Appetite 54 (2010) 84–92

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Decision-making impairments in women with binge eating disorder

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ARTICLE INFO

Article history:
Received 16 June 2009
Received in revised form 6 August 2009
Accepted 18 September 2009

Keywords:
Risky decision-making
Game of dice task
Binge eating disorder

ABSTRACT

Even though eating is frequently driven by overindulgence and reward rather than by energy balance, few studies so far have analyzed decision-making processes and disturbances in feedback processing in women with binge eating disorder (BED). In an experimental study, 17 women with BED (DSM-IV) and 18 overweight healthy controls (HC) were compared in the game of dice task (GDT). This task assesses decision-making under risk with explicit rules for gains and losses. Additionally, differences in dispositional activation of the behavior inhibition and behavior approach system as well as cognitive flexibility were measured. Main results revealed that women with BED make risky decisions significantly more often than HC. Moreover, they show impaired capacities to advantageously utilize feedback processing. Even though these deficits were not related to disease-specific variables, they may be important for the daily decision-making behavior of women with BED, thus being relevant as a maintenance factor for the disorder.

Introduction

Uncontrolled eating in the form of binge attacks is the core feature of women suffering from binge eating disorder (BED). Several studies indicate that the consequences of binge eating include overweight and obesity, medical (Bulik, Sullivan, & Kendler, 2002; Johnson, Spitzer, & Williams, 2001) and psychological sequelae (Hudson, Hiripi, Pope, & Kessler, 2007) and an increased mortality risk (Fichter, Quadflieg, & Hedlund, 2008). Research so far has mostly focused on the role of negative emotions (Arnow, Kenardy, & Agras, 1995; Hilbert & Tuschen-Caffier, 2007; Stein et al., 2007; Svaldi, Caffier, & Tuschen-Caffier, in press; Telch & Agras, 1996) and over evaluation of weight and shape (Grilo, Hrabosky, et al., 2008; Masheb & Grilo, 2008; Mond, Hay, Rodgers, & Owen, 2007; Svaldi, Caffier, Blechert, & Tuschen-Caffier, 2009) in the onset and maintenance of binge attacks in BED. Comparably, neuropsychological paradigms have been neglected or have mainly focused on subclinical eating disorders, anorexia nervosa (AN), bulimia nervosa (BN) and obesity.

Given the high availability of palatable food, gluttonous eating may not only be a response to powerful physiological drives. Specifically, on several occasions, resisting omnipresent temptations may require skills such as behavior inhibition, attention shift and delay of gratification. Such skills are supposed to be associated with prefrontal cortex regions and distinct subcortical structures (so-called fronto-striatal loops) that mediate executive functions (Lie, Specht, Marshall, & Fink, 2006; Markela-Lerenc et al., 2004; Masterman & Cummings, 1997; Petrides & Pandya, 2002; Robbins, 1996). For example, Nederkoorn, Van Eijs, and Jansen (2004) used the stop signal task (Logan, Schachar, & Tannock, 1997) to test behavior inhibition in restrained eaters. In the stop signal task, participants have to respond as fast as possible in a choice reaction time task, unless a stop signal is presented. In this case, participants have to inhibit their response. Nederkoorn et al. (2004) found restrained eaters to be significantly worse in the inhibition of non-food-related motor responses. Similarly, obese women (Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006) and obese children (Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006) are affected by less adequate response inhibition, although null results for AN and BN have been reported as well (e.g., Claes, Nederkoorn, Vandereycken, Guerrieri, & Vertommen, 2006).

In neuropsychological research, another task to evaluate intentional motor inhibition is the Go/No-Go task (Nigg, 2000). In this task, participants are required to press a key whenever a target stimulus is presented. At the same time, they have to refrain from pressing the key whenever a non-target stimulus is presented. Rosval et al. (2006) found women with BN and women with AN binge/purging type to display significantly more errors than women with AN restricting type and healthy controls. Mobbs, Van der Linden, d'Acremont, and Perroud (2008) assessed inhibitory control in women with BN and healthy controls by

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doi:10.1016/j.appet.2009.09.010

use of an adapted Go/No-Go task which included stimuli related to the body and food. Again, participants with BN expressed inhibition problems, especially on food-related targets.

