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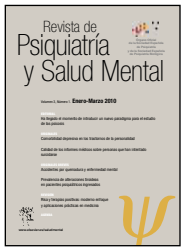

ORIGINAL ARTICLE

Bulimia nervosa: emotions and making decisions

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KEYWORDS
Bulimia nervosa;
Emotions;
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Abstract
Objective: The purpose of this article is to add to the knowledge of the neurobiology and aetiopathogenesis of bulimia nervosa, a common disorder in routine clinical practice. To do this, we will study decision making in low risk and low uncertainty patients.
Material and methods: The study consisted of 19 females who fulfilled the diagnostic criteria of bulimia nervosa according to the DSM-IV and a control group of 28 healthy female students from the Faculty of Psychology. They performed two tasks: one a "cups task" risk and the other an "ambiguity task", both associated with emotions and decision making.
Results: The patients with bulimia took more risks in the win domain than in the lose domain, whereas the reverse was observed in the control group. In the decision making task, low ambiguity, and the number of decisions risked, was similar in both bulimia nervosa and the control group.
Conclusions: Our results support those of previous investigations and theories that postulate that the making of decisions is not only mediated by cognitive processes, but the emotions also play an important role in these processes.

PALABRAS CLAVE
Bulimia nerviosa;
Emociones;
Toma de decisiones

Bulimia nerviosa: emociones y toma de decisiones

Resumen
Objetivo: Profundizar en el conocimiento de la neurobiología y etiopatogenia de la bulimia nerviosa, un trastorno común en la práctica clínica diaria. Para ello estudiaremos la toma de decisiones en pacientes bajo riesgo y bajo incertidumbre.
Material y método: Se incluyeron 19 mujeres que cumplían criterios diagnósticos de bulimia nerviosa según DSM-IV y un grupo control de 28 mujeres sanas estudiantes de la Facultad de Psicología. Van a realizar dos tareas: una de riesgo *cups task* y otra de ambigüedad *ambiguity task*, ambas relacionadas con las emociones y la toma de decisiones.
Resultado: En las tareas de riesgo las pacientes con bulimia se arriesgan más en el dominio de ganancia que en el de pérdida y en el grupo control encontramos el patrón inverso.

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En la toma de decisiones bajo ambigüedad el número de decisiones arriesgadas es similar entre bulimia nerviosa y el grupo control.
Conclusiones: Nuestros resultados refuerzan las investigaciones previas y las teorias que postulan que la toma de decisiones no está mediada solo por procesos cognitivos, sino que también las emociones tienen un papel importante en ellas.

Introduction

In recent decades, eating behaviour disorders have become a major focus of interest in both basic and clinical research. Currently, they are believed to be of multifactorial aetiology, with an unknown pathophysiology involving multiple potential factors. They are usually associated with a certain degree of neuropsychological dysfunction accompanied by neurobiological abnormalities.[1]

Generally speaking, in bulimia nervosa (BN), it is primarily abnormalities in executive functions that are prominent. Some authors, such as Laessle et al,[2] stress that patients with BN may have a vigilance deficit. They also typically have a propensity for focusing their attention on words related to body weight and shape, and they tend to have deficits in information processing.[3]

There is speculation that the lack of impulse control seen in these patients, as reflected in their high levels of impulsivity, suicide, and self-harm behaviours, may be mediated by deficits in executive function. Steiger et al[4] have proposed the hypothesis that problems with impulse control would contribute to the start of serious food gorging; thus, there would be a link between deficits in executive function and the existence of gorging or purging.

In a 1999 study conducted by Lauer, structural studies in patients diagnosed with bulimia showed atrophy of the cerebral cortex and an increase in the size of cerebral ventricles.[5] Functional studies have shown increased cortical activity, specifically in the left inferior frontal area,[6] prior to eating and with serious gorging, while during periods of fasting and food restriction, reduced cortical activity is noted in the parietal, temporal, and occipital lobes in comparison with healthy subjects.[7]

Among the executive functions, decision making represents a complex behaviour that relies upon both analytical and emotional processes.[8] Recent research suggests that emotions play a critical role in decision making under uncertainty.[9] In this regard, it has been observed that alterations in the brain structures associated with emotional processing may impair the individual's decision-making ability.[10]

Decisions may be made under different levels of probability (risk). When the chances of winning or losing are unknown, decisions are made under ambiguity, for the subject does not have enough information to calculate the prospects of his choices being successful. In contrast, when the chances of winning or losing are known, the choices are considered to be made under risk, for the subject is able to calculate the prospects for his choice.[11]

Some authors[12] have suggested that different neuronal circuits (amygdala, anterior cingulate cortex, ventromedial prefrontal cortex) respond to different degrees of uncertainty.

