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MEASUREMENT OF INHIBITORY CONTROL AND ATTENTIONAL BIAS TO DISORDER SPECIFIC STIMULI IN INDIVIDUALS WITH EATING DISORDERS: THE USE OF EMOTIONAL GO/NO-GO TASK

Master's thesis

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Subtitle: ED specific emotional Go/No-Go task

Tartu 2019

Contents

Abstract

Impaired inhibitory control and attentional bias related to disorder specific stimuli, i.e. body and food, could have a potential role in the development and maintenance of eating disorders (ED). We aimed to measure inhibitory control and attentional bias to body and food related stimuli by using emotional Go/No-Go task in individuals with ED compared to psychiatrically controlled healthy individuals (HC) and psychiatric controls, and test whether inhibitory control and attentional bias in individuals with ED are related to ED specific stimuli. ED specific emotional Go/No-Go task, clinical interview and self-report questionnaires were administered to 87 women (with mean age±*SD* of 23.0±6.4), of whom 19 were diagnosed with anorexia nervosa restrictive (AN-R) subtype, 17 with bulimia nervosa binge/purge (BN-BP) subtype, 15 with major depression, 17 with comorbid mood, anxiety and substance use disorders, and 19 were HC. We found that individuals with AN-R and BN-BP were significantly slower in reaction times (RTs) for body related stimuli compared to HC. There were no significant differences in RTs for food related stimuli between the groups. However, duration of illness had a moderating effect on RTs for food stimuli in individuals with ED. Moreover, individuals with BN-BP made significantly more commission and omission errors to body and food related stimuli compared to individuals with AN-R. Our results indicate that emotional Go/No-Go task could be a valid measure to assess inhibitory control and attentional bias to ED related stimuli, however, primarily based on the commission and omission errors rather than RTs.

Keywords: eating disorders, emotional Go/No-Go task, impulsivity, inhibitory control, attentional bias

Kokkuvõte

Pidurdusliku kontrolli ja tähelepanu kallutatuse hindamine häirespetsiifilise stiimulmaterjaliga söömishäiretega indiviididel: emotsionaalne Go/No-Go katse

Häirespetsiifilise stiimulmaterjaliga (s.o. keha ja toit) seotud vähenenud pidurduslik kontroll ja tähelepanu kallutatus võivad omada potentsiaalset rolli söömishäirete (SH) väljakujunemisel ning nende säilitamisel. Uurimuse eesmärgiks oli hinnata emotsionaalse Go/No-Go katsega SH indiviidide pidurduslikku kontrolli ja tähelepanu kallutatust keha ja toiduga seotud stiimulmaterjali suhtes võrreldes psühhiaatriliselt kontrollitud tervete indiviidide ja psühhiaatriliste kontrollidega ning hinnata, kas SH indiviidide pidurduslik kontroll ja tähelepanu kallutatus on seotud söömishäirete spetsiifilise stiimulmaterjaliga. Uurimuses osales kokku 87 naist (keskmine vanus±*SD* 23.0±6.4), kellest 36 olid SH diagnoosiga, 32 SA TÜK Psühhiaatriakliiniliku üldpsühhiaatria osakonna indiviidid ning 19 olid psühhiaatriliselt kontrollitud terved indiviidid. SH indiviididel oli diagnoositud *anorexia nervosa* piirav (AN-P; n=19) ja *bulimia nervosa* väljutav (BN-V; n=17) alatüüp ning üldpsühhiaatria osakonna indiviididel depressioon (n=15) ja meeleolu-, ärevus ja sõltuvushäired (n=17). Meetoditena kasutati emotsionaalset Go/No-Go arvutikatset, kliinilist intervjuud ning enesekohaseid küsimustikke. Tulemustest selgus, et AN-R ja BN-V indiviidide keskmine reaktsiooniaeg keha stiimulile oli oluliselt aeglasem võrreldes psühhiaatriliselt kontrollitud tervete indiviididega. Samas ei esinenud statistiliselt olulisi erinevusi reaktsiooniaegades seoses toidu stiimuliga võrreldes teiste gruppidega. Lisaks ilmnes, et häire kestusel on modereeriv mõju toiduga seotud reaktsiooniaegadele SH indiviididel. Samuti tegid BN-V indiviidid oluliselt rohkem distraktor- ja sihtmärkstiimulite vigu seoses keha ja toiduga seotud stiimulitega võrreldes AN-P indiviididega. Tulemustest võib järeldada, et keha ja toiduga seotud stiimulmaterjaliga emotsionaalne Go/No-Go katse mõõdab efektiivsemalt SH indiviidide pidurduslikku kontrolli ja tähelepanu kallutatust lähtudes ennekõike vigade (s.o. distraktor- ja sihtmärkstiimul) sageduse analüüsist.

Märksõnad: söömishäired, emotsionaalne Go/No-Go katse, impulsiivsus, pidurduslik kontroll, tähelepanu kallutatus

Introduction

Eating disorders and the role of psychiatric comorbidity in eating disorders

Eating disorders (ED), such as anorexia nervosa (AN) and bulimia nervosa (BN), are complex and widespread psychiatric disorders with elevated morbidities and mortality rates (Arcelus, Mitchell, Wales, & Nielsen, 2011; Wu, Hartmann, Skunde, Herzog, & Friederich, 2013). Unique symptoms to ED are disordered eating behavior (e.g. restrictive, binging/purging), dissatisfaction with body weight, body image distortions, relentless need to lose weight and minimization of symptoms (Wierenga et al., 2014). It has been previously indicated that biological, sociocultural and psychological factors are related to the development and maintenance of ED (Blodgett Salafia, Jones, Haugen, & Schaefer, 2015; Hilbert et al., 2014).

Psychiatric comorbidity, e.g. mood, anxiety and substance use disorders (SUD), is common in individuals with ED and it has been found to be associated with severity of ED symptoms and chronicity (Blinder, Cumella, & Sanathara, 2006; Milos, Baur, Muehlebach, & Spindler, 2013; Spindler & Milos, 2007). Spindler and Milos (2007) have indicated that anxiety disorders seem to be closely associated with severity of ED symptoms compared to affective and substance-related disorders. Psychiatric comorbidity appears to have also potential influence on diagnostic crossover within ED subtypes (Castellini et al., 2011; Milos et al., 2013), whereas Milos et al. (2013) have suggested that affective disorders (e.g. major depression) may more precisely facilitate instability of diagnoses within ED subtypes. It has been also suggested to consider and evaluate the role of impulsivity in the changes in ED symptoms as a potential factor that could possibly influence the expression of ED behavior and diagnostic crossover within ED subtypes (Lavender & Mitchell, 2015; Waxman, 2009).

Impulsivity in the psychopathology context

Impulsivity refers to the tendency to react rapidly upon stimuli, prematurely without foresight, sufficient evidence or consideration of the consequences, or in the way that is risky, poorly conceived or inappropriate (Aichert et al., 2012; Bari & Robbins, 2013; Bartholdy, Dalton, O'Daly, Campbell, & Schmidt, 2016; Dalley, Everitt, & Robbins, 2011). The construct of impulsivity captures a set of different characteristics, i.e. behavioral, that clinicians can recognize as contributing to psychopathology, e.g. ED, attention deficit/hyperactivity, substance use and other impulse control disorders (Dalley et al., 2011; Lavender & Mitchell, 2015). Impulsivity is considered as a multifaceted construct and could be measured by different methods, such as self-report questionnaires, behavioral measures or laboratory tasks (Bari & Robbins, 2013; Dalley et al., 2011; Evenden, 1999). It has been suggested that impulsivity is a consequence of deficits in inhibitory control processes, which indicates that impulsive action is determined by the co-occurrence of dysfunctional inhibitory processes as well as strong impulses, whereas functional inhibitory control processes would prevent the impulsive action and help to regulate behavior (Bari & Robbins, 2013; Claes, Mitchell, & Vandereycken, 2012).

