

## DECISION-MAKING, IMPULSIVENESS AND TEMPERAMENTAL TRAITS IN EATING DISORDERS

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### Abstract

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**Objective:** To explore decision-making, impulsiveness and temperamental traits in patients suffering from eating disorders (EDs), as compared with healthy controls (HC).

**Method:** Fifty-one patients affected by ED (fourteen with anorexia restricting subtype, AN-R; fourteen with bulimia, BN; thirteen with anorexia bingeing/purging subtype, AN-BP; ten with binge-eating disorder, BED) and twenty-eight HC. The patients, recruited at the Section of Psychiatry of the University of Pisa (Italy), were evaluated with a battery of neuropsychological questionnaires, including the IOWA Gambling Task (IGT), the Barratt Impulsiveness Scale (BIS-11), the Temperament and Character Inventory (TCI), the Frontal Assessment Battery (FAB) and the Hamilton Depression Rating Scale (HAM-D).

**Results:** The results indicated that AN-R, AN-BP and BN patients showed poorer IGT performances than HC ( $p < .05$ ), while BED performances were similar to those of HC. IGT scores suggested the existence of similarities in decision-making performances of AN-BP and BN patients, as they performed differently from HC starting from block 3 ( $F(16.2)=1.7$ ). In addition, differences between AN-BP/BN and AN-R patients were detected, given that they performed differently starting from block 4. As far as BIS-11 is concerned, AN-BP and BN patients reached the highest BIS total scores, when compared with the other groups. Further, they shared similar temperamental and impulsiveness profiles, as demonstrated by their BIS-11 'motor impulsiveness' scores, and by their TCI 'novelty seeking', 'reward dependence' and 'persistence' dimensions. The post-hoc analyses revealed that both AN groups (namely, AN-R and AN-BP) scored significantly lower than HC on the FAB. No patients fulfilled the criteria for the diagnosis of a current major depression.

**Conclusions:** Decision-making deficits are common in EDs. In AN-R these seem related to cognitive styles, while in AN-BP and BN patients with temperament features and impulsiveness traits.

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**Key words:** eating disorders, eating-disorders spectrum, decision-making, impulsiveness, temperament, frontal lobe functioning

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### 1. Introduction

Decision-making is the ability to make decisions about a course of action: it is a complex process involving sensitivity to reward/punishment and response reversal (Bechara, Damasio, & Damasio, 2000). Behavioral performances at the Iowa Gambling Task (IGT) are considered a reliable index of decision-making performances, as derived by studies carried out in patients with ventromedial prefrontal cortex lesions

(VMPC) (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara et al., 2001). These patients are characterized by a pathological 'myopia for the future', with behaviors guided by immediate reward and poor ability to evaluate their actions' consequences (Bechara et al., 1994). Personality traits underlying decision-making deficits have been also extensively explored, with impulsiveness being the most studied feature, as it involves acting without planning and without considering the long-term consequences of actions

(Whiteside & Lynam, 2001). Impulsive actions are defined as '*poorly conceived, prematurely expressed, undue risk or inappropriate to the situation and resulting in undesirable consequences*' (Evenden, 1999). As with many behavioral constructs, impulsiveness is multifaceted and encompasses behaviors without adequately sampled sensory evidence ('*reflection impulsiveness*'), failure of motor inhibition ('*impulsive action*'), tendency to accept small immediate or likely rewards versus large delayed or unlikely ones and risky behaviors in the context of decision-making ('*impulsive choices*') (Dalley, Everitt, & Robbins, 2011). Patients suffering from eating disorders (EDs) show some features similar to those of subjects with decision-making impairment, as they are unable to make advantageous decisions on the mid-long term, while preferring an immediate reward to their actions (Brand, Franke-Sievert, Jacoby, Markowitsch, & Tuschen-Caffier, 2007). Immediate reward is obtained in anorexia nervosa (AN) through the restriction/avoidance of food intake; in bulimia nervosa (BN) through binge-eating/purging; in binge eating disorder (BED) through compulsive overeating, despite the risk of long-term severe medical consequences (Cavedini et al., 2004; Boeka & Lokken, 2006; Danner et al., 2012). Interestingly, some of the brain areas involved in ED pathophysiology, such as the orbitofrontal cortex, the prefrontal cortex, the dorsolateral prefrontal cortex, and the striatum, are also involved in decision-making (Kaye, Fudge, & Paulus, 2009; Rogers, 2011). Almost all studies, except two (Bosanac et al., 2007; Guillaume et al., 2010) showed how AN, and BN patients have poor abilities in decision-making, when compared with healthy controls (HC) (Cavedini et al., 2004; Boeka & Lokeen, 2006; Liao et al., 2009; Brogan, Hevey, & Pignatti, 2010; Abbate-Daga et al., 2011), while data on BED patients are not univocal (Davis, Patte, Curtis, & Reid, 2010; Svaldi, Brand, & Tuschen-Caffier, 2010). A negative correlation between impulsiveness and IGT performances is described in the general population (Zermatten, Van der Linden, d'Acremont, Jermann, & Bechara, 2005). Within the AN category, AN-R patients are prone to perfectionism and rigidity, while AN-BP is more similar to BN patients (more impulsive), as summarized in a recent meta-analysis (Guillaume et al., 2015).