From the neuroscience perspective, a model has been proposed that is consistent with the model for affections such as information on decision making under uncertainty. According to this model, risk decisions are guided by 2 neurological processes, both of which generate emotions.[12]

The first process generates an automatic judgment and is focused on immediate results. This judgment arises from the primary induction process, a stimulus from the environment such as the risk the choice may entail, which evokes an emotional response. This induction is believed to be mediated by the amygdala. The amygdala generates quick and automatic responses to emotional stimuli.[13] A lesion in the amygdala causes an impairment in the primary response to aversive stimuli (or experiences) which, in turn, results in the patient being unable to use such responses effectively in the future.[14]

A second process that guides decision making is more deliberate. The region of the brain that is responsible for it is the ventromedial prefrontal cortex (VMPFC). This structure is involved in decision making in that it mediates between the working memory and the emotional systems,[15] for it receives projections from different regions involved in emotional processing, such as the amygdala or the insula.[16] This region makes a more detailed and deliberate analysis of the decisions, offering secondary emotional responses arising from thoughts about risk decisions. These emotional responses are essential to making advantageous decisions.[17] Patients who have a VMPFC lesion, even though their amygdala may be intact, are incapable of generating anticipatory emotional responses, which reflect an early detection system warning of future dangers or adverse circumstances; this has been interpreted as the basis for the impaired decision making seen in these patients both on laboratory tasks and in daily living.[18]

Therefore, we may conclude that both brain structures—the amygdala and the VMPFC—are essential for proper decision making.

Psychological research on decision making has also shown that these vary depending on the potential losses or potential gains the subject may realize. It has been shown that the potential for loss has a stronger impact than the potential for gain. Therefore, when a decision is to be made in terms of loss, individuals will look for the risk in order to avoid this loss; however, when a decision is to be made in terms of gain, subjects will be more averse to the risk, to avoid the possible loss. Thus, risk preference differs between these 2 domains of win or lose.[7]

In this regard, Weller et al indicate that, in decision making under risk, there must be separate brain systems for the potential losses and the potential gains; that is, decision making in a context of winning would require different neuronal structures than decision making in a context of losing. Along this line, subjects who had lesions of the amygdala (the area of the brain responsible for the processing of emotional responses) demonstrated impaired decision making when it involved potential wins but not when it involved potential losses. In other words, patients who have a lesion of the amygdala make more risky decisions in the win domain, but their decisions are similar to those of healthy subjects in the lose domain. In contrast, patients who have a lesion in the ventromedial prefrontal cortex—the area responsible for integrating cognitive and emotional information—showed impairment in both the win domain and the lose domain. Therefore, the authors concluded that lesions in the amygdala are associated with suboptimal decision making in the win domain, when decisions are made under risk; their results are consistent with those obtained in previous research on decision making under uncertainty.[19]

For its part, the VMPFC is necessary for making the best possible decisions, regardless of the domain in which they are made—given the propensity for these patients to take risks, even when the chances of success are small—which is consistent with data from the previous scientific literature.

Generally speaking, impaired decision making has been observed in patients with eating behaviour disorders. In particular, patients with BN show a tendency toward immediate gratification (rewards), ignoring the long-term negative consequences. Impaired decision making on laboratory tasks in BN is associated with dysfunctional behaviour in decision making in their activities of daily living. The BN is related to impaired impulse control and to a deficiency in anticipating the long-term negative consequences.[20]

In BN, there is a deficit in specific cognitive functions, such as reduced attention and dysfunction in various subcomponents of executive function, which has been related to changes in serotonin. These functions are under the control of the medial prefrontal cortex and the anterior cingulate gyrus—both of which are also associated with decision making. Thus, for example, it has been confirmed that patients with BN are slower in processing complex information than subjects in a control group, and this is related to problems with cognitive flexibility. When specific risk tasks were used, patients who had greater cognitive flexibility chose the less risky options.[21]

Therefore, the deficient decision making seen in patients with BN could reflect functional changes in the medial prefrontal area (which could be related to changes in dopamine and serotonin levels). In other words, functional impairment in the medial prefrontal area could bring about a reduction in cognitive flexibility and a deficit in other executive components that are important in decision making.