Against the background of the widespread accessibility of high caloric, tasty food, healthy nutrition is, to a large degree, dependent on conscious decisions with regard to food choices, quantity and frequency of meals. A task recognized to detect decision-making impairments is the Iowa Gambling Task (IGT) which requires subjects to choose from various alternatives (card decks) without having any information about the outcome (gains or losses). Patients with AN (Cavedini et al., 2004), patients with BN (Boeka & Lokken, 2006) as well as obese individuals (Davis, Levitan, Muglia, Bewell, & Kennedy, 2004) expressed disadvantageous decision-making patterns in this task. However, the transfer of these results to actual eating behavior is problematic. While the IGT simulates situations in which the outcome of a decision is unpredictable – at least before the contingencies have been understood on the basis of feedback following previous trials – in everyday life, individuals with eating disorders most often know explicitly the deleterious long-term consequences of their disturbed eating behavior. A laboratory task that simulates decision-making with explicit rules for gains and losses and obvious probabilities is the game of dice task (GDT; Brand, Fujiwara, et al., 2005). In the GDT, individuals are required to decide between various alternatives explicitly related to a specific amount of gain or loss. Thereby, the alternatives have obvious winning probabilities. Several studies have demonstrated the GDT's sensitivity to differentiate between healthy controls and patients with a variety of clinical syndromes such as pathological gambling (Brand, Kalbe, et al., 2005), Korsakoff's syndrome (Brand, Fujiwara, et al., 2005), Parkinson's disease (Brand, Labudda, et al., 2004; Euteneuer et al., 2009), Alzheimer's disease (Delazer, Sinz, Zamarian, & Benke, 2007) and selective amygdala damage (Brand, Grabenhorst, Starcke, Vandekerckhove, & Markowitsch, 2007). There is further evidence that poor decision-making in the GDT is linked to impaired capacities to advantageously utilize feedback processing and to deficits in executive function (Brand, 2008; Brand, Labudda, & Markowitsch, 2006; Brand, Roth-Bauer, Driessen, & Markowitsch, 2008; Brand, Laier, Pawlikowski, & Markowitsch, 2009; Brand, Pawlikowski, et al., 2009; Clark et al., 2008; Euteneuer et al., 2009; Labudda et al., 2008). In eating disorders, to our knowledge, only one study so far has tested decision-making processes if rules for reinforcement and punishment are explicitly clear and the outcome is defined by probabilities. Brand, Franke-Sievert, Jacoby, Markowitsch, and Tuschen-Caffier (2007) compared women with BN to a group of healthy controls in the GDT. Results revealed that, under explicit rules, patients with BN chose disadvantageous alternatives significantly more frequently than controls. Moreover, decision-making impairments were significantly related to deficits in executive functions. Several other studies indicate that women with BN have impairments in executive functions, such as attention and memory deficits (see Duchesne et al., 2004 for a review). These deficits are supposed to be linked to alterations of the serotonin system (Kaye et al., 2005) which, in turn, is thought to affect functions of the (medial) prefrontal cortex. This brain region is also involved in decision-making processes, as yielded by several studies on patients with selective damage to the ventromedial part of the prefrontal cortex (Bechara, Damasio, Tranel, & Anderson, 1998; Bechara, Tranel, & Damasio, 2000; Manes et al., 2002).

Contrary to the case with BN, to our knowledge, no neuropsychological studies have been conducted in BED. One study conducted by Woolley et al. (2007) allows us to draw some comparisons to individuals affected by BED. To identify the brain regions associated with binge eating, the authors compared 32 patients with neurodegenerative disease and 18 healthy control subjects in a free-feeding task using MR voxel-based morphometry (VBM). From the clinical group, those patients who binged in the task had all been previously diagnosed with frontotemporal dementia. Results using VBM revealed that binge eating patients had significantly greater atrophy in the right ventral insula, striatum and orbitofrontal cortex. Hence, in BED, functions of the prefrontal cortex may play an important role in the maintenance of binge attacks.

Overall, compared to BN and AN, little research has been conducted on cognitive biases and executive functions in BED. However, in line with a transdiagnostic approach to eating disorders (Fairburn, Cooper, & Shafran, 2003), some assumptions for BED may be drawn from BN. Similarly to patients with BN, women with BED are often well aware of the deleterious consequences of ongoing binge attacks and often feel ashamed about them. Especially in periods preceding a binge attack, the ability to make advantageous decisions may be important. Clinical observations suggest that women affected by BED frequently "know" that the binge is coming and nevertheless decide to go to the supermarket to buy junk food. Or, they say that they "know" that not talking about their anger will lead to a binge attack but they still choose to say nothing. Similarly, they often know that chaotic eating patterns may trigger binge attacks but they still make attempts at restricting caloric intake at times (Masheb & Grilo, 2000; Raymond, Neumeyer, Warren, Lee, & Peterson, 2003; Rossiter, Agras, Telch, & Bruce, 1992; Yanovski & Sebring, 1994). This is especially important, as persistent caloric restraint predicts relapse following treatment for BED (Safer, Lively, Telch, & Agras, 2002). Thus, even though other factors such as negative emotions may be the immediate trigger for the occurrence of a binge attack, decision-making processes may be of relevance in handling preceding events. We were therefore interested in analyzing decision-making processes in this group of patients.