The aim of present study was to explore phenomenological characteristics of decision-making, impulsiveness, and related temperamental traits in a sample of ED patients. We hypothesized that differences of temperamental and psychopathological signs and symptoms across the various types of EDs should clearly emerge when focusing attention, through a specific battery of tests, on features such as impulsivity, compulsivity, distress, or inhibition vs. risk taking. Moreover we were interested in highlighting differences between ED patients and a group of healthy controls (HC) on the above-mentioned dimensions. Thus, we hypothesized that impulsivity and risk-taking behaviors should be over-represented in ED patients, when compared to HC.

## 2. Subjects and Method

### 2.1. Sample

Fifty-one patients (mean age:  $31.5 \pm 9.9$  years), recruited at the Section of Psychiatry of the University of Pisa, Italy, between March and December 2011, fulfilled the diagnostic criteria for AN, BN or BED of

the Diagnostic and Statistical Manual-Forth Edition Text Revised (DSM-IV-TR) (American Psychiatric Association [APA], 2000). Fourteen (27.4%) patients were suffering from AN-R, 13 (25.4%) from AN-BP, 14 (27.4%) from BN, and 10 (19.6%) from BED, as assessed with the Structured Clinical Interview for the DSM-IV Axis I Disorders (First, Williams Janet, Spitzer, & Gibbon, 1997). Thirty-eight healthy women (mean age:  $26.4 \pm 4.5$  years) who volunteered for the study were also included, as healthy control subjects (HC). Exclusion criteria for the whole sample (both patients and HC) were a history of brain injury or neurological diseases and the lifetime or current substances abuse/dependence. The local ethics committee approved the study that conformed to recognized standards (Declaration of Helsinki). All subjects signed written informed consent prior to their inclusion in the study.

### 2.2. Instruments

We utilized, according to the available literature, rating scales already tested for their validity and reliability in this field. Thus, participants were assessed with the Iowa Gambling Task (IGT) (Bechara et al., 1994), the Barratt Impulsiveness Scale (BIS-11) (Fossati, Di Ceglie, Acquarini, & Barratt, 2001), the Temperament and Character Inventory (TCI) (Cloninger, Przybeck, Svrakic, & Wetzel, 1994), the Frontal Assessment Battery (FAB) (Dubois, Slachevsky, Litvan, & Pillon, 2000; Appollonio et al., 2005), and the Hamilton Rating Scale for Depression (HAM-D) (Hamilton, 1960).

These are all.

#### Iowa Gambling Task (IGT)

The Iowa Gambling Task (IGT) (Bechara et al., 1994) was administered in a computerized version (E-Prime 2 software, Psychology Software Tools, Pittsburgh, PA, USA). The task involved 100 selections from four decks of cards (A, B, C, and D). Each selection was always followed by the gain of money, but sometimes, and at unpredictable points, the selection of any card could also be followed by a loss of money. Decks A and B were disadvantageous, with high rewards but higher losses, leading to a negative net loss of 250 € in 10 cards. Decks C and D were advantageous, with low rewards but lower future losses, leading to a positive net gain of 250 € in 10 cards. Participants were free to switch from a deck to the other at any time. The 100 selections were divided into 5 blocks of 20 consecutive selections, to examine how the subjects learned from the task sequence. A net score was measured by calculating the number of cards picked from advantageous decks (C and D) and the number of cards picked from the disadvantageous ones (A and B) in each block of 20 cards. Positive net scores were related to the preference for the advantageous decks, whereas the negative net scores were consequent to the preference for the disadvantageous ones. A total net score for the 100 selections was also calculated, with a total score of <10 as the threshold for a significant deficit in decision-making. At the end of the task, in order to assess the explicit knowledge of the advantageous strategy, the examiner asked the subject: '*which desk is advantageous in your opinion? Which one is disadvantageous?*' The tasks took 10-15 minutes to be completed.