Liao et al studied decision making in patients diagnosed with BN and compared their performance with that of anorexic patients and a control group. These authors used the Iowa Gambling Test (IGT) as a decision-making task and measured skin conductance as patients were performing this task. Bechara and Damasio[22] documented the association between individual differences on the IGT and the results obtained from measuring skin conductance. The relationship between the IGT results and the skin conductance measurements lend support to the "somatic marker hypothesis," which states that decision making is influenced by the combination of emotional responses, measured via skin conductance, and previous experiences. The bulimic patients obtained quite unfavourable results on the IGT task while, in contrast to what happened with the anorexic patients, no reduction in skin conductance was appreciated.

As mentioned above, among the features of the bulimic patient's character, their high level of impulsivity and their difficulty with impulse control are also of great importance. In this way, the loss of an inhibitory response in impulse control will result in them choosing options that involve immediate reinforcement, even though it causes a general loss in the long run; in daily living, this would be reflected in their unrestrained eating and their gorging.[23]

The objective of this study was to examine decision making under risk and under uncertainty in bulimic patients. To do this, we used 2 different tasks related to these types of decisions: the *cups task* (related to risk) and the *ambiguity task* (related to uncertainty).

Because decision making under risk varies depending on the domain in which the decision occurs (win domain or lose domain), another objective of the study was to see whether the impaired decision making in bulimic patients varies between the win context and the lose context which, in turn, depends on different brain structures.

Therefore, the following hypotheses are the starting point for our study:

1. Patients with BN, given their reduced impulse control, will have a tendency to engage in higher-risk behaviours; that is, their decision making will be more risky than that of healthy subjects.
2. Likewise, given their impulsivity, their latency response times will be shorter than those of healthy subjects.

Patients or subjects

The sample was composed of 19 females who met the DSM-IV-TR criteria for a diagnosis of bulimia nervosa, whose age range was 17 to 31 years (m=23, DT=4.24), and who were selected from various mental health centres in the Murcia region.

Among the selection criteria were absence of addiction to any type of substance, absence of systemic diseases that could affect the nervous system, and that the patients selected would have a normal IQ. All patients selected had been followed for their disorder over a minimum of 2 years.

The control group was made up of 28 healthy females, whose age range was 19 to 34 years (m=22, DT=3.44), who were students in the Department of Psychology, who were participating in the study voluntarily (receiving credits in one of their subjects for their participation).

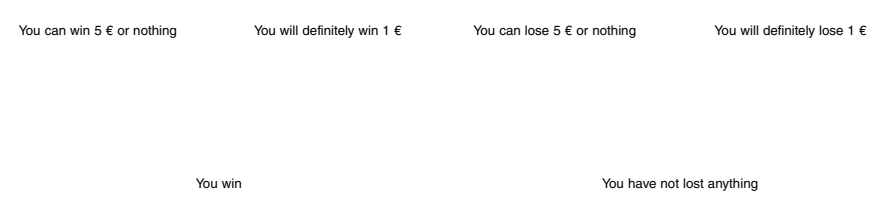

Figure 1 *Cups task* (left, win domain; right, lose domain).

Methodology

Risk Task: *cups task*

Performance of this task was used to assess whether, in decision making, arriving at the best possible solution requires the use of different neuronal structures in a context of potential gains than in a context of potential losses.

In other words, we used this test to establish whether the impairment in the brain's emotional circuits results in a different impairment in decision making when the risk is presented in terms of potential gains than when it is presented in terms of potential losses.