Elevated levels of impulsivity have been found among individuals with all ED subtypes (Claes, Robinson, Muehlenkamp, Vandereycken, & Bijttebier, 2010; Lavender & Mitchell, 2015; Waxman, 2009). It has been suggested that impulsivity could be an important construct in differentiating ED subtypes, specifically marked by higher levels of bingeing or purging behaviors, such as BN and anorexia nervosa binge/purge (AN-BP) subtype from anorexia nervosa restrictive (AN-R) subtype (Cassin & von Ranson, 2005; Claes et al., 2010). Waxman (2009) has reported that individuals with AN-R have shown lower levels of impulsivity compared to individuals with BN. However, Butler and Montgomery (2005) have suggested that individuals with AN demonstrate impulsivity based on the behavioral measures, but may still self-report reduced impulsivity and higher subjective self-control. Claes et al. (2012) have found similar results as self-report measures and behavioral tasks did not have significant associations. However, there is also evidence that self-report and behavioral measures have significant correlations (e.g. between Barratt Impulsiveness Scale (BIS-11) and Go/No-Go task) (Aichert et al., 2012). These findings indicate that convergence between self-report measures and behavioral tasks could be weak or moderate, as self-report measures assess rather how individuals perceive themselves, whereas behavioral tasks reflect more specifically actual behavior (Butler & Montgomery, 2005; Emery & Levine, 2017). However, diagnostic crossover between ED binge/purge and restrictive subtypes is common, individual's diagnostic subtype may change over time and many individuals with AN-R are found to move to AN-BP or BN subtype, experiencing the loss of control and higher levels of impulsivity (Butler & Montgomery, 2005; Eddy et al., 2008; Keel, Dorer, Franko, Jackson, & Herzog, 2005; Lavender & Mitchell, 2015; Peat, Mitchell, Hoek, & Wonderlich, 2009). According to the previous studies, measuring impulsivity over time is important as it appears to be a possible factor influencing the development and maintenance of different psychiatric disorders, including ED. In the present study, we examine specifically deficits in inhibitory control in individuals with ED with an emotional Go/No-Go task.

Deficits in inhibitory control

Inhibitory control is a key for controlling unwanted behaviors and thoughts and refers to the general ability to withhold or inhibit an inappropriate or unwanted already-initiated response (Bartholdy et al., 2016; Mobbs, Iglesias, Golay, & Van der Linden, 2011; Smith, Mason, Johnson, Lavender, & Wonderlich, 2018). However, impulsivity and inhibitory control are terms that should not be used synonymously (Bartholdy et al., 2016). Generally, inhibitory control is a valuable concept that helps to examine impulsivity (Evenden, 1999).

It has been suggested that individuals with AN and BN have a tendency to have opposite sides of inhibitory control (Wierenga et al., 2014). As individuals with ED are associated with executive functioning deficits, they may also have poorer performance in the behavioral tasks (Hirst et al., 2017). Individuals with AN are thought to have increased inhibitory control, therefore they could require fewer resources of inhibitory control during more difficult inhibitory control tasks, which suggests that higher cortical regions that are involved in inhibitory control may be recruited to a lesser degree (Bartholdy et al., 2016; Oberndorfer, Kaye, Simmons, Strigo, & Matthews, 2011). Based on the inhibitory control, individuals with AN-R seem to be over-controlled and tend to resemble psychiatrically controlled healthy individuals (HC) compared to individuals with BN binge/purge (BN-BP) subtype (Rosval et al., 2006). However, it is important to consider that while individuals with BN show lack of impulse control, they may also have reduced opportunities to recruit and strengthen inhibitory control compared to individuals with AN, which could overall promote poorer executive functioning (Hill, Peck, Wierenga, & Kaye, 2016; Hirst et al., 2017). Individuals with ED binge/purge subtype seem to have more deficits in inhibitory control than individuals with ED restrictive subtype, which overall manifests in poorer results in the behavioral task (Claes et al., 2012).

Deficits in inhibitory control could be considered as a potential mechanism underlying the impulsive behaviors in individuals with ED binge/purge subtype and may also facilitate the consumption of an excessive amount of food, the loss of control over eating and the self-induced vomiting for weight control (Claes et al., 2012; Culbert, Racine, & Klump, 2015; Mobbs et al., 2011; Wierenga et al., 2014). Measuring inhibitory control in individuals with ED may be essential for differentiating ED subtypes and it could allow to gather more information about the mechanisms that may possibly influence impulsive behaviors in individuals with ED.

Attentional bias to disorder specific stimuli

Within the field of psychopathology, attentional bias indicates a tendency to selectively attend to disorder specific stimuli (Smeets, Roefs, Furth, & Jansen, 2008; Williamson, White, York-Crowe, & Stewart, 2004). Attentional bias in individuals with ED may manifest when individuals could detect and identify body and food related stimuli faster (i.e. speeded detection), focus their attention longer on the mentioned stimuli (i.e. slower disengagement) or altogether avoid them (Mobbs et al., 2011). Furthermore, reaction times (RTs) in the behavioral tasks have been interpreted as reflecting possible attentional bias to ED specific stimuli (Meule, Lukito, Vögele, & Kübler, 2011; Stojek et al., 2018). Previous studies indicate that there have been contrary findings on RTs in relation to disorder specific stimuli, which means that interpretation of RTs could vary in individuals with ED, as RTs could be slower or faster compared to control group or neutral stimuli (Mobbs et al., 2011; Smeets et al., 2008; Stojek et al., 2018). For instance, slower reactions could indicate attentional bias (e.g. difficulties with attentional disengagement) to disorder specific stimuli in comparison to HC (Stojek et al., 2018).

It has been suggested that attentional bias could also be a mechanism that contributes to the development and maintenance of ED (Aspen, Darcy, & Lock, 2013; Stojek et al., 2018; Williamson et al., 2004). Furthermore, individuals with ED seem to demonstrate consistent and implicit attentional bias to disorder specific stimuli (e.g. body or food related) (Aspen et al., 2013).

Individuals with BN have demonstrated the activation of brain patterns in response to body stimuli when comparing themselves to the slim women in the pictures, which suggests increased self-focus among individuals with BN (Van den Eyne et al., 2013). It has been proposed that ED specific stimuli could be a proxy of the feared outcome (e.g. being rejected as a result of the weight gain) and underlying fear may possibly explain why an ambiguous cue (e.g. reflection in a mirror) could be creating anxiety, as well as why and how as a result attentional bias may be escalating (e.g. checking mirror reflection multiple times a day) (Aspen et al., 2013; Fairburn et al., 2009). Stojek et al. (2018) have reported that attentional bias to body shape and weight related stimuli may be a consequence and/or a maintenance factor of ED features, which could be related to dissatisfaction with own body shape and weight. Also, Fairburn et al. (2009) have suggested that self-worth in individuals with ED is primarily evaluated regarding their body shape and weight and the escalation of overvaluation of own body shape, weight and eating could be crucial in the maintenance of ED. Stice, Marti and Durant (2011) have identified body dissatisfaction as a significant predictor of ED onset. These findings indicate that concerns about body shape and weight appear to be central to ED psychopathology.

Findings suggest that individuals with binge eating behaviors may exhibit attentional bias also to food related stimuli in the automatically facilitated attentional engagement and purposeful attentional disengagement phases, which means that food related stimuli could capture their attention and as a result there could be difficulties with attentional disengagement and as well with inhibitory control (Stojek et al., 2018). Neimeijer, Roefs and de Jong (2017) have found that more severe ED psychopathology is associated with an increased attentional bias for food related cues in individuals with AN-R, as their target detection is inhibited when it is preceded by a visual food related stimuli, which indicates that their attention is automatically captured by food related stimuli. According to the previous studies, it may be assumed that ED specific stimuli for individuals with ED would also be reflected in slower RT compared to HC and individuals with other psychiatric disorders.

Emotional Go/No-Go task

Go/No-Go task is a behavioral measure that is considered to assess selective motor response inhibition while the indicator of impulsivity is the frequency of commission errors, which suggests that a participant failed to inhibit the response to the distractor stimulus (Aichert et al., 2012). In addition to inhibitory control assessment, it is possible to measure attentional bias to disorder specific stimuli with an emotional Go/No-Go task (Gole, Köchel, Schäfer, & Schienle, 2012). The higher number of the commission errors in the Go/No-Go task appears to reflect deficits in inhibitory control, whereas RTs assess response speed, i.e. how fast the differentiation between presented stimuli can be made (Calvo, Galioto, Gunstad, & Spitznagel, 2014). Also, experimental neurocognitive tasks could help differentiate ED subtypes to develop specific treatment targets in everyday clinical practice (Wu et al., 2013).