#### Barratt Impulsiveness Scale (BIS-11)

Impulsiveness was assessed by means of the BIS-

11 questionnaire validated into Italian (Fossati et al., 2001). The BIS-11 is a self-report scale developed to measure impulsiveness as a stable characteristic, composed by 30 items, which are answered on a four-point Likert scale; items are scored 1, 2, 3, 4, where 4 indicates the most impulsive response: the higher the total scores for all items, the higher the level of impulsiveness. The total score ranges between 30 and 120, with no established cut-off point and is the result of the sum of three different subscales: 'attentional' (rapid shifts of attention and impatience with complexity), 'motor' (impetuous action), and 'non-planning' (lack of future orientation) impulsiveness. In addition, the 30 items form six factors determined by main component analyses: attention, motor impulsiveness, self-control, cognitive complexity, perseverance and cognitive instability.

### Temperament and Character Inventory (TCI)

The TCI is a self-reported questionnaire with 240 questions subdivided into 'minor clusters' (sub-dimensions or facets) and 'major clusters' (dimensions or personality traits) (Cloninger et al., 1994). Four major dimensions describe temperament: 'novelty seeking' 'harm avoidance' 'reward dependence' and 'persistence'. Three dimensions describe characters: 'self-directedness' 'cooperativeness' and 'self-transcendence'. The items are listed in random order and grouped into facets. Approximately, half of the items are reverse scored. The temperament facets were as follows: a) novelty seeking, exploratory excitability, impulsiveness, extravagance and disorderliness; b) harm avoidance: anticipatory worry, fear of uncertainty, shyness with strangers and fatigability; c) reward dependence: sentimentality, openness to warm, attachment and dependence; d) persistence: eagerness of effort, work hardened, ambitious and perfectionist. The character facets were as follows: a) self-responsibility, purposefulness, resourcefulness, self-acceptance and enlightened second nature; b) cooperativeness: social acceptance, empathy, helpfulness, compassion, pure-hearted conscience; c) self-transcendence: self-forgetful, transpersonal identification and spiritual acceptance.

### Frontal Assessment Battery (FAB)

The FAB consists of 6 subtests exploring different functions related to the frontal lobes and correlated with frontal metabolism (Dubois et al., 2000; Appollonio et al., 2005). The 6 subtests of the FAB explore the following: (1) conceptualization and abstract reasoning (similarities test); (2) mental flexibility (verbal fluency test); (3) motor programming and executive control

of action (Luria motor sequences); (4) resistance to interference (conflicting instructions); (5) inhibitory control ('go-no go'); and (6) environmental autonomy (prehension behavior). Each subtest is scored from '3' (better score) to '0', for a maximum score of 18. The FAB has shown good validity (correlation of  $\rho = 0.82$  with the Mattis Dementia Rating Scale) and inter-rater reliability ( $\rho = 0.87$ ) (Dubois et al., 2000; Appollonio et al., 2005).

### Hamilton Rating Scale for Depression (HAM-D)

HAM-D is a 21-item clinician-rated scale designed to assess the severity of depressive symptoms (Hamilton, 1960). Each item is ranging between 0 and 4 (8 items), or between 0 and 2 (9 items). A total score  $<7$  is rated as 'normal or in remission', a score between 8 and 13 is rated as 'mild depression', a score between 14 and 18 as 'moderate depression', a score between 19 and 22 as 'severe depression', and  $\geq 23$  as 'very severe depression'.