In line with the research just mentioned, the following hypotheses were made: first, compared to healthy controls, women with BED were expected to select disadvantageous choices significantly more often. Second, women with BED were expected to show impaired capacities to advantageously utilize feedback processing compared to healthy controls. As a multidimensional construct (Guerrieri, Nederkoorn, & Jansen, 2008), impulsivity is conceptualized as a tendency to think, plan and control insufficiently (Solanto et al., 2001), which – in the case of BED – may result in the maladaptive response of bingeing. Furthermore, impulsivity has been linked with risk-taking behavior (Lejuez et al., 2002; Leland & Paulus, 2005; Nicholson, Soane, Fenton-O'Creevy, & Willman, 2005). Therefore, our third hypothesis was that, compared to healthy controls, women with BED were expected to be characterized by an under-activation of the behavioral inhibition system and a higher activation of the behavior approach system concerning fun seeking and reward responsiveness (Gray, 1991, 1994), as measured by the BIS/BAS scale (Carver & White, 1994). Fourth, because of the correlations found between executive dysfunction and disadvantageous decision-making, we expected women with BED to score significantly worse in a task measuring cognitive flexibility. Fifth, we expected a significant positive correlation between disadvantageous decision-making and severity of eating pathology in women with BED.

Participants and methods

Participants

Seventeen women with BED and 18 healthy controls (HC) participated in the study. Inclusion criterion for the BED group was the presence of a DSM-IV-TR diagnosis (APA, 2000) of BED. Exclusion criteria were the presence of substance abuse or addiction, bipolar disorder, current or past psychosis, schizophrenia, current suicidal ideation, pregnancy or lactation. As we wanted to make explicit assertions on decision-making alterations in BED, our HC were required to have a Body Mass Index (BMI = weight/height^2) >25. This was especially important because other studies have found decision-making abilities to be reduced in obese participants (Davis, Levitan, et al., 2004; Pignatti et al., 2006). HC were excluded if they were pregnant, lactating or had a lifetime diagnosis of a mental disorder, as indicated by the DSM-IV-TR (APA, 2000).

Participants were recruited through advertisements in local newspapers and announcements at the University of Freiburg. They were screened for eligibility by means of a telephone interview and then scheduled for a diagnostic session. Diagnoses were determined by the Structured Clinical Interview for DSM-IV Axis I (SCID; Spitzer, Williams, Gibbon, & First, 1992; Wittchen, Zaudig, & Fydrich, 1997, German version) and the Eating Disorder Examination (Cooper & Fairburn, 1987; Hilbert & Tuschen-Caffier, 2006, German version). In addition, height and weight measures were obtained. All participants signed informed consent. The study was approved by the local ethics committee.

See Tables 1 and 2 for means [*M*], χ^2 and *F*-values. Groups did not differ with respect to age and BMI, years of education, monthly income and employment. There was a trend towards significance regarding marital status. Consistent with Hay and Fairburn (1998), women with BED were less likely to be married or live with a partner, but were more likely to be separated, divorced or single. Naturally, the BED group differed significantly from HC on all questionnaires measuring eating pathology. Moreover, women with BED scored significantly higher on the Beck Depression Inventory (BDI; Beck, Steer, & Garbin, 1988). However, this did not influence their motor speed and mental tracking ability, as revealed by the non-significant group difference in the Trail Making Test Part A (TMT; Reitan, 1992; see Methods section for more details on the TMT).

Consistent with other studies (e.g., Hudson et al., 2007; Telch & Stice, 1998; Wilfley, Schwartz, Spurrell, & Fairburn, 2000; Yanovski, Nelson, Dubbert, & Spitzer, 1993), comorbidity in the group of women with BED was high. 23.5% of women in the BED group had no comorbid disorder, 64.7% two, 5.9% three and 5.9% six additional comorbid disorders. Specifically, 23.5% had a diagnosis of current major depression, 64.7% of past major depression, 5.9% of past minor depression, 17.6% of panic disorder with agoraphobia, 11.8% of social phobia, 5.9% of post-traumatic stress disorder, 5.9% of generalized anxiety disorder, and 5.9% of somatization disorder. With regard to binge eating, they had a mean of 12.5 (standard deviation [S.D.] = 6.38) binges over the month prior to testing.

Table 1
Anthropometric data.

Measure	BED (n = 17) N (%)	HC (n = 18) N (%)	χ^2 [df]	p
Marital status			9.63 [5]	.086
Unmarried, with partner	0 (0.00)	5 (27.8)		
Unmarried, without partner	6 (35.3)	4 (22.2)		
Married, living together	7 (41.2)	9 (50.0)		
Married, separated	2 (11.8)	0 (0.00)		
Divorced	1 (5.90)	0 (0.00)		
Widowed	1 (5.90)	0 (0.00)		
Employment			5.72 [5]	.334
Employee	7 (41.2)	6 (33.3)		
Self-employed	0 (0.00)	2 (11.1)		
Unemployed	3 (17.6)	1 (5.60)		
Student	3 (17.6)	6 (33.3)		
Housewife	4 (23.5)	2 (11.1)		
other	0 (0.00)	1 (5.60)		
Monthly income (Euro)			3.81 [6]	.703
≤1000	6 (37.5)	7 (38.9)		
1000–1500	3 (18.8)	5 (27.8)		
1500–2000	3 (18.8)	1 (5.60)		
2000–2500	2 (12.5)	1 (5.60)		
2500–3000	1 (6.30)	1 (5.60)		
3000–4000	0 (0.00)	2 (11.1)		
≥4000	1 (6.30)	1 (5.6)		
	M (S.D.)	*M* (S.D.)	F^a	p
Age (years)	42.4 (12.3)	38.3 (13.1)	3.07	.088
BMI	32.8 (3.54)	30.7 (3.92)	.941	.339
Education (years)	10.8 (1.81)	11.7 (2.08)	1.85	.183

BED = group of women with binge eating disorder; HC = healthy control group; BMI = Body Mass Index = weight in kilograms/height in meters^2.
[a] df (1,35).