Significant number of studies have assessed inhibitory control and attentional bias in individuals with ED based on the behavioral tasks (Albery et al., 2016; Claes et al., 2012; Mobbs, Van der Linden, d'Acremont, & Perroud, 2008; Petenberg, 2013; Rosval et al., 2006; Stojek et al., 2018; Wu et al., 2013). It has been suggested that individuals with BN have attention disengagement problems and deficits in inhibitory control to disorder specific stimuli (Wu et al., 2013). For instance, individuals with binge-type ED have greater RT variability and higher number of commission errors in the Go/No-Go task compared to individuals with AN-R and HC, which refers to the deficits in inhibitory control (Claes et al., 2012; Mobbs et al., 2008; Rosval et al., 2006). A meta-analysis by Wu et al. (2013) indicated that individuals with BN have a larger impairment in inhibitory control in response to ED specific stimuli (e.g. food and body weight related, highly palatable foods). Individuals with BN compared to HC had also a higher number of commission errors, indicating deficits in inhibitory control, and slower RTs, referring to possible attentional bias (Petenberg, 2013). Although Meule et al. (2011) have found that restrained eaters made fewer commission errors in the Go/No-Go task compared to unrestrained eaters, restrained eaters had remarkably slower RTs related to food stimuli, which indicates a potential attentional bias to food related stimuli.

Smeets et al. (2008) have suggested that there may be automatic biases, i.e. speeded detection, to body related stimuli in individuals with BN and AN. In addition, Albery et al. (2016) have reported that individuals with BN compared to HC demonstrated increased attentional bias to body related stimuli relative to food stimuli. These findings support the idea that ED specific stimuli could have a potentially important role in the maintenance of ED behavior.

Behavioral tasks (e.g. Go/No-Go task) are used, besides ED, for other psychiatric disorders as well to measure inhibitory control and attentional bias to disorder specific stimuli. For instance, individuals with alcohol dependence were slower to process alcohol-related stimuli and made remarkably more commission and omission errors to alcohol-related stimuli in the Go/No-Go task compared to HC, which indicates attentional bias to alcohol-related stimuli as well as deficits in inhibitory control (Noël et al., 2007). It is possible that attentional bias to addiction-related stimuli could increase response activation and impair inhibitory control, therefore contributing to the difficulties that individuals with SUD experience when resisting substance use, as they encounter addiction-related stimuli in the environment (Weafer & Fillmore, 2012). In addition to findings of SUD, impaired inhibitory control processes have been found in individuals with acute depression, as they had higher commission errors rate as well as attentional bias to negative emotion in the emotional Go/No-Go task (Maalouf et al., 2012). Difficulties in disengaging attention from threat stimuli are common among anxious individuals and indicate that threat stimulus could capture attention in an impaired way meanwhile making it difficult to switch attention to another stimulus (Cisler & Koster, 2010). For instance, worry-prone individuals seem to be threat-sensitive, which is observed in the higher frequency of commission and lower frequency of omission errors, indicating that when a threat has captured attention, it is more complicated to disengage their attention from aversive stimuli (Gole et al., 2012).

Based on the previous findings, disorder specific stimuli could have different effects among psychiatric disorders, which indicates that measuring effectively inhibitory control and attentional bias depends on stimuli and material adjusted to specific disorders. Therefore, the emotional Go/No-Go task with body and food related stimuli used in the present study gives an opportunity to explore and assess attentional bias and inhibitory control to ED specific stimuli in individuals with ED compared to HC and individuals with other psychiatric disorders. In addition, it is possible as a future direction to include potential outcomes of attentional bias and inhibitory control in developing specific treatment targets for ED.

Purpose of the present study

We aimed to measure inhibitory control and attentional bias to body and food related stimuli by using emotional Go/No-Go task in individuals with ED compared to HC and psychiatric controls and examine whether inhibitory control and attentional bias are related to ED specific stimuli in individuals with ED. Another aim of the study was to assess whether the present emotional Go/No-Go task differentiates ED subtypes and also ED subtypes from HC and psychiatric controls. As known to the author, individuals with other psychiatric disorders have not been included before as a control group in the emotional Go/No-Go task with ED specific stimuli.

The author of the present study contributed by testing and conducting the experiments among patients, collecting, scoring and analyzing the data, organizing databases, doing systematic literature search and synthesis of the previous findings, and writing the thesis.

Based on the prior research and literature the following hypotheses were postulated:

1. Mean RTs for ED specific stimuli, i.e. body and food related stimuli, in individuals with ED are slower compared to HC and psychiatric controls.
2. Mean RTs for ED specific stimuli, i.e. body and food related stimuli, have significant differences between individuals with AN-R and BN-BP.
3. Individuals with BN-BP have a higher frequency of commission and omission errors to body and food related stimuli compared to HC and psychiatric controls.
4. Individuals with AN-R have a lower frequency of commission and omission errors to body and food related stimuli compared to individuals with BN-BP and psychiatric controls.

Methodology

The data collection took place from October 2016 to March 2019.

Participants

The sample consisted of 87 women (with mean age±*SD* of 23.0±6.4), of whom 19 were diagnosed with AN restrictive (AN-R) and 17 with BN binge/purge (BN-BP) subtype, 15 with major depression (MD), 17 with comorbid mood, anxiety and substance use disorders (MAD/SUD), and 19 were age and education matched psychiatrically controlled healthy individuals (HC). Descriptive data about the groups is presented in Results section in Table 1. Individuals with AN binge/purge subtype could not be included in the present study as the sample was not sufficient.

There were no significant differences between the groups based on the age [$F(4.80)=0.62$; $p>0.05$; $\eta^2=0.030$] and on the educational level [$F(4.82)=0.11$; $p>0.05$; $\eta^2=0.005$]. Inclusion criteria encompassed AN-R or BN-BP diagnosis for ED patients, mood, anxiety and/or SUD diagnosis for psychiatric controls and voluntary hospitalization. Exclusion criteria included comorbid schizophrenia or other psychotic disorders, intellectual developmental disorder and involuntary hospitalization. Mean duration of ED in individuals with AN-R was 3 (*SD*=±4.0) and in individuals with BN-BP 8.2 (*SD*=±6.8) years. There were significant differences in duration of ED between individuals with AN-R and BN-BP [$t(30)=-2.67$; $p<0.05$; *equal variances assumed*]. Additional information on the selection of psychiatric controls can be found in Supplementary Material.

For individuals with ED, major depression and anxiety disorders (i.e. panic disorder, generalized anxiety disorder, social and agoraphobia) were the most common comorbid diagnoses, followed by SUD (i.e. due to use of alcohol and cannabinoids). For individuals with MAD/SUD, anxiety disorders included generalized anxiety disorder, panic disorder, social and agoraphobia, and SUD were due to use of alcohol and cannabinoids. The group of individuals with MD comprised diagnoses of moderate and severe depression, single depressive episode and recurrent depression. The frequency of comorbid psychopathology among groups is presented in Results section in Table 2.

Patients were recruited from Tartu University Psychiatry Clinics of the general ward and inpatient unit of ED. All the hospitalized patients were given the opportunity to voluntarily participate in the study. HC were recruited through university lists and public advertisements. Also, HC were assessed for any psychiatric disorders with The Mini-

International Neuropsychiatric Interview (MINI; Sheehan, Lecrubier, Sheehan, & Amorim, 1994; Estonian version Shlik, Aluoja, & Kihl, 1999), which was conducted by experienced psychiatrist or clinical psychologist.

Measures

Descriptive data

Information about patients' age, education level, weight and height was filled out by a psychiatrist or clinical psychologist and the same data for HC was filled out by an experimenter before the testing procedure. Additionally, a psychiatrist or clinical psychologist filled in diagnoses, duration of illness (except for psychiatric controls) and if needed essential missing information for the hospitalized patients. Duration of illness was determined for individuals with ED from the time they got ED diagnosis. Based on participants' weight and height, patients' BMI was calculated during the standardized procedures in the hospital and HC' BMI was calculated by the experimenter.

Clinical interview

The Mini-International Neuropsychiatric Interview (MINI 5.0.0; Sheehan et al., 1994; Estonian version Shlik et al., 1999) was developed as a short structured interview for diagnosing DSM-IV and ICD-10 psychiatric disorders. Clinical interview was conducted by experienced psychiatrist or clinical psychologist in the present study.

Self-report questionnaires

Eating Disorders Assessment Scale (EDAS; Akkermann, Herik, Aluoja, & Järv, 2010) was used to assess ED symptoms. The 29-item self-report questionnaire is based on a 6-point Likert scale (from "never" as 0 to "always" as 5) and consists of four subscales: 1) Restrained eating; 2) Binge eating; 3) Purging; 4) Preoccupation with body image and body weight.