### 2.3. Statistical analyses

Descriptive analyses were reported as mean ( $\pm$  standard deviations) for continuous variables. Comparisons between groups were performed using Student's t-test (two-tailed) or ANOVA for continuous variables. One-way ANOVA was used to compare BIS-11, TCI and FAB scores between groups, followed by the Fisher's Least Significant Difference (LSD) post-hoc analysis. Performances on the IGT and IGT net scores were compared by repeated-measures ANOVA. A standard multiple regression analysis was performed using total NS score, P score, total BIS-11 score and 'go-no go' FAB scores as the independent variables, and total IGT net score as the dependent variable in both the overall sample and in patients group. The same regression analysis was performed in a third group obtained merging AN-BP and BN, to investigate the relationship between IGT performance and impulsiveness measures in clinically different EDs. All possible relationships between the different parameters were assessed by two-tailed Pearson's analysis. All statistical analyses were carried out with the *Statistical Package for Social Sciences* (SPSS), Version 22.0

## 3. Results

### 3.1. Demographic and Clinical Characteristics

The demographic and clinical characteristics of patients and HC are summarized in **table 1**. Significant

**Table 1.** Demographic and clinical characteristics

	AN-R (n=14)	AN-BP (n=13)	BN (n=14)	BED (n=10)	HC (n=28)	p<.05	Group differences (LSD post-hoc comparison)
	Mean/sd	Mean/sd	Mean/sd	Mean/sd	Mean/sd		
Age	28.9 $\pm$ 11.7	32.9 $\pm$ 8.7	27.0 $\pm$ 8.1	37.4 $\pm$ 11.3	26.4 $\pm$ 4.5	F(4.7)=3.9	BED>AN-R; AN-BP>HC; BED>BN; BED>HC
BMI	16.0 $\pm$ 1.4	16.9 $\pm$ 1.7	22.9 $\pm$ 3.1	34.3 $\pm$ 8.9	21.5 $\pm$ 1.6	F(4.7)=13.9	HC>AN-R, AN-BP; BN>AN-R, AN-BP; BED>AN-R, AN-BP, HC
Education (ys)	12.3 $\pm$ 2.5	14.0 $\pm$ 3.4	13.8 $\pm$ 1.7	15.0 $\pm$ 2.5	17.9 $\pm$ 2.7	F(4.7)=8.0	HC>AN-R; HC>AN-BP; HC>BN; HC>BED; BED>AN-R
Age at onset (ys)	23.3 $\pm$ 9.0	22.8 $\pm$ 7.4	21.2 $\pm$ 8.9	32.1 $\pm$ 9.8	-	F(3.4)=3.2	BED>AN-R; BED>AN-BP; BED>BN
Illness duration (ys)	6.0 $\pm$ 7.2	10.5 $\pm$ 6.6	6.7 $\pm$ 5.4	6.0 $\pm$ 4.3	-	ns	

intergroup differences for age were found: BED patients were older than AN-R, BN and HC, whereas AN-BP patients were older than HC ( $F(4.7)=3.9$ ;  $p<.05$ ). There were also significant differences in the level of education, with HC showing the highest educational level, and BED higher education levels than AN-R ( $F(4.7)=8.0$ ;  $p<.05$ ). The illness duration was the same in all EDs; age at onset was significantly higher in BED than in AN-R, AN-BP and BN patients ( $F(3.4)=3.2$ ,  $p<.05$ ). BMI values were statistically different in the various subgroups ( $F(4.7)=13.9$ ,  $p<.05$ ), with the lowest BMI for AN-R ( $16.6\pm 1.4$ ), the highest for BED patients ( $34.6\pm 8.9$ ), and intermediate values for AN-BP ( $16.9\pm 1.7$ ), BN ( $22.9\pm 3.1$ ) and HC ( $21.5\pm 1.6$ ).

### 3.2. IGT

The LSD post-hoc comparisons on IGT scores showed that HC performed better than ED patients, with the exception of BED ( $p < .05$ ) (table 2; graphs 1-6). The ANOVA for repeated-measures highlighted a significant main effect of group and of the block, as well as of 'block x group' interaction, while indicating significant intergroup differences. Moreover, the overall learning occurred during the test performance, with a significant 'block x group' interaction, starting from

the third block, where HC performed better than AN-BP and BN. Scores resulting from block 4 and block 5 showed a better performance in HC than in AN-R, AN-BP and BN. Post-hoc analyses in the 2 (group) x 5 (IGT block) regarding the total patient group and HC showed a significantly lower score in IGT patients starting in blocks 3, 4 and 5 ( $F(16.2)=1.7$ ).

The impact of impulsiveness psychometric variables was analyzed with a regression model. IGT scores revealed that the 'total BIS' score and the FAB 'go-no go' score were the two predicting factors for the IGT total score (table 3). After excluding HC, the model still accounted for the 37% of variance in IGT net score (table 4). In this case, the analysis highlighted also significant predicting factors, thus 'persistence' and FAB 'go-no go' reached statistical significance.

