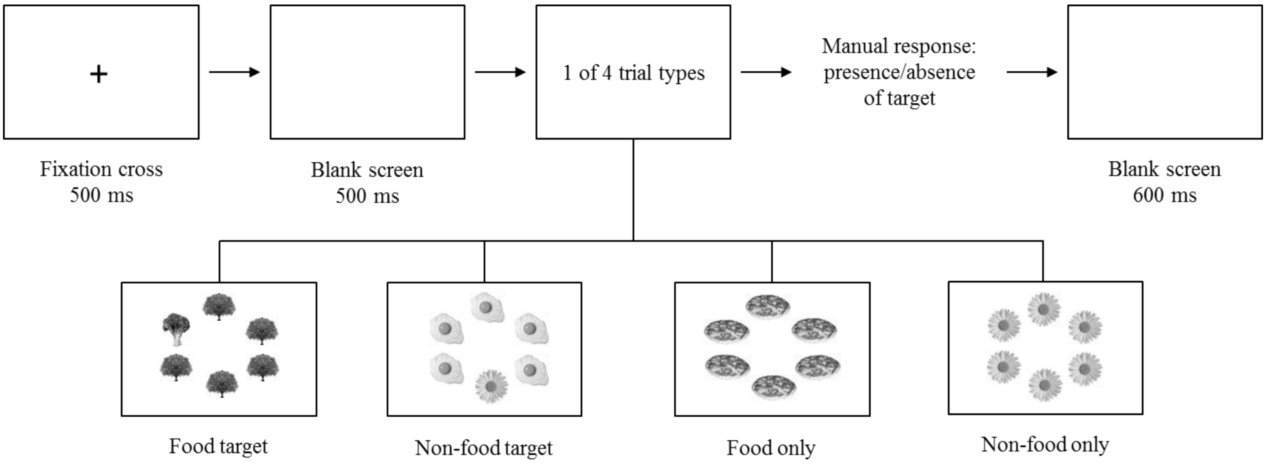

Figure 2. Experimental procedure of the visual search task (Task 2). Each trial started with a fixation cross followed by a blank screen and one of four possible trial types: (1) food target: a food target among corresponding matched non-food distractors; 2) non-food target: a non-food target among corresponding matched food distractors; 3) food only: only food stimuli (same stimulus on all positions); and (4) non-food only. The search array was presented until the participant gave a manual response, after which a blank screen was displayed and the next trial was initiated.