Montgomery-Åsberg Depression Rating Scale (MÅDRS; Montgomery & Åsberg, 1979; Svanborg & Åsberg, 1994) measures the severity of depression symptoms and consists of nine items (mood, feelings of unease, sleep, appetite, ability to concentrate, initiative, emotional involvement, pessimism, zest for life). The self-report version was used in the present study (MÅDRS-S; Svanborg & Åsberg, 1994).

Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995; Estonian version Paaver et al., 2007) assesses impulsivity (specifically subscales of attentional, motor and non-planning) and is answered on a 4-point Likert Scale (from "rarely/never" as 1 to "almost always/always" as 4). Total score of BIS-11 was used in the present data analysis.

State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) is a 40-item self-report questionnaire, which contains separate scales for measuring state and trait anxiety (both 20-item scales). State anxiety is evaluated on a 4-point Likert scale (from "not at all" as 1 to "very much so" as 4) as well as trait anxiety (from "almost never" as 1 to "almost always" as 4).

Emotional Go/No-Go task

The emotional Go/No-Go task was used to assess behavioral impulsivity (Matlab R2007b, MathWorks, Inc; DELL Latitude E6500). Pictorial material was used for measuring attentional bias to ED specific stimuli (i.e. body and food related pictures). Additionally, there was only one experimenter present during the testing to avoid interfering factors.

Neutral and food related pictures were taken from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2005) and collected from personal contacts. Pictures related to body were taken using a voluntary female model apart from two pictures that were obtained from IAPS (Lang et al., 2005).

Neutral, food and body related stimuli were presented for 1000 milliseconds (ms) with 1000 ms intervals on a 15.4-inch computer screen. All the participants were given instructions when and which button on the keyboard they have to press as quickly as possible with their dominant hand. The purpose of the task was to inhibit a response when a distractor stimulus was presented and to press a spacebar on the keyboard as fast as possible when a target stimulus was presented. Also, a 2000 Hz sound signal was generated from the computer for 50 ms when the spacebar was pressed in response to the distractor stimulus. There were three categories of responses: correct answers, commission and omission errors. Commission errors were made when the participant pressed a spacebar in response to the distractor stimulus. Omission errors were made when the participant did not respond to the target stimulus.

The emotional Go/No-Go task consisted of two main parts. Before two main parts, there was a trial phase where the participants learned the principle of the task. In the trial phase, living objects were alternated with non-living objects. In the first main part, the inhibition effect was assessed in relation to body stimuli which alternated with neutral stimuli. In the second main part, the same effect was measured in relation to food stimuli which alternated with neutral stimuli.

Altogether two main parts of the emotional Go/No-Go task consisted of 15 test blocks where in each of those 12 stimuli were presented consecutively (see Figure 1). Before every new test block, an instruction appeared on the screen which determined target and distractor stimulus. After every two test blocks, target and distractor stimulus were reversed. In total, there were 75% distractor and 25% target stimuli. All the target and distractor stimuli were pictures associated with body, food or neutral objects.

For each test block, RTs and the number of commission and omission errors for all the stimuli (i.e. body, food, neutral) were recorded. RTs reflect attentional bias to specific stimuli, whereas commission errors indicate difficulties in inhibitory control and omission errors in attention.

RTs that were less than 300 ms and more than 900 ms were considered as missing values in the present emotional Go/No-Go task, which indicated that these responses were made either too early or too late to carry out a significant meaning. Also, it is possible that too fast RTs could reflect anticipation (Meule, Lutz, Vögele, & Kübler, 2014). In sum, there were 1.4% of RTs that were excluded from the analyses in the present study.

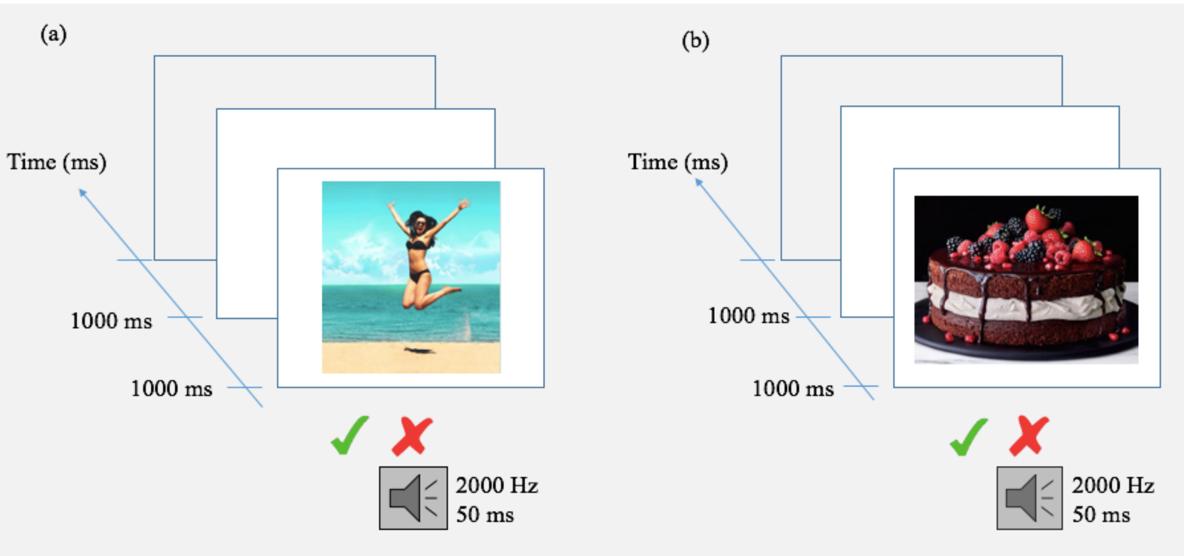

Figure 1. Representative screen displays of body (a) and food (b) stimuli of the present emotional Go/No-Go task (pictures are illustrative).

Procedure

The study was approved by the Research and Ethics Committee of the University of Tartu. Before the testing procedure, written informed consent was collected from the participants. Also, written informed consent from parents was obtained from underage (<18 years old) participants. All the recruited patients were assessed individually during the first days of their hospitalization approximately an hour after breakfast in the hospital. As it has been found that hunger is associated with decreased inhibitory control to food related stimuli in the emotional Go/No-Go task (Loeber, Grosshans, Herpertz, Kiefer, & Herpertz, 2013), then it was essential that the experiment and procedures took place after the meal.

After written informed consent was obtained from the participants, they were assessed for any psychiatric disorders with The Mini-International Neuropsychiatric Interview (MINI; Sheehan et al., 1994; Estonian version Shlik et al., 1999). Clinical interview with the participant was conducted by experienced psychiatrist or clinical psychologist. After the emotional Go/No-Go task was conducted, the self-report questionnaires were administered to all the participants. Specifically, HC filled out the state questionnaires, i.e. MÅDRS-S, BIS-11, EDAS, STAI, in a laboratory at the university setting. Patients filled out their state questionnaires during the first days of hospitalization after the emotional Go/No-Go task was conducted.

Statistical analysis

Preliminary data was processed in Excel (version 15.13.3). After data transcription, categorization and scoring, the data was processed further in SPSS Statistics (version 24.0). Participants were divided into five groups based on their major diagnoses, respectively individuals with AN-R, BN-BP, MD or MAD/SUD, and HC.

To analyze differences in RTs for all the stimuli and differences in mean scores of self-report measures between five groups, One-Way Analysis of Variance (ANOVA) and Tukey's post hoc test were conducted. Differences in duration of illness were analyzed with an appropriate T-Test between individuals with AN-R and BN-BP. Power analyses were performed with G*Power (version 3.1.9.4).

Mean scores of self-report questionnaires (i.e. MÅDRS-S, BIS-11, EDAS, STAI), BMI and also duration of illness for individuals with ED were included in the analysis of covariance (ANCOVA) as covariates to examine possible moderating effects on RTs.

To explore differences in frequencies in comorbid psychopathology and responses, i.e. commission and omission errors and correct answers, Chi-square test of independence (χ^2- test) was used. Additionally, Pearson's correlation coefficient was used for examining the correlations between emotional Go/No-Go task (e.g. RTs and frequencies of responses for all the stimuli) and self-report impulsivity measure (BIS-11).

Although all the participants had the opportunity to participate in the present study, only participants who were between 14-45 years old were included in the analyses. 14

participants were excluded from the preliminary sample (101 participants). Of the 27 individuals with AN-R three 13 years old and five individuals, who minimized their ED symptoms based on self-reported EDAS scores, were excluded from the analyses. One individual with BN-BP, who had in addition comorbid psychotic disorder, was as well excluded from the analyses. Also, in the group of MAD/SUD, two individuals, who had in addition comorbid obsessive-compulsive disorder, and one individual, who was considered to be out of age limit in the present study, were excluded from the current analyses. Two HC were considered as outliers in RTs for all the stimuli as they were remarkably slower compared to other HC and were as well excluded from the analyses.