After merging two groups, AN-BP and BN, while considering their clinical similarities, the analysis showed a significant model that accounted for 58% of variance in IGT patients' net score, with 'persistence' only resulting significantly different. Finally, we found that 50% of AN-R ( $n=6$ ), 50% of AN-BP ( $n=6$ ), 70% of BN ( $n=9$ ) and 44% ( $n=4$ ) of BED patients were beyond the threshold ( $IGT<10$ ) for a significant impairment on the IGT total net scores task, whereas only 7.4% of HC fell within this range ( $n=2$ ).

**Table 2.** IGT scores, descriptive analysis and post-hoc comparisons for each group

	AN-R (n=14)	AN-BP (n=13)	BN (n=14)	BED (n=10)	HC (n=28)	p<.05	Group differences (LSD post-hoc comparison)
	Mean/sd	Mean/sd	Mean/sd	Mean/sd	Mean/sd		
Block 1	0.0±0.0	-2.5±3.6	-3.2±3.7	-4.4±5.0	-2.4±4.3	-	-
Block 2	1.3±1.3	2.5±7.3	2.1±4.0	1.3±4.3	4.2±4.2	-	-
Block 3	5.0±5.0	3.6±6.3	3.3±7.1	4.2±6.3	8.4±5.9	F (16.2)=1.7	HC>AN-BP, BN
Block 4	4.3±4.3	5.0±8.7	3.8±5.6	6.4±9.4	9.9±5.9	F (16.2)=1.7	HC > AN-BP, BN
Block 5	4.5±4.5	3.1±12.2	5.2±7.5	7.7±10.7	12.4±6.5	F (16.2)=1.7	HC > AN-R, AN-BP, BN
Total net score	15.1±15.1	11.8±33.2	11.3±21.3	15.3±28.2	32.5±16.4	F (4.6)=2.7	HC > AN-R, AN-BP, BN

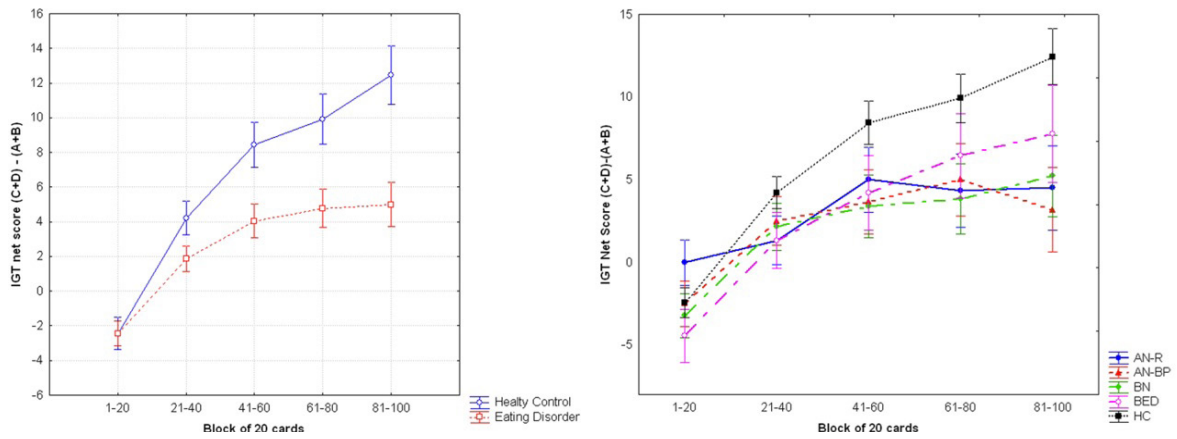
**Table 3.** Impulsiveness Psychometric Dimensions in the overall sample (EDs patients and HC) (n= 79)

	B [CI 95%]	Beta	p	F	p
<i>Regression model</i>				F 4.4=5.9	.001
Novelty seeking	1.0 [-.008; 2.1]	0.262	.52		
Persistence	-3.1 [-6.3; .03]	-0.243	.52		
BIS total score	-0.7 [-1.5; -.03]	-0.307	.04		
FAB Go/no-go	14.4 [4.7; 24.2]	0.381	.004		