Table 2
Participant characteristics.

Measure	BED (n = 17) *M* (S.D.)	HC (n = 18) *M* (S.D.)	F^a	p
EDE-Q_{global}	4.63 (0.79)	2.47 (1.08)	46.9	<.000
EDE-Q_{EC}	3.56 (1.31)	1.39 (0.48)	56.3	<.000
EDE-Q_{SC}	5.63 (0.77)	3.07 (1.45)	43.9	<.000
EDE-Q_{WC}	5.00 (0.89)	2.78 (1.22)	39.0	<.000
EDE-Q_R	3.07 (1.49)	2.08 (1.11)	5.72	.022
BDI	16.1 (8.54)	3.00 (2.20)	39.4	<.000
TMT A	26.6 (6.46)	22.5 (7.18)	3.00	.093

BED = group of women with binge eating disorder; HC = healthy control group; EDE-Q_{global} = Eating Disorder Examination Questionnaire, global score; EDE-Q_{EC} = EDE-Q eating concern subscale; EDE-Q_{SC} = EDE-Q shape concern subscale; EDE-Q_W = EDE-Q weight concern subscale; EDE-Q_R = EDE-Q restraint subscale; BDI = Beck Depression Inventory; TMT A = Trail Making Test Part A.
[a] df (1,35).

Methods

Decision-making under risk

The computerized Game of Dice Task (GDT; Brand, Fujiwara, et al., 2005) was used to assess decision-making. In this task, participants have to guess the outcome of a dice game with the aim of maximizing their gains within 18 throws of a virtual die. They can choose to click on one die or a combination of two, three or four dice. Dice throws are associated with different probabilities for gains and losses (winning probabilities 1:6, 2:6, 3:6 and 4:6 and gains/losses 1000 Euros, 500 Euros, 200 Euros and 100 Euros, respectively). Participants start with a virtual capital of 1000 Euro. If there is congruency between the selected dice number or combination of numbers and the number thrown, participants win the specified gain. In case of incongruency between the number selected and the number thrown, the loss is subtracted from the current capital. The choice of a single number or the combination of two numbers is considered to be a risky selection, because winning probabilities are lower than 34% and over the long run lead to substantial losses (because the losses are relatively high, i.e. 500 Euros or 1000 Euros). By contrast, because winning probabilities are higher than 50%, selected combinations of three or four numbers are analyzed as safe decisions (gains and losses are low to moderate, i.e. 200 Euros or 100 Euros). The aim of the task is to maximize the fictitious starting capital. A "GDT net score" is calculated by subtracting the number of risky choices from the number of non-risky choices. Consequently, a higher net score indicates safer performance. For a more detailed description of the task, see Brand, Fujiwara, et al. (2005).

Questionnaires

The following questionnaires were administered: (1) The Eating Disorder Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994; Hilbert, Tuschen-Caffier, Karwautz, Niederhofer, & Munsch, 2007, German version) assesses the presence and severity of eating pathology. It consists of four subscales (restraint scale, eating concern scale, weight concern scale and shape concern scale) with high internal consistency and stability (Hilbert et al., 2007). Internal consistencies in our study were satisfactory, with Cronbach's α .70 for the restraint scale, .88 for the eating concern scale, .81 for the weight concern scale and .92 for the shape concern scale. (2) The Beck Depression Inventory (Beck et al., 1988; Hautzinger, Bailer, Worall, & Keller, 1994, German version) is a 21-item self-rating questionnaire that measures severity of depression. Several studies have confirmed the BDI's high internal consistency, reliability and discriminant validity (Richter, Werner, & Bastine, 1994). (3) The BIS/BAS Scale (Carver & White, 1994; Strobel, Beauducel, Debener, & Brocke, 2001, German version) is a 24-item self-report measure that assesses individual dispositional differences of behavior and affect according to Gray's concept of behavioral inhibition and behavioral approach systems (Gray, 1991, 1994). The questionnaire consists of four subscales (behavioral inhibition system [BIS], behavioral approach system [BAS] fun seeking, BAS Drive and BAS reward responsiveness) and is linked to impulsivity. From this questionnaire, the subscales BIS, BAS fun seeking and BAS reward responsiveness were analyzed. The scale has acceptable internal consistency and satisfactory split-half reliability (Strobel et al., 2001). Reliability analyses in our sample revealed a satisfactory internal consistency ($.70 \geq$ Cronbach's $\alpha \leq .78$).