Results

Descriptive statistics

One-Way ANOVA was conducted to compare differences in age, BMI and mean scores of self-report measures (i.e. MÅDRS-S, BIS-11, EDAS, STAI) between the groups. Descriptive data and differences between the groups are presented in Table 1.

The frequency of comorbid psychopathology in individuals with AN-R, BN-BP and MAD/SUD is presented in Table 2. There were no statistically significant differences among groups in relation to mood disorders [$\chi^2(2)=1.8$; $p>0.05$], anxiety disorders [$\chi^2(2)=0.8$; $p>0.05$] and SUD [$\chi^2(2)=1.4$; $p>0.05$]. As well, there were no significant differences between individuals with AN-R, BN-BP and MAD/SUD in relation to mood, anxiety and SUD ($p>0.05$).

Table 1. *Descriptive characteristics of individuals with ED, MD, MAD/SUD, and HC.*

Variables	AN-R (*N*=19) *M* (±*SD*)	BN-BP (*N*=17) *M* (±*SD*)	MD (*N*=15) *M* (±*SD*)	MAD/SUD (*N*=17) *M* (±*SD*)	HC (*N*=19) *M* (±*SD*)	ANOVA $F_{(4.82)}$	p	η^2
Age (years)	21.2 (±5.7)	24.6 (±8.0)	23.2 (±4.8)	23.2 (±5.5)	23.2 (±7.8)	0.62	0.651	0.030
BMI (kg/m^2)	16.3 (±1.5)[b,c,d,e]	22.2 (±4.2)[a]	22.7 (±3.8)[a]	23.3 (±5.0)[a]	22.4 (±3.5)[a]	10.86	<0.001	0.346
MÅDRS-S	17.3 (±10.7)[e]	23.2 (±12.0)[e]	18.5 (±11.5)[e]	25.8 (±8.6)[e]	5.8 (±2.7)[a,b,c,d]	11.77	<0.001	0.368
BIS-11	56.7 (±11.3)	64.9 (±12.7)	55.5 (±27.6)	68.3 (±8.7)[e]	52.2 (±8.0)[d]	3.62	0.009	0.158
EDAS								
EDAS total	47.7 (±24.7)[b]	92.1 (±20.8)[a,c,d,e]	36.6 (±32.9)[b]	37.5 (±20.9)[b]	24.9 (±15.3)[b]	21.90	<0.001	0.520
Restrained eating	19.8 (±11.3)[c,d,e]	26.1 (±8.5)[c,d,e]	7.6 (±7.9)[a,b]	9.1 (±6.7)[a,b]	8.1 (±4.0)[a,b]	18.35	<0.001	0.475
Binge eating	8.9 (±7.5)[b]	25.7 (±11.4)[a,c,d,e]	13.3 (±12.5)[b]	12.4 (±6.3)[b]	9.4 (±5.8)[b]	10.41	<0.001	0.340
Purging	2.6 (±4.1)[b]	11.9 (±5.4)[a,c,d,e]	1.7 (±3.0)[b]	1.1 (±1.9)[b]	0.0 (±0.0)[b]	34.58	<0.001	0.631
Preoccupation	16.4 (±10.3)[b]	28.2 (±8.6)[a,c,d,e]	13.9 (±14.1)[b]	14.9 (±11.0)[b]	7.4 (±9.5)[b]	8.74	<0.001	0.301
STAI								
State	49.0 (±14.1)[e]	53.6 (±14.7)[e]	41.1 (±20.8)	53.3 (±12.1)[e]	28.0 (±5.4)[a,b,d]	10.81	<0.001	0.351
Trait	53.5 (±11.9)[e]	55.2 (±13.7)[e]	44.9 (±22.8)[d]	61.8 (±10.3)[c,e]	32.6 (±6.6)[a,b,d]	12.14	<0.001	0.384

Notes: AN-R – anorexia nervosa restrictive subtype; BN-BP – bulimia nervosa binge/purge subtype; MD – major depression; MAD/SUD – comorbid mood, anxiety and SUD; HC – psychiatrically controlled healthy individuals; BMI – body mass index (kg/m^2); MÅDRS-S – Montgomery-Åsberg Depression Rating Scale; BIS-11 – Barratt Impulsiveness Scale; EDAS – Eating Disorders Assessment Scale; EDAS total – total score of EDAS; Preoccupation – Preoccupation with body image and body weight; STAI - State-Trait Anxiety Inventory; State – state anxiety; Trait – trait anxiety; *N* – sample size; *M* – mean; *SD* – standard deviation; *F* – F-statistic; *p* – p-value; η^2 – eta squared; [a] – statistically significant differences from AN-R; [b] – statistically significant differences from BN-BP; [c] – statistically significant differences from individuals with MD; [d] – statistically significant differences from individuals with MAD/SUD; [e] – statistically significant differences from HC. Statistically significant differences between the groups are presented when *p*-value is <0.05.

Table 2. *The frequency of comorbid psychopathology in individuals with AN-R, BN-BP and MAD/SUD based on the number of cases.*

	AN-R (*N*=19)	**BN-BP (*N*=17)**	**MAD/SUD (*N*=17)**
Mood disorders	52.6%	76.5%	100%
Anxiety disorders	52.6%	82.4%	82.4%
Substance use disorders	21.1%	47.1%	41.2%

Notes: AN-R – anorexia nervosa restrictive subtype; BN-BP – bulimia nervosa binge/purge subtype; MAD/SUD – comorbid mood, anxiety and SUD; *N* – sample size; [a] – statistically significant differences from AN-R; [b] – statistically significant differences from BN-BP; [c] – statistically significant differences from individuals with MAD/SUD. Statistically significant differences between the groups are presented when *p*-value is <0.05.

Emotional Go/No-Go task

Differences in mean reaction times

RTs for all the stimuli and differences between the groups are presented in Table 3. There were statistically significant differences among groups in RTs only in relation to body stimuli [$F(4.82)=3.13$; $p<0.05$; $\eta^2=0.132$], however not to food [$F(4.82)=1.40$; $p>0.05$; $\eta^2=0.064$] or neutral [$F(4.82)=1.60$; $p>0.05$; $\eta^2=0.072$] stimuli.

Power analyses were performed to determine whether the sample sizes were representative. Cohen's *f* values in relation to body, food and neutral stimuli in the whole sample were 0.39, 0.26 and 0.28, respectively.

Table 3. *Mean RTs and differences in relation to body, food and neutral stimuli between individuals with ED, MD, MAD/SUD, and HC.*

	AN-R (*N*=19) *M* (±*SD*)	BN-BP (*N*=17) *M* (±*SD*)	MD (*N*=15) *M* (±*SD*)	MAD/SUD (*N*=17) *M* (±*SD*)	HC (*N*=19) *M* (±*SD*)
RT for body	470.4 (±57.7)[e]	488.8 (±73.7)[e]	452.3 (±53.6)	468.6 (±60.5)[e]	425.0 (±39.9)[a,b,d]
RT for food	488.8 (±56.0)	484.2 (±66.2)	464.2 (±46.4)	484.5 (±62.4)	451.6 (±55.5)
RT for neutral	491.8 (±45.9)	504.3 (±62.1)[e]	485.6 (±42.2)	499.4 (±62.6)[e]	464.8 (±43.0)[b,d]

Notes: AN-R – anorexia nervosa restrictive subtype; BN-BP – bulimia nervosa binge/purge subtype; MD – major depression; MAD/SUD – comorbid mood, anxiety and SUD; HC – psychiatrically controlled healthy individuals; *N* – sample size; *M* – mean; *SD* – standard deviation; RT for body – reaction time for body related stimuli (ms); RT for food – reaction time for food related stimuli (ms); RT for neutral – reaction time for neutral stimuli (ms); [a] – statistically significant differences from AN-R; [b] – statistically significant differences from BN-BP; [c] – statistically significant differences from individuals with MD; [d] – statistically significant differences from individuals with MAD/SUD; [e] – statistically significant differences from HC. Statistically significant differences between the groups are presented when *p*-value is <0.05.