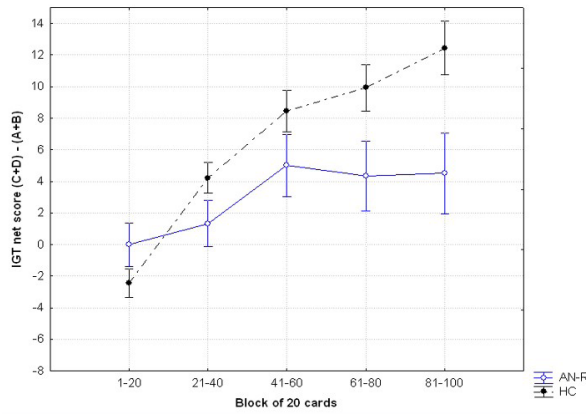
**Table 4.** Impulsiveness Psychometric Dimensions in the EDs sample (n= 51)

	B [CI 95%]	Beta	p	F	p
<i>Regression model</i>				F 4.2=3.9	.001
Novelty seeking	0.7 [-.61; 2.0]	0.19	.02		
Persistence	-5.1 [-9.0; -1.1]	-0.43	.001		
BIS total score	-0.8 [-1.79; 0.2]	-0.38	.055		
FAB Go/no-go	10.7 [.13; 21.3]	0.33	.04		

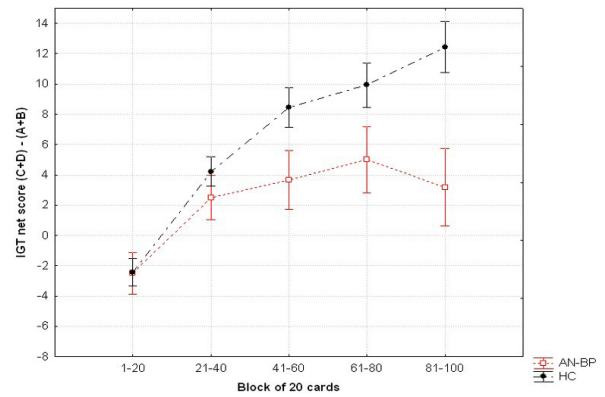
**Graphs 1 and 2.** IGT performances in the overall sample of EDs patients (n=51) vs HC (n=28)



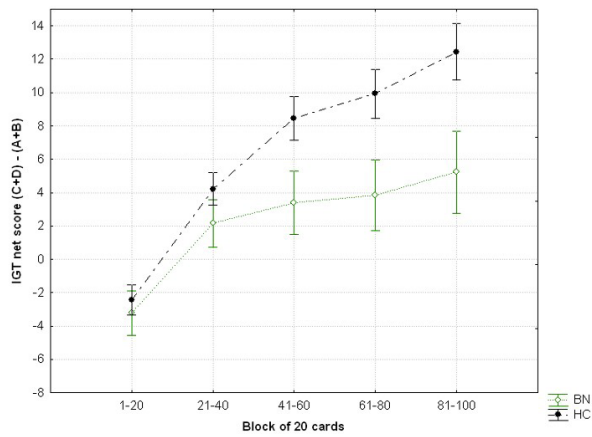
**Graph 3.** IGT performances in AN-R (n=14) vs HC (n=28)



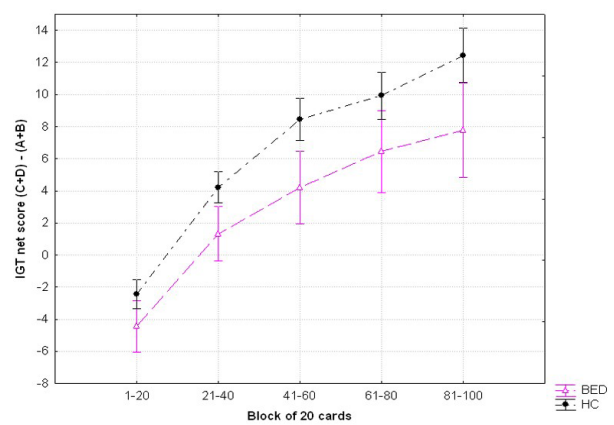
**Graph 4.** IGT performances in AN-BP (n=13) vs HC (n=28)