Neuropsychological background testing

As a basic neuropsychological screening, the Trail Making Test A and B (Reitan, 1992) were administered. TMT A requires subjects to connect as quickly and correctly as possible 25 encircled numbers in ascending order distributed on a sheet of paper. In TMT B, participants have to alternate between numbers and letters while connecting them. The amount of time required to complete each task reflects the respective score. While TMT A captures mental tracking (Fernandez & Marcopulos, 2008) and motor speed (Levine, Miller, Becker, Selnes, & Cohen, 2004), TMT B additionally measures cognitive flexibility (Fernandez & Marcopulos, 2008) and selective attention (Levine et al., 2004). The proportional score (TMTB–TMTA/TMTA) provides a sensitive index of prefrontal cortex functioning (Stuss et al., 2001). The instrument has proven to be sensitive to various forms of neuro-cognitive deficits and brain injuries (Fernandez & Marcopulos, 2008; Reitan & Wolfson, 2004). Reported reliability coefficients are around .80 (Strauss, Sherman, & Spreen, 2006).

Results

A univariate analysis of variance (ANOVA) computed with the GDT net score as dependent variable revealed that women with BED had a significant lower net score than the women in the HC group, $F(1, 34) = 5.60$, $p = .024$, effect size (Cohen's d) = 0.79 (see Fig. 1 for M and S.D.). This means that the women with BED selected the disadvantageous choices (i.e. a single number or two

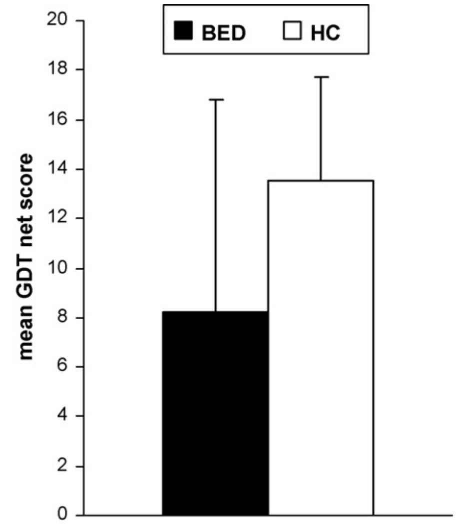

Fig. 1. Mean GDT net score (subtraction of the number of risky choices from the number of non-risky choices). Results are presented separately for the group of women with binge eating disorder (BED) and healthy controls (HC). The higher the GDT net score, the safer the selected choices.

numbers) significantly more often than women in the HC group did. Accordingly, women with BED ended the game with a significantly lower final balance than HC, $F(1, 34) = 4.47$, $p = .042$, $d = -0.71$ (BED group: $M_{Euro} = -394$, S.D. = 2137; HC group: $M_{Euro} = 794$, S.D. = 1028). Looking at the single comparisons for each alternative separately, the group of women with BED chose the risky combination of one number, $F(1, 34) = 3.961$, $p = .055$, $d = .66$, and two numbers, $F(1, 34) = 4.09$, $p = .051$, $d = .68$, more often than HC. Even though these differences were slightly non-significant, the effect sizes indicate differences in these variables with moderate effects (Cohen, 1988). There was also a tendency for women with BED to select the safest choice – four numbers together – less frequently, compared to the HC group, $F(1, 34) = 3.09$, $p = .088$, $d = .59$.

Regarding capacities to advantageously utilize feedback processing, a univariate ANOVA was conducted on strategy selection in response to positive and negative feedback after a risky or safe decision. It revealed that women with BED changed their game strategy significantly less often than HC in response to negative feedback after a risky choice, $F(1, 34) = 4.61$, $p = .039$. Also, women with BED continued with the selection of a safe choice in response to positive feedback after a safe choice significantly less often than HC, $F(1, 34) = 6.48$, $p = .016$. No significant differences were found in strategy continuation in response to negative (positive) feedback after a safe (risky) choice. Similarly, there were no differences in strategy change in response to a negative (positive) feedback after a safe (risky) choice (Fs < 2.64, ps > .114). See Table 3 for M and S.D.

Table 3
Means of strategy selection in dependence of feedback (S.D. shown in parentheses).

	BED ($n = 17$)	HC ($n = 18$)
Stay with safe decision after negative feedback on a safe decision	4.00 (2.87)	4.72 (2.27)
Stay with safe decision after positive feedback on a safe decision	6.06 (3.44)	8.67 (2.59)[a]
Switch to risky decision after positive feedback on a safe decision	1.41 (1.18)	1.06 (0.87)
Switch to risky decision after negative feedback on a safe decision	0.94 (0.90)	0.56 (0.70)
Stay with risky decision after negative feedback on a risky decision	1.82 (2.72)	0.39 (0.78)[a]
Stay with risky decision after positive feedback on a risky decision	0.41 (0.71)	0.11 (0.32)
Switch to safe decision after positive feedback on a risky decision	0.71 (0.99)	0.39 (0.50)
Switch to safe decision after negative feedback on a risky decision	1.65 (1.27)	1.11 (0.90)

[a] $p < .05$.