Moderating effects on reaction times

ANCOVA was used to assess possible moderating effects on RTs for all the stimuli. All possible moderators, i.e. duration of illness, BMI, MÅDRS-S, BIS-11, total score and subscales of EDAS, state and trait anxiety (STAI), were examined individually. Only duration of illness had a moderating effect on RTs in individuals with ED. Specifically, duration of illness had a significant moderating effect on RTs in relation to food stimuli [$F(1.29)=5.12$; $p<0.05$; $\eta^2=0.150$], whereas duration of illness did not have significant effect on RTs in relation to body [$F(1.29)=0.35$; $p>0.05$; $\eta^2=0.012$] or neutral [$F(1.29)=1.12$; $p>0.05$; $\eta^2=0.037$] stimuli in individuals with AN-R and BN-BP. Taking into consideration the effect of duration of illness on RTs related to food stimuli, the estimated RT related to food stimuli was on average 470.53 ms (*SE*=15.2) in individuals with BN-BP as they became remarkably faster. However, individuals with AN-R became slower as their estimated RT related to food stimuli was on average 490.26 ms (*SE*=13.2). There were no statistically significant differences in estimated RTs for food stimuli between individuals with AN-R and BN-BP when duration of illness was controlled for [$F(1.29)=0.87$; $p>0.05$; $\eta^2=0.029$].

Additionally, ANCOVA was conducted to examine the effect of the variable “group” on RTs for all the stimuli, when BMI, MÅDRS-S, BIS-11, total score and subscales of EDAS, state and trait anxiety were controlled for.

The main effect of the group remained statistically significant on RTs only in relation to body related stimuli when BMI [F(4.81)=3.00; p<0.05; η^2=0.129], BIS-11 [F(4.76)=3.23; p<0.05; η^2=0.145], total score of EDAS [F(4.80)=2.90; p<0.05; η^2=0.127], Binge eating of EDAS [F(4.80)=3.17; p<0.05; η^2=0.137], Purging of EDAS [F(4.80)=2.83; p<0.05; η^2=0.124] and Preoccupation with body image and body weight of EDAS [F(4.80)=3.04; p<0.05; η^2=0.132] were individually controlled for. However, there were no significant main effects of the group on RTs in relation to food and neutral stimuli when BMI, MÅDRS-S, BIS-11, total score and subscales of EDAS, state and trait anxiety were controlled for.

Differences in the frequency of the responses

Response frequencies and differences between individuals with AN-R, BN-BP, MD, MAD/SUD and HC are presented in Table 4. There were statistically significant differences among groups in commission errors in relation to body [χ^2(4)=15.70; p<0.05] and neutral [χ^2(4)=31.26; p<0.05] stimuli, however, not to food [χ^2(4)=7.09; p>0.05] stimuli. Significant differences among groups were observed in omission errors in relation to food [χ^2(4)=10.06; p<0.05] and neutral [χ^2(4)=37.26; p<0.05] stimuli, but not to body [χ^2(4)=7.17; p>0.05] stimuli. Based on the correct answers, significant differences were found among groups in relation to body [χ^2(4)=67.34; p<0.05], food [χ^2(4)=64.51; p<0.05] and neutral [χ^2(4)=133.28; p<0.05] stimuli.

Individuals with BN-BP made significantly more commission and omission errors related to body, food and neutral stimuli than individuals with AN-R. Also, our results indicated that there were significant differences in the correct answers between individuals with BN-BP and all the other groups apart from individuals with MAD/SUD.

Table 4. *The frequency of responses in relation to body, food and neutral stimuli between individuals with ED, MD, MAD/SUD, and HC.*

	AN-R (*N*=19)	BN-BP (*N*=17)	MD (*N*=15)	MAD/SUD (*N*=17)	HC (*N*=19)
Commission (%)					
Body	1.1[b,c]	2.5[a,e]	3.3[a,e]	2.0	1.4[b,c]
Food	1.4[b,c,d]	2.6[a]	3.0[a]	2.7[a]	1.8
Neutral	0.6[b,e]	2.1[a,c,d,e]	1.1[b]	0.9[b]	1.2[a,b]
Omission (%)					
Body	0.5[b]	1.4[a,c,e]	0.7[b]	0.8	0.6[b]
Food	0.8[b]	1.6[a,c,e]	0.8[b]	1.0	0.5[b]
Neutral	0.7[b,c,d]	2.1[a,c,d,e]	1.6[a,b,e]	1.4[a,b,e]	0.5[b,c,d]
Correct (%)					
Body	98.4[b,c,d]	96.1[a,c,e]	96.0[a,b,d,e]	97.2[a,c,e]	98.0[b,c,d]
Food	97.8[b,c,d]	95.8[a,c,e]	96.2[a,b,d,e]	96.3[a,c,e]	97.7[b,c,d]
Neutral	98.7[b,c,d]	95.8[a,c,e]	97.3[a,b,d,e]	97.7[a,c,e]	98.3[b,c,d]

Notes: AN-R – anorexia nervosa restrictive subtype; BN-BP – bulimia nervosa binge/purge subtype; MD – major depression; MAD/SUD – comorbid mood, anxiety and SUD; HC – psychiatrically controlled healthy individuals; Commission (%) – percentage of commission errors; Omission (%) – percentage of omission errors; Correct (%) – percentage of correct answers; Body – body related stimuli; Food – food related stimuli; Neutral – neutral stimuli; *N* – sample size; [a] – statistically significant differences from AN-R; [b] – statistically significant differences from BN-BP; [c] – statistically significant differences from individuals with MD; [d] – statistically significant differences from individuals with MAD/SUD; [e] – statistically significant differences from HC. Statistically significant differences between the groups are presented when *p*-value is <0.05.

Correlations between emotional Go/No-Go task and self-report impulsivity

Pearson's correlation coefficient was used to examine possible correlations between RTs, response frequencies (i.e. commission and omission errors) and self-report impulsivity (BIS-11) in individuals with ED. Correlations between mentioned variables are presented in Table 5. Specifically, omission errors correlated significantly with commission errors ($r=0.36$; $p<0.05$) and with RTs in relation to food ($r=0.43$; $p<0.01$) and neutral ($r=0.44$; $p<0.01$) stimuli. Also, there was significant correlation between self-report impulsivity measure (BIS-11) and commission errors ($r=0.42$; $p<0.05$).

Table 5. *Correlations between emotional Go/No-Go task and self-report impulsivity measure (BIS-11) in individuals with ED.*

	RT for body	**RT for food**	**RT for neutral**	**Commission**	**Omission**	**BIS-11**
RT for body	1					
RT for food	0.64**	1				
RT for neutral	0.85**	0.81**	1			
Commission	-0.16	-0.13	-0.14	1		
Omission	0.28	0.43**	0.44**	0.36*	1	
BIS-11	-0.18	-0.07	-0.09	0.42*	0.18	1

Notes: RT for body – reaction time for body related stimuli (ms); RT for food – reaction time for food related stimuli (ms); RT for neutral – reaction time for neutral stimuli (ms); Commission (%) – percentage of commission errors; Omission (%) – percentage of omission errors; BIS-11 – Barratt Impulsiveness Scale; * - statistically significant when *p*-value is <0.05; ** - statistically significant when *p*-value is <0.01.

Discussion

Individuals with ED are thought to exhibit consistent and implicit attentional bias to disorder specific stimuli, which indicates that attentional bias could also be a potential mechanism that contributes to the development and maintenance of ED (Aspen et al., 2013; Gilon Mann et al., 2018; Stojek et al., 2018; Williamson et al., 2004). Also, it has been suggested that individuals with AN-R have increased inhibitory control, and individuals with BN have decreased inhibitory control as their performance in the behavioral tasks appears to be more impulsive (Claes et al., 2012; Kemps & Wilsdon, 2010; Rosval et al., 2006; Smith et al., 2018; Wierenga et al., 2014; Wu et al., 2013). The purpose of the present study was to measure inhibitory control and attentional bias to body and food stimuli by using emotional Go/No-Go task in individuals with AN-R and BN-BP compared to individuals with MD, MAD/SUD, and HC. We also aimed to examine whether inhibitory control and attentional bias in individuals with ED are related to ED specific stimuli and assess whether the present emotional Go/No-Go task differentiates ED subtypes as well as ED subtypes from HC and psychiatric controls.