The cups task is a task that simulates decision making under risk; it is appropriate for assessing sensitivity in decision making and adaptation to contingencies. The task is divided into 2 parts or domains: the win domain and the loss domain. The subject is presented with 2 options in each domain: on one side of the screen is the option to obtain a secure win or loss (safe option), while on the other side of the screen (risk option) is the chance of winning or losing a greater amount (all or nothing). On each trial, 2, 3, or 5 cups appear on the screen with the prospect of winning or losing 2, 3, or 5 euros in play money—amounts that vary on each trial, which are also shown on the screen.

There are different expected values (EV) for each trial, in both the win domain and the loss domain: on some plays, deciding to take a risk will be advantageous (AR) and on others clearly disadvantageous (DR), while on some others the expected value will be equal (EEV) for both options (risk and safe).

The task consists of 54 trials: 27 in the win domain and 27 in the loss domain. Within the 27 trials for each domain, the 3 possible expected values are presented (AR, DR, and EEV), with 9 trials for each one.

For the risk option, a random process, with a probability equal to 1 divided by the number of cups presented on each play, determines whether the cup chosen by the subject turns out to be the winner or loser.

The win and loss domains are presented in separate blocks, and within each of these blocks, the combined probabilities for the advantageous risk, disadvantageous risk, and equal value risk options are presented randomly.

On each of the 54 trials, a variable number cups—2, 3, or 5 cups, depending on the type of trial—is presented on each side of the screen. On each trial, one side of the screen is presented as the safe option and the other side as the risk option (fig. 1). Throughout the task, the right and left sides of the computer screen, where the risk option and safe option are presented, alternate randomly.

The amounts won or lost on each of the 54 trials are added up and, at the end of the task, the subject is presented with the total amount of money she has won.

Subjects must win the maximum amount in the win domain and lose the minimum amount in the lose domain, with the objective of having the most money possible at the end of the task,[21] which they are told in the instructions.

Ambiguity Task: *ambiguity task*

This constitutes an ambiguity task because the subject cannot calculate the chances of winning (or losing) when making a risky choice.

The task consists of a series of card choices. On each play, the subject may choose between 2 options: winning a safe amount of money or betting an amount of money determined by a card. Of the subject's 2 options, therefore, one has a secure outcome and the other an uncertain outcome (i.e., winning an amount of money hinges on whether the card chosen is the winning card).[22]

A number is shown on the screen above the cards, indicating the number of cards in each stack (fig. 2). The number below the cards indicates the amount of money to be won if the colour chosen (red or blue) is the same as the colour of the card that will be turned up. How many red cards and blue cards there are is not known—only the total number (the sum) of red cards and blue cards between the 2 stacks is known. Therefore, on each trial, the subject must choose between the red card, the blue card, or the safe outcome.

The subject has a total of 24 trials available; on each one, the amount of money she can win varies, whether she chooses the safe option or the risk option. Also, the amount

Figure 2 Ambiguity task.

of money she can obtain with the safe option will always be less than with the ambiguity option. The number of cards presented on each of the 24 trials also varies.

The subjects performed the 2 tasks described above individually, according to the instructions indicated above. The order of administration for the tasks was varied between subjects to avoid entrainment effects from one task to the other.

For analysis of the data, on the *cups task*, choices made by the subjects were analysed starting with calculation of the proportion of risk choices in each domain (win and lose). Within each domain, we calculated the proportion of risk choices for the 9 trials where the risk was advantageous (AR), for the 9 trials where the risk choice had the same expected value as the safe option (EEV), and for the 9 trials where the risk choice was disadvantageous (DR). We also recorded the response latency for each trial, obtaining an average for each expected value level (AR, EEV, and DR) in each domain (win and lose). For both task performance and response latency, the data was analysed using a mixed repeated measures design, ANOVA, 2 (groups—bulimia nervosa and control) x 2 (domains—win and lose) x 3 (expected value—advantageous risk, equal expected value, and disadvantageous risk).

On the ambiguity task, the proportion of risk choices (number of risk choices / total number of trials) as well as the response latency time were calculated. The 2 groups were compared using Student's t-test for both.

The level of probability was set at 0.05. All analyses were done using the SPSS statistical package.

Results

Cups Task

Performance of the Task

First of all, we found no differences between the 2 groups in terms of the general proportion of risk choices made, $F<1$.