Table 4
Questionnaire means and means on TMT B (S.D. shown in parentheses).

	BED (n = 17)	HC (n = 18)
BIS	2.99 (3.66)	2.82 (3.21)
BAS_fun	2.34 (0.63)	2.90 (0.41)
BAS_reward	2.88 (0.46)	3.29 (0.52)
TMT-B (s)	60.4 (18.9)	48.9 (13.0)
TMT-prefrontal	59.4 (18.9)	47.9 (12.9)

BIS = Behavior Inhibition Scale; BAS = Behavior Approach Scale; BAS_fun = BAS funseeking subscale; BAS_reward = BAS reward responsiveness subscale; TMT-B = Trail Making Test B; TMT-prefrontal = TMT proportional score (TMTB–TMTA/TMTA), as a sensitive index of prefrontal cortex functioning.

A univariate ANOVA with the BIS/BAS subscales as the dependent variables revealed that compared to HC, women with BED scored significantly lower on the BAS reward responsiveness subscale, $F(1, 32) = 5.97$, $p = .020$, $d = 0.84$, and on the BAS fun seeking subscale, $F(1, 32) = 9.078$, $p = .005$, $d = 1.05$. Hence, women with BED dispositionally seek fun to a lesser degree and are less reward responsive than HC (see Table 4 for M and S.D.). No significant difference was found in behavior inhibition, as measured by the BIS subscale, $F(32) = 3.062$, $p = .090$ (see Table 4 for M and S.D.).

With regard to cognitive flexibility, a univariate ANOVA revealed that women with BED were significantly slower in Trail Making Test B than HC, $F(1, 35) = 4.48$, $p = 0.42$, $d = 0.71$. The proportional score (TMTB–TMTA/TMTA) also yielded a significant group difference, $F(1, 34) = 4.48$, $p = .042$, $d = 0.71$, indicating lower executive functioning in our clinical group compared to HC (see Table 4 for M and S.D.). However, both groups were still in the normal range (Perianez et al., 2007).

Correlations

There were no significant correlations between decision-making and eating pathology, as measured by the EDE-Q (Fairburn & Beglin, 1994). Neither was there a correlation between decision-making and BMI, BDI, age, years of education and binge frequency. There was, however, a significant negative correlation between the GDT net score and the BAS fun seeking subscale in the group of women with BED, $r = -.544$, $p = .029$. Hence, the riskier the decisions made, the higher was the score on the fun seeking subscale. Kendall's τ correlations between the GDT net score and marital status were not significant.

Discussion

With the enormous availability of palatable food, the ability to decide oneself against the hedonic pleasure of eating to avoid negative long-term consequences becomes more and more important and difficult. In BED, the ability to make advantageous decisions may be especially important in periods preceding binge episodes. For example, after a period of restrained eating (Howard & Porzelius, 1999; Masheb & Grilo, 2000; Raymond et al., 2003; Rossiter et al., 1992; Yanovski & Sebring, 1994), the capacity to circumvent a binge attack may be limited due to physiological drives (Cowen & Smith, 1999). However, to adopt a regular eating schedule with a sufficient amount of food is much more reliant on conscious decisions. Similarly, by definition, binge attacks go along with loss of control. However, clinical observations suggest that sometimes they are "planned" hours or days ahead. Hence, a "planned" binge attack may be related to some extent to the decision to shop for junk food. In line with this, we hypothesized that women with BED may be characterized by decision-making impairments. Specifically, we hypothesized that they would more often make disadvantageous decisions compared to overweight healthy control participants. Consistent with our prediction, women with BED chose disadvantageous decisions significantly more often than HC. As our BED sample and the BN sample in the study of Brand, Franke-Sievert, et al. (2007) are similar with respect to years of education and equal in gender, it is possible to draw some comparisons. Looking at the single comparisons for each alternative separately, the risky choices women with BED made were comparable to the ones made by patients with BN. However, they seem to have chosen the safest alternative slightly more often than BN patients. Thus, with regard to decision-making performance, women with BED may be somewhat less impaired than women with BN. However, they seem to be slower in processing complex information than women with BN, as revealed by the TMT B score, while they were similar in motor speed, as assessed by TMT A.