Inhibitory control and attentional bias in relation to reaction times

The first hypothesis, that mean RTs for body and food related stimuli in individuals with AN-R and BN-BP are slower compared to HC and psychiatric controls, was not fully confirmed. However, the first hypothesis was supported partially as mean RTs in relation to body stimuli were significantly slower in individuals with ED compared to HC. Our results are to some extent in line with previous findings that individuals with ED have a greater attentional bias to body than food related stimuli compared to HC (Albery et al., 2016). According to the previous studies, ED specific stimuli could capture and maintain attention in individuals with ED compared to HC, making it difficult to disengage their attention from ED specific stimuli and possibly resulting in slower reactions (Renwick, Campbell, & Schmidt, 2013; Stojek et al, 2018). Also, concerns about body shape and weight seem to be central to ED psychopathology (Fairburn et al., 2009; Forrest, Jones, Ortiz, & Smith, 2018). Therefore, as body dissatisfaction and concerns about body shape and weight could affect attentional bias in individuals with ED, then it is possible that difficulties in disengaging their attention from ED specific stimuli may manifest in slower mean RTs for body related stimuli compared to HC in the present study. It has been also found that higher preoccupation with body image is associated with greater attentional bias to body related stimuli, which indicates that preoccupation with body image and weight involves over-engagement with own body figure during later processing stages (Uusberg, Peet, Uusberg, & Akkermann, 2018). These findings support a speculation that individuals with ED compared to HC exhibit greater attentional bias to body related stimuli, which in our study manifested in slower RTs for body related stimuli.

However, we could not detect significant differences in mean RTs for food stimuli in individuals with ED compared to HC. Stojek et al. (2018) have suggested that binge-type ED have attentional disengagement problems as they have difficulties to disengage their attention from body and food related stimuli. Also, Neimeijer et al. (2017) have reported that food related stimuli appear to automatically capture attention in individuals with AN-R, which refers to possible attentional bias to food related stimuli. Although there was an overall nonsignificant tendency towards being slower for also food stimuli in individuals with ED compared to HC, which indicates that pictorial stimuli seem to be sensitive in the emotional Go/No-Go task, yet the question remains whether pictorial stimuli (especially food related stimuli) is really sensitive and relevant enough to differentiate individuals with ED from HC and other psychiatric disorders.

Smith et al. (2018) have reported that the nature of stimuli is an essential aspect of the behavioral tasks as it could be also a methodological limitation. However, attentional bias and deficits in inhibitory control are still most observed in the presence of ED specific stimuli, i.e. weight, shape or food related, in individuals with ED (Gilon Mann et al., 2018; Smith et al., 2018). Meule and Kübler (2014) have suggested based on the sample of HC that high-calorie food pictures could be salient stimuli that may capture and maintain attention, resulting in slower reactions. These findings indicate that it may be important to examine food related stimuli in the future research as well from the high- or low-calorie or appetitive perspective.

Also, we did not observe any significant differences in mean RTs for body and food related stimuli between individuals with ED and other psychiatric disorders. Individuals with BN-BP and MAD/SUD seem to be rather similar based on the comorbid psychopathology. Similarity is supported by our results that there were no significant differences in mean RTs, in the frequency of commission and omission errors and also in their mean scores of self-report questionnaires, apart from self-reported ED symptoms. According to the previous research, psychiatric comorbidity in individuals with ED is common, especially mood, anxiety and SUD are prevalent, and it potentially influences the severity and behavior of ED (Milos et al., 2013; Ulfvebrand, Birgegård, Norring, Högdahl, & von Hausswolff-Juhlin, 2015). These results indicate that high psychiatric comorbidity could also be an important aspect that may be contributing to the similarities in the clinical groups.

Contrary to our second hypothesis, there were no significant differences in RTs related to body and food stimuli between individuals with AN-R and BN-BP. It has been suggested that deficits in inhibitory control could also be associated with duration of illness (Smith et al., 2018). The duration of illness in individuals with ED in our study varied and our results indicated that duration of illness had a significant moderating effect on RTs for food related stimuli in individuals with ED. According to Hirst et al. (2017), it is possible that older individuals with ED, as also their duration of illness is longer, could exhibit greater effects of ED diagnosis on executive functioning because of the cumulative impact of ED symptoms over time. These findings suggest that individuals with ED who have had longer duration of illness could also have deficits in inhibitory control as their executive functions may be affected by the longevity and severity of the illness. Also, deficits in inhibitory control may influence attention, which could manifest in attentional difficulties. Considering the effect of duration of illness on RTs in individuals with ED, our results indicated that duration of illness has an evident effect on the performance in the emotional Go/No-Go task.

Although previous studies have demonstrated that inhibitory control and attentional bias tend to be different in individuals with AN and BN, the present emotional Go/No-Go task has shown that there are rather similarities in RTs related to ED specific stimuli. Our results indicated that mean RTs do not differentiate ED subtypes or individuals with ED from other clinical groups.

Inhibitory control and attentional bias in relation to response frequencies

Our third hypothesis was supported partially as individuals with BN-BP made significantly more omission errors related to body and food stimuli as well as more commission errors related to body stimuli compared to HC. Furthermore, individuals with BN-BP compared to MD made also significantly more omission errors to body and food stimuli, which indicates that individuals with BN-BP missed more body and food related stimuli and had possibly more difficulties in attention related to ED specific stimuli (Meule, 2017). However, lack of significant differences in commission and omission errors between individuals with BN-BP and other psychiatric controls could be perhaps explained by high comorbid psychopathology, as discussed above.

In line with previous findings, higher frequency of commission errors related to body stimuli in our study suggests deficits in inhibitory control in individuals with BN-BP compared to HC, as they had more difficulties in inhibiting their response related to body stimuli (Calvo et al., 2014; Claes et al., 2012; Mobbs et al., 2008). Although individuals with AN and BN have demonstrated increased activation of visual cortex in response to ED specific stimuli, individuals with BN have overall decreased visual cortex response compared to HC (Brooks, O'Daly et al., 2011). These findings indicate that attention in individuals with ED, especially individuals with BN, may be occupied and maintained by ED specific stimuli. It could also explain significantly higher frequency of errors to food (apart from commission errors) and body related stimuli in individuals with BN-BP compared to HC in our study, which refers to problems in inhibiting their response to ED specific stimuli and difficulties in attention as their attention seems to be possibly occupied by ED specific stimuli.

Even though there were no significant differences in RTs for food or body related stimuli between individuals with AN-R and BN-BP, the key findings of the present study were significantly lower frequencies of commission and omission errors to body and food stimuli in individuals with AN-R compared to BN-BP, which is also in accordance with our fourth hypothesis. However, our fourth hypothesis was still not fully confirmed, as significant lower frequency of commission and omission errors were also expected from individuals with AN-R compared to other clinical groups. For instance, individuals with AN-R compared to MD had significant lower frequency of commission errors to body and food related stimuli and they also made significantly fewer commission errors to food related stimuli than individuals with MAD/SUD. Our results still demonstrated that individuals with AN-R could inhibit their response to body and food related stimuli more successfully than psychiatric controls, as they had significantly lower frequency of commission errors, which refers to increased inhibitory control in individuals with AN (Hill et al., 2016; Wierenga et al., 2014).

Previous studies have found in support of the fourth hypothesis that individuals with BN have higher number of commission errors compared to individuals with AN, which also refers to deficits in inhibitory control, as individuals with BN-BP had significantly more difficulties to inhibit their responses and also potential attentional bias to ED specific stimuli in the present study (Brooks, O'Daly et al., 2011; Claes et al., 2012; Mobbs et al., 2008; Oberndorfer et al., 2011; Smith et al., 2018).

Higher frequency of omission errors demonstrated that individuals with BN-BP compared to individuals with AN-R missed significantly more body and food related stimuli, which suggests attentional difficulties (Butler & Montgomery, 2005; Meule, 2017). Brooks, Prince, Stahl, Campbell and Treasure (2011) have implied that attentional bias to food stimuli is greater in individuals with ED compared to HC, specifically in individuals with BN, as it could elicit stronger incentive saliency and a heightened appetitive response in the brain that may likely interfere with other cognitions. However, individuals with AN and restrained eating may utilize cognitions that restrict appetitive responses in the brain, decreasing the intensity of saliency in food pictures and allowing them to focus more rigidly on the task at the moment (Brooks, Prince et al., 2011). Individuals with BN-BP in the present study could have had also difficulties decreasing the intensity of saliency in food related stimuli when they were presented with mentioned stimuli, which may explain higher frequency of errors. Our results indicate in addition to deficits in inhibitory control that there could have been also potential attentional bias to food related stimuli in individuals with BN-BP. Higher frequency of omission errors to food as well as body related stimuli indicates that individuals with BN-BP had perhaps also more difficulties focusing their attention in the behavioral task than individuals with AN-R (Meule, 2017; Mobbs et al., 2011).