However, we did find a significant interaction effect between the variables Domain and Group, $F(1.45)=5.67$; $P<.05$. While the patients with bulimia nervosa took more risks in the win domain (m=0.69; DT=0.09) than in the lose domain (m=0.62; DT=0.15), we found the inverse pattern in the control group—that is, more risks in the lose domain than in the win domain (fig. 3).

When we compared the groups, we found no differences in the proportion of risky decisions in the win domain, $t(45)=1.22$; $P=.227$; however, we did find a marginally significant trend in the lose domain, indicating that the control group subjects made more risky choices than the bulimic patients in this domain, $t(45)=-1.83$; $P=.075$.

We found a significant primary effect for the expected value, $F(2.90)=60.02$; $P<.0001$ (linear effect, $F(1.45)=129.57$, $P<.0001$). The paired analyses showed differences for all comparisons (fig. 4), indicating that 1) the subjects took more risks when the risk was advantageous than when there was an equal expected value ($P<.0001$) or a disadvantageous risk ($P<.0001$), and 2) they made more risky choices in trials with equal expected value than in trials where there was disadvantageous risk ($P<.0001$).

However, we also found a significant interaction between the variables EV and Group, $F(2.90)=6.79$; $P<.01$. Comparisons between groups at each level of the variable Expected Value (AR, EEV, and DR) showed that the bulimic patient group took more risks than the control group when it was an advantageous risk, $t(45)=2.15$; $P<.05$. In contrast, in the trials with equal expected value and disadvantageous risk, we found no differences between the 2 groups in terms of the proportion of risky choices made, $t(45)=-1.37$ and $t(45)=-1.78$, respectively (fig. 5).

Response latency

With regard to response latency, the bulimic patients were more quick to respond (m=1.91; DT=0.51) than the control group (m=3.06; DT=0.65), $F(1.45)=40.78$; $P<.0001$. We also found an effect for the variable Domain, indicating that both groups took longer in the lose domain (m=2.90; DT=1.05) than in the win domain (m=2.29; DT=0.76), $F(1.45)=22.73$; $P<.0001$.

We also found a significant primary effect in relation to the EV, $F(2.90)=12.99$; $P<.0001$ (quadratic effect $F(1.46)=28.19$; $P<.0001$). The paired comparisons showed that subjects took less time on trials with equal expected value than on trials involving an advantageous risk ($P<.005$) or a disadvantageous risk ($P<.0001$) (fig. 6).

We also found a statistically significant interaction, however, between the variables Domain, EV, and Group,

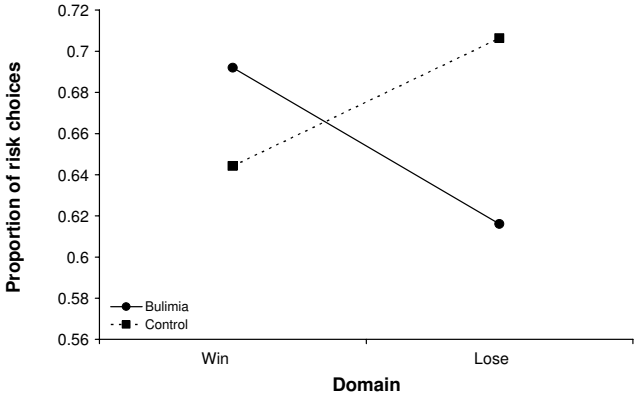

Figure 3 Proportion of risk choices by domain for each group of subjects.

Table 1 Response Latency on the *Cups Task*

	Domain					
	Win			Lose		
	AR	EEV	DR	AR	EEV	DR
Bulimia	1.91 (0.88)	1.71 (0.55)	1.76 (0.40)	2.10 (0.97)	1.88 (0.48)	2.13 (0.78)
Control	2.92 (0.94)	2.43 (0.63)	2.52 (0.73)	3.19 (0.85)	3.08 (0.89)	4.18 (1.32)

DR, disadvantageous risk; EEV, equal expected value; AR, advantageous risk.