As there was no significant difference between the groups with regard to BMI, our results are attributable to the psychopathology of BED itself, rather than being a correlate of overweight. This is important, because decision-making impairment has also been related to obesity (Davis, Levitan, et al., 2004). One possible explanation for the results stems from Gray's concept of arousal (Gray, 1991, 1994) which postulates, that a non-specific arousal system retrieves excitatory inputs from both the behavior inhibition (BIS) and the behavior activation system (BAS). Thereby, the BIS is responsible for the inhibition of behavior in punishment and non-reward situations. Accordingly, it is assumed that risk takers experience chronically low arousal. Thus, women with BED may chronically experience an under-activation of the behavioral inhibition system. However, in our study no significant group differences in the BIS were found. Also, no correlations were found between disadvantageous decision-making and the behavior inhibition subscale of the BIS/BAS scale. From another perspective, some authors (Cooper, Agocha, & Sheldon, 2000; Cooper, Wood, Orcutt, & Albino, 2003) propose that risky behavior results either from a desire to pursue (enhance) positive affect, or a desire to avoid (reduce) negative affect. Contrary to traditional risk models, the authors do not assume that individuals make risky decisions because they seek risk. In fact, in our study women with BED did choose the risky alternatives more frequently, but at the same time they scored significantly lower on the BAS fun seeking subscale. Clinical observations allow the assumption that women with BED do not engage in binge eating for the thrill of beating the odds of contracting a medical disease. They rather engage in bingeing because, for example, they previously experienced that bingeing has the capacity to alter a negative mood state in the short run, even though long-term consequences are potentially negative. Several studies, in fact, indicate that women with BED do have difficulties regulating emotions in daily life and adopt unhealthy emotion-regulation strategies (Svaldi et al., in press; Whiteside et al., 2007). Additionally, results from several studies emphasize the potential role of affect-regulation deficits in the maintenance of the BED (e.g., Agras & Telch, 1998; Chua, Touyz, & Hill, 2004; Hilbert & Tuschen-Caffier, 2007). Hence, rather than being a consequence of chronically low arousal, advantageous decision-making in women with BED may serve as a coping mechanism against emotionally aversive states.

Another aspect of our results concerns the reward responsiveness in the BED group. Recent studies suggest that natural rewards such as food are linked to dopamine availability (Berridge, 2003; Wise, 2004a, 2004b). Individuals who are more reward-sensitive are more likely to detect rewarding stimuli and have a stronger drive to exert behaviors with potentially pleasurable outcomes (Cohen, Young, Baek, Kessler, & Ranganath, 2005). With regard to consumption of food, Davis et al. (2007) found sensitivity to reward to be positively linked to overeating and to preferences for high caloric food. On the basis of these results, we originally hypothesized that women with BED would be characterized by increased reward responsiveness, as measured by the BAS reward responsiveness subscale. By contrast, compared to HC, our BED group was found to score significantly lower in reward responsiveness. This unexpected result may be explicable by the mean BMI (33 kg/m^2) in our BED group. In fact, two studies (Davis & Fox, 2008; Davis, Strachan, & Berkson, 2004) found a non-linear relationship between BMI and reward sensitivity. While in overweight individuals there was a positive correlation between reward sensitivity and BMI, this correlation was inverse in obese individuals. Due to the subjectively diminished reward potential of food, such reduced reward sensitivity should lead to a depressed appetite and, as a consequence, weight reduction. However, low reward sensitivity may foster the use of highly palatable food to elevate negative emotions which, in turn, could explain the BMI in our BED group despite their reduced reward sensitivity. Actually, a study conducted by Svaldi, Tuschen-Caffier, Peyk, and Blechert (submitted for publication) found that, compared to HC, women with BED allocate their attention significantly more to high caloric than low caloric food pictures, as expressed by larger late positive potential amplitudes (LPP) in the electroencephalogram (EEG).

The second issue of the study focused on group differences in feedback processing. Our group of women with BED was found to utilize feedback processing significantly more disadvantageously compared to HC. Decision-making to a great extent certainly involves the cognitive evaluation of risk by weighing probabilities of outcome with concern about gains and losses. On the other hand, even though people may evaluate risks cognitively, they react to them emotionally (Loewenstein, Weber, Hsee, & Welch, 2001). Contrary to cognitive evaluations, emotional reactions are largely dependent on proximity in time. Thus, even though women with BED may cognitively consider the options available in confrontation with risky situations (i.e. medical sequelae or weight gain as a consequence of bingeing), they still make inappropriate use of this feedback because they may be more confined to the rewarding properties of readily available palatable food. Several studies relate disadvantageous utilization of feedback to the regions of the orbitofrontal and ventromedial prefrontal cortex and limbic structures (e.g., Bechara, Damasio, Damasio, & Lee, 1999; Bechara, Damasio, & Damasio, 2003; Euteneuer et al., 2009; Markowitsch, 1998). The serotongergic and dopaminergic system are thought to mediate between these brain regions and subcortical structures involved in reward processing, decision-making and reward learning (Denk et al., 2005; Rogers, Everitt, et al., 1999; Rogers, Owen, et al., 1999; Scarna, McTavish, Cowen, Goodwin, & Rogers, 2005; Schultz, 2006; van Gaalen, van Koten, Schoffelmeer, & Vanderschuren, 2006). Even though studies with women with BED are still pending, alterations of serotonin have been reported both for AN and BN (Kaye et al., 2005). Against the background of the short-term efficacy of pharmacotherapy in BED with selective serotonin reuptake inhibitors (SSRIs) with regard to the reduction of binges and overall psychopathology (Reas & Grilo, 2008; Stefano, Bacaltchuk, Blay, & Appolinario, 2008), it is possible that impaired feedback processing in women with BED is related to alterations of the serotonergic system.