Based on the results of the emotional Go/No-Go task, response frequencies seem to differentiate ED subtypes more successfully in our study. Individuals with AN-R compared to BN-BP appear to have increased inhibitory control as well as less attentional difficulties, as they had overall better performance in the emotional Go/No-Go task related to ED specific stimuli. Wu et al. (2013) have reported that ED specific stimuli could affect inhibitory control in individuals with BN-BP and they may become more impulsive, i.e. making more errors, to body and food related stimuli, which was also pronounced in our study.

Previous studies have suggested that self-report and behavioral measures have methodological differences in their assessment of impulsivity (Claes, Nederkoorn, Vandereycken, Guerrieri, & Vertommen, 2006; Galimberti, Martoni, Cavallini, Erzegovesi, & Bellodi, 2012; Waxman, 2009). However, we found significant association between trait impulsivity, assessed by BIS-11, and commission errors in the emotional Go/No-Go task in individuals with ED. Considering previous findings, it could be speculated that individuals with ED who have higher levels of self-reported impulsivity may also demonstrate higher frequency of commission errors in the present Go/No-Go task (Aichert et al., 2012; Enticott, Ogloff, & Bradshaw, 2006; Reynolds, Ortengren, Richards, & de Wit, 2006).

Conclusion of the results in the present study

Consistent with previous research, more deficits in inhibitory control and attentional bias to disorder specific stimuli, i.e. body related, were examined in individuals with BN-BP compared to individuals with AN-R and HC in our study (Brooks, O'Daly et al., 2011; Claes et al., 2012; Renwick et al., 2013; Smith et al., 2018; Stojek et al., 2018; Wu et al., 2013). In summary, mean RTs related to body and food stimuli in the emotional Go/No-Go task did not differentiate ED subtypes and individuals with ED from other clinical groups. However, slower RTs indicated attentional bias to body stimuli in individuals with ED compared to HC. Moreover, response frequencies of the commission and omission errors seem more clearly to differentiate ED subtypes and also individuals with BN-BP from HC based on commission errors to body stimuli and omission errors to body and food stimuli.

However, differentiating individuals with ED from psychiatric controls using emotional Go/No-Go task seems to be considerably more complexed, which could be explained perhaps by high comorbid psychopathology that may be contributing to similarities in clinical groups. The complexity of differentiation could also be perhaps explained by features of depression that may be similar in all clinical groups. However, examining deficits in inhibitory control and attentional bias also in psychiatric controls with the present ED specific Go/No-Go task could give valuable information in the future research in comparison to individuals with ED.

Based on the previous findings, assessing inhibitory control and attentional bias specifically to ED specific stimuli could help identify components of inhibitory control and attentional bias in individuals with ED that may be potential targets for more effective treatment (Bartholdy et al., 2016). Also, insight in the inhibition and attentional processes may give important information about individuals with AN-R, who develop ED binge/purge subtype or BN symptoms later in life, and explain more precisely why individuals with binge/purge subtype or BN develop impulse control problems (Claes et al., 2012). Furthermore, Claes et al. (2012) have suggested that early assessment of the strength and weaknesses of inhibition processes may be essential to identify the individual at risk for developing further loss of control over a variety of impulsive behaviors. However, higher levels of impulsivity could also make it more difficult to apply knowledge and skills that are taught in treatment or to maintain benefits when treatment ends, which indicates that modifications to treatment for individuals with higher levels of impulsivity may be useful (Manasse et al., 2016). These findings indicate that it is essential to consider different aspects of impulsivity when developing a treatment for individuals with ED. Also, it is necessary to detect possible mechanisms, i.e. impaired inhibitory control and/or attentional bias, that may contribute to the etiology and maintenance of binge eating behaviors for targeted interventions (Stojek et al., 2018).

Limitations

The present study has several limitations. The sample sizes of the clinical groups and HC were too small to make strong generalizations. Also, the present study included individuals with AN-R and BN-BP subtypes, which means that the results cannot be generalized to all individuals with AN and BN (i.e. AN binge/purge or BN restrictive subtypes). Future research is needed for other ED subtypes, i.e. AN binge/purge and BN restrictive, as well to examine possible patterns among these subtypes and comparisons to psychiatric controls and HC.

Furthermore, information about duration of illness was collected only from individuals with ED, which means that these analyses were limited to the individuals with ED. However, for better generalization in the future, it is essential to gather the same data also from other psychiatric controls.

Implications and future directions

The results of the present study have valuable implications for future research and in clinical practice. The present emotional Go/No-Go task with ED specific stimuli could be a valid measure to reflect attentional bias to ED specific stimuli and indicate deficits in inhibitory control in individuals with ED, however, based on commission and omission errors rather than RTs.

As the present study demonstrated, duration of illness could have a potential effect on RTs and overall performance in the emotional Go/No-Go task, which indicates that it is essential in the future to include and examine more precisely possible associations and interactions between duration of illness and other relevant variables.

Moreover, developing interventions to improve inhibitory control and attentional bias in individuals with ED could be promising. It has been found that improving ED disorder specific, i.e. food related, inhibitory control could reduce binge eating behavior in individuals with binge-type ED (Treasure, Cardi, Leppanen, & Turton, 2015). For instance, inhibitory control training to ED specific stimuli in individuals with binge-type eating pathology could help develop individualized training programs that include individual’s most frequent “trigger” stimuli (e.g. food related) (Juriascio, Manasse, Espel, Kerrigan, & Forman, 2015). Renwick et al. (2013) have proposed that attentional bias modification through implicit and direct cognitive training to ED specific stimuli, i.e. food and body related, may be also promising in the treatment of ED to decrease attentional bias to ED specific stimuli. In conclusion, examining mechanisms and ED specific stimuli could give valuable information in the development and maintenance of ED, which is necessary for differentiating ED subtypes and developing specific treatment targets for individuals with ED.

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Supplementary Material

Selection of psychiatric controls

Preliminary psychiatric groups were major depression (MD; n=15), comorbid mood and anxiety disorders (MAD; n=10) and comorbid mood, anxiety and substance use disorders (MAD/SUD; n=7). As diagnoses in psychiatric groups varied, One-Way ANOVA was conducted to control whether there were significant differences in mean scores of self-report questionnaires, i.e. MÅDRS-S, BIS-11, EDAS, STAI, and RTs for all the stimuli between preliminary psychiatric groups. There were significant differences in mean scores of trait anxiety between preliminary psychiatric groups [$F(2.25)=3.79$; $p<0.05$; $\eta^2=0.233$]. These significant differences were observed in mean scores of trait anxiety between MD and preliminary MAD, as well as between MD and preliminary MAD/SUD. As a result, individuals with MD stayed as an independent group (n=15) and two preliminary comorbid groups were able to put together as an independent MAD/SUD (n=17) in the present study. Mean RTs for all the stimuli is presented in Table A.

Table A. *Mean RTs in relation to body, food and neutral stimuli between individuals with MD, MAD, and MAD/SUD.*

	MD (*N*=15)	MAD (*N*=10)	MAD/SUD (*N*=7)	ANOVA		
	M (±*SD*)	*M* (±*SD*)	*M* (±*SD*)	$F_{(2.29)}$	*p*	η^2
RT for body	452.3 (±53.6)	475.9 (±51.5)	458.2 (±74.5)	0.51	0.605	0.034
RT for food	464.2 (±46.4)	488.3 (±58.5)	479.1 (±72.0)	0.57	0.569	0.038
RT for neutral	485.6 (±42.3)	502.7 (±52.2)	494.7 (±79.4)	0.29	0.747	0.020

Notes: MD – major depression; MAD – comorbid mood and anxiety disorders; MAD/SUD – comorbid mood, anxiety and SUD; *N* – sample size; *M* – mean; *SD* – standard deviation; *F* – F-statistic; *p* – p-value; η^2 – eta squared; RT for body – reaction time for body related stimuli (ms); RT for food – reaction time for food related stimuli (ms); RT for neutral – reaction time for neutral stimuli (ms); [a] – statistically significant differences from individuals with MD; [b] – statistically significant differences from individuals with MAD; [c] – statistically significant differences from individuals with MAD/SUD. Statistically significant differences between the groups are presented when *p*-value is <0.05.

Acknowledgements

I am very grateful to my supervisor Kirsti Akkermann for her encouragement, valuable guidance and support she has provided me throughout the entire project. I would also like to thank Elis Paasik for her feedback and cooperation with the data collection. As well, I would like to thank all the participants of the present study for contributing their effort and time.