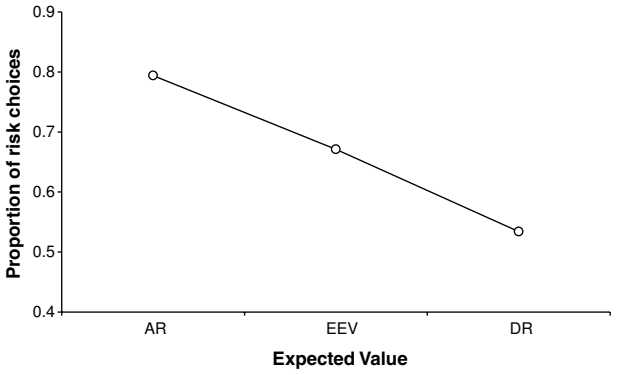

Figure 4 Expected value for all subjects. The paired comparisons show differences in all categories.

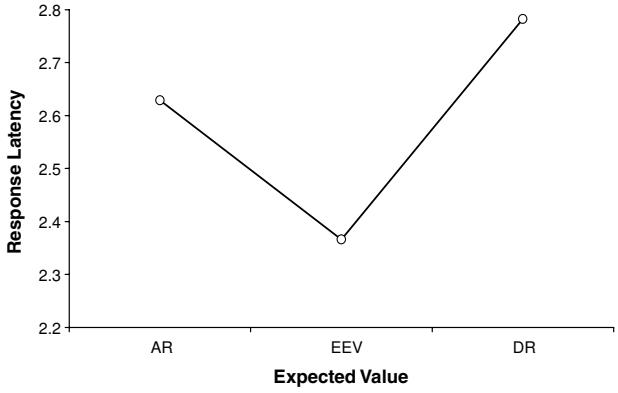

Figure 6 Response latency in relation to expected value.

F(2.90)=6.21; $P<.005$. We analysed this interaction in each group using a repeated measures analysis (ANOVA), 2 (Domain) x 3 (EV). In the bulimic patients, a significant effect was found only for the variable Domain, F(1.18)=5.53; $P<.05$, which indicated that they took less time in the win domain than in the lose domain, regardless of the EV (table 1). In the control group, however, we found an effect for the variable Domain, F(1.27)=23.72; $P<.0001$, for EV, F(2.54)=19.92; $P<.0001$, and a significant interaction for Domain and EV, F(2.54)=20.66; $P<.0001$. The analyses on this group show that these subjects take longer in the lose domain than in the win domain on trials with EEV, t(27)=–3.5; $P<.005$, and with DR, t(27)=–5.93; $P<.0001$, but we found no differences between the 2 domains in terms of the time taken on trials with AR.

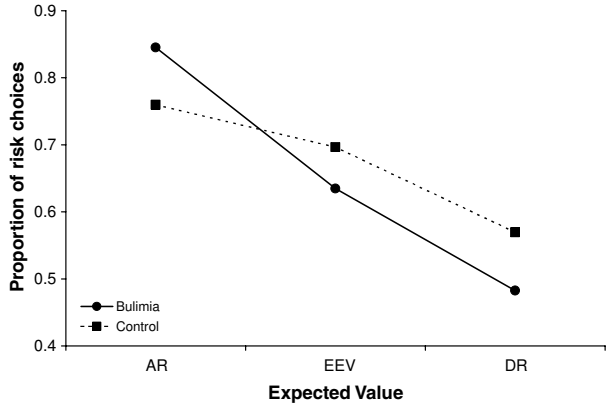

Figure 5 Proportion of risky choices for each group at each level of the variable Expected Value.

The analyses by domains showed that time patterns were similar for the 2 groups in the win domain, non-significant interaction between Group and EV, F(2.90)=1.59; $P=.210$. EV showed a significant primary effect, F(2.90)=8.47; $P<.0001$. Both groups took more time on choices involving an advantageous risk than on choices that had an EEV ($P<.005$) or a disadvantageous risk ($P<.05$). In the lose domain, the data showed an effect for EV, F(2.90)=13.47; $P<.0001$, the paired comparisons showing that subjects took longer on choices involving a DR than on choices with an EEV ($P<.0001$) or an AR ($P<.005$). However, we also found a significant interaction between the variables Group and EV, F(2.90)=7.43; $P<.005$. Analysis of the EV for bulimic patients in the lose domain revealed no differences in the time taken at each level of the variable, F<1. In the control group, a significant effect for EV in the lose domain was appreciated, F(2.54)=25.74; $P<.0001$. Paired comparisons showed that control subjects took longer on choices involving a disadvantageous risk than on choices involving EEV ($P<.0001$) or AR ($P<.0001$).