One more issue with regard to riskier decision-making concerns BED women's higher BDI (Beck et al., 1988) scores. This may yield to the assumption that our results may have been mediated by the current severity of depression. As ANCOVA is not designed to control for naturally occurring group differences (Jamieson, 2004; Miller & Chapman, 2001) and depressiveness is commonly increased in individuals with BED compared to HC (Grilo, White, & Masheb, 2008, 2009), we did not statistically control for depression in our analyses. Even though over 60% of the women in our BED group had a DSM-IV diagnosis of lifetime major depression and over 20% qualified for a current major depression, several points speak against the assumption that increased depressiveness is responsible for the results found. First of all, there was no significant correlation between the severity of depression and the GDT net score. Second, there is evidence that currently depressed individuals tend towards less risk in decision-making than healthy controls (Smoski et al., 2008). From this perspective, depressiveness in our clinical sample would have reduced, rather than increased BED women's risk-taking behavior. Furthermore, there is evidence that remitted depressed individuals do not differ from HC in decision-making as assessed by the IGT (Westheide et al., 2007). Therefore, it is unlikely that lifetime depression had an influence on risky decision-making in our sample of BED. Nevertheless, to fully address this issue, it would be important to test decision-making by means of the GDT in individuals with major depression, and to compare these results to a group of BED individuals with and without current major depression.

This apart, it seems that disadvantageous decisions are not specifically related to eating pathology itself, as no significant correlations were found between risky decisions and the EDE-Q subscales and binge frequency. Against the background of the significantly higher amount of time needed to complete the TMT B by the BED group, it is more likely that dysfunctional decision-making in women with BED may be embedded in a broader context of reduced executive functions. The prefrontal cortex is considered the neuroanatomical basis for skills such as mental flexibility, regulation of affective impulses and inhibition of behavioral actions. The subregions of the prefrontal cortex that mediate decision-making are the orbitofrontal (OFC; Malloy, Bihrle, Duffy, & Cimino, 1993) and dorsolateral prefrontal cortex (DLPFC; Brand, Labudda, et al., 2004). Several studies reported relationships between decision-making and executive functions in situations with explicit rules for gains and losses (e.g., Bechara, Damasio, & Damasio, 2000; Bechara, Tranel, et al., 2000; Brand, Kalbe, et al., 2004; Brand et al., 2006; Brand, Recknor, Grabenhorst, & Bechara, 2007; Clark et al., 2008; Hsu, Bhatt, Adolphs, Tranel, & Camerer, 2005; Labudda et al., 2008; Manes et al., 2002; Tanaka et al., 2006). Brand et al. (2006), for example, argue that, when rules for punishment and reinforcement are stable over time, as is the case in the GDT, executive functions mainly associated with the DLPFC are involved in the decision-making process. Interestingly, several other studies have linked control of hedonic feeding to inhibitory processes localized in the area of the DLPFC (Cummings, 1995; Gautier et al., 2001; Le et al., 2006, 2007; Tataranni et al., 1999). Thus, impaired decision-making and lack of inhibitory control, both relevant for BED, share common pathways.

In sum, our results lead to the conclusion that women with BED do suffer from decision-making impairments. From a therapeutic perspective, to actively decide oneself against chaotic eating patterns or against shopping for junk food may not be a question of motivation or lack of motivation. Especially, constant confrontation with palatable food may inevitably trigger the desire to eat. Thus, lacking the ability to decide oneself for meal plans and regular meal consumption and against hoarding junk food at home may increase the likelihood of binge attacks, especially in the face of lacking adaptive emotion-regulation skills. To reduce binge episodes, cognitive behavioral therapy (CBT) modifies eating behavior and dysfunctional attitudes by mediation of behavioral strategies and cognitive skills to encounter triggers identified as predisposing binge attacks (Chambless & Ollendick, 2001; Wilfley & Cohen, 1997; Wilfley et al., 2002; Wilson & Fairburn, 2001). Interpersonal psychotherapy aims at a direct alteration of social and interpersonal deficits to reduce binge frequency (Wilfley et al., 1993, 2002). As women with BED were shown to be riskier in their behavior and, as risky behavior may be the consequence of the desire to avoid or reduce negative affect (Cooper et al., 2000, 2003), our results propose a therapeutic integration of a module that conceptualizes binge eating as a maladaptive emotion-regulation strategy and thus focuses on the mediation of more adaptive affect-regulation skills. In fact, similarly to CBT and IPT, dialectical behavior therapy (DBT) adapted for BED has proven to be effective in the reduction of binge episodes (Telch, 1997; Telch, Agras, & Linehan, 2000, 2001). Last but not least, it may be worth reconsidering neuro-cognitive functions in the treatment of BED.

Acknowledgement

We thank all participants for their cooperation.

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