Ambiguity

In the case of choices made under ambiguity, the number of risky choices was similar for the bulimics (m=13.11; DT=3.13) and the control group (m=13.96; DT=3.87), t<1.

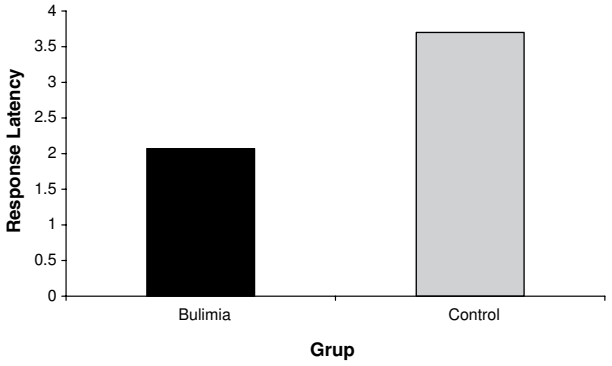

Figure 7 Response latency for the 2 groups.

With regard to response latency, the bulimic patients (M=2.07, DT=0.59) showed a shorter response latency than the control subjects (m=3.70; DT=1.16), t(45)=–5.62; *P*<.0001 (fig. 7).

Discussion

Our results support previous research and theories postulating that decision making is not mediated by cognitive processes alone and that emotions also play an important role in decisions. Therefore, to arrive at a correct or appropriate decision, we also need affective information.

On the task for decision making under risk *(cups task)*, even though there were no differences between the 2 groups in terms of the number or proportion of risky decisions, we found that, in both groups, choices differed depending on the expected value and the domain. Patients diagnosed with bulimia nervosa took more risks in the context of winning than in the context of losing, but the opposite pattern appeared in our control group. Analysis of the expected value also showed differences between the 2 groups, with the bulimics taking more risks than the control group when the risk could be advantageous.

The bulimic patients obtained a shorter response latency—that is, they were more quick to respond than the control subjects—and it they responded more quickly in the win domain than in the lose domain.

We can relate these findings to features of the bulimic patient's character and temperament: they are more impulsive, excitable, and uninhibited, and they have less ability to wait when there is a possible immediate gratification, with a tendency to be dysphoric and irritable when they do not get it—in other words, they are very easily frustrated when they do not get the expected reward. These are also patients in whose behaviour the pursuit of emotions prevails. This characterisation could be related to the tendency they have, as observed on the *cups task*, to make more risky choices when the risk is advantageous—that is, to show more risky behaviour when there are potential winnings or rewards—in contrast to the control subjects who, to avoid loss, maintained a more conservative approach in the context of winning. This is consistent with previous research on decision making related to the context within which the decision is framed (win or lose). These findings are similar to or may be extrapolated to the results of the De Martino et al study, in which injury of the amygdala resulted in risk-seeking behaviours for winnings and avoidance of risk for losses.[12]

On the ambiguity test, however, we found that the bulimic patients and the control subjects had a similar proportion of risky choices but, again, the bulimic patients responded more quickly. Therefore, just as with the risk task, we can relate this data to the temperament characteristics and personality features that are markedly and predominantly associated with these patients: they are less inhibited and more impulsive. On tasks where the risk cannot be calculated or there is no immediate reward obtained, both groups perform in the same way—that is, the bulimic patients perform just like the controls when there is no immediate reward and when the risk cannot be calculated. It would be interesting, also, to study the differential effect on risk behaviour in these patients when they have both the opportunity to calculate the risk and the opportunity to get immediate feedback.

Lastly, we should consider some limitations of our study. First of all, we must point out that the number of subjects in the experimental sample is low, which may compromise the generalisation of our data to the general population. Second, the lack of physiological and brain measurements limits somewhat the scope of our results.

Conflict of interest

The authors declare no conflict of interest.

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