**Graph 5.** IGT performances in BN (n=14) vs HC (n=28)



**Graph 6.** IGT performances in BED (n=10) vs HC (n=28)



### 3.3. BIS-11

The BIS-11 sub-scales and total scores are summarized in **table 5**. The one-way ANOVA showed several differences when the five groups (AN-R, AN-BP, BN, BED and HC) were compared. AN-BP and BN patients reached the highest BIS total scores, when compared with the other groups. Differences were statistically significant in both groups when compared with HC. BN scored higher than HC in ‘attention-total’, ‘attention sub-scale’, ‘cognitive instability’, ‘motor-total’ and ‘self-control’. AN-BP reached higher scores than HC in ‘attention-total’, ‘motor-total’ and ‘perseverance’. AN-R scored higher than HC in ‘attention-total’, ‘attention sub-scale’ and ‘cognitive instability’. BN scored higher than BED in ‘attention-total’, ‘attention’ and ‘total BIS’. BN scored higher than AN-R in ‘self-control’. AN-R scored higher than BED in ‘attention-total’ and ‘attention’. AN-BP scored higher than BED in ‘perseverance’. No differences were found between BED and HC.

### 3.4. TCI

The results for TCI are shown in **table 6**. ‘Novelty seeking’ total score resulted significantly higher in BED than in AN-R (21.1±7.3 vs 15.3±4.9;  $F(4.66)=145$ ;  $p<.05$ ). ‘Harm avoidance’ (HA) total score was higher in BN than in HC (23.9±5.7 vs 18.5±7.4;  $F(4.78)=1.70$ ;  $p<.05$ ). ‘Total reward dependence’ score was higher in HC, as compared with AN-R (16.5±4.4 vs. 13.5±4.3;  $F(4.6)=1.6$ ;  $p<.05$ ). Persistence was higher in AN-R than in BN (6.2±1.4 vs. 4.6±1.8;  $F(4.6)=1.2$ ;  $p<.05$ ). Several differences in character dimensions emerged between patients and HC that scored higher than all other groups in the ‘self-directedness’ total score (HC>AN-R; 32.7±6.9 vs. 21.9±8.6); (HC>AN-BP; 32.7±6.9 vs. 20.5±8.3) HC>BN; 32.7±6.9 vs. 19.9±9.0); HC>BED (32.7±6.9 vs. 24.3±10.7;  $F(4.6)=7.4$ ;  $p<.05$ ). HC scored higher than AN-R, AN-BP and BN in ‘cooperativeness’ total score (34.1±6.3 vs. 29.0±5.8, 28.0±8.9, and 28.3±6.8, respectively;  $F(4.6)=2.5$ ;  $p<.05$ ). BED scored higher than control subjects in ‘self-transcendence’ (12.8±5.6 vs. 9.4±6.5;  $F(4.6)=2.0$ ;  $p<.05$ ).

**Table 5.** BIS-11 scores, descriptive analysis and post-hoc comparisons for each group

	AN-R (n=14)	AN-BP (n=13)	BN (n=14)	BED (n=10)	HC (n=28)	p<.05	Group differences (LSD post-hoc comparison)
	Mean/sd	Mean/sd	Mean/sd	Mean/sd	Mean/sd		
Attention-Total	18.2±4.0	17.2±4.0	19.5±4.8	14.8±3.1	13.8±3.1	$F(4.7)=6.6$	AN-R>HC; AN-BP>HC; BN>HC; AN-R>BED; BN>BED
Attention	11.0±2.8	10.3±3.7	12.0±3.4	8.4±1.1	8.4±1.6	$F(4.7)=5.6$	AN-R>HC; BN>HC; AN- R>BED; BN>BED
Cognitive instability	7.2±2.6	6.9±1.2	7.5±2.4	6.4±3.0	5.3±2.2	$F(4.7)=2.6$	AN-R>HC; BN>HC
Motor-Total	18.5±4.2	21.2±4.6	20.5±5.5	18.6±4.4	17.6±2.8	$F(4.7)=1.8$	AN-BP>HC; BN>HC
Motor impulsiveness	11.8±3.4	13.5±4.3	13.6±4.7	12.5±4.2	11.3±2.3	ns	-
Perseverance	6.6±1.5	7.7±1.8	6.8±1.7	6.1±1.2	6.3±1.3	$F(4.7)=1.8$	AN-BP>BED; AN-BP>HC
Non-planning impulsiveness	23.7±3.6	25.7±4.7	26.8±6.4	25.3±2.5	24.4±3.7	ns	-
Self Control	11.4±3.4	13.4±3.2	14.6±3.8	13.1±1.6	12.6±2.5	$F(4.7)=2.0$	BN>AN-R; BN>HC
Cognitive complexity	12.2±2.1	12.3±1.8	12.2±3.2	12.2±1.4	11.7±2.1	ns	-
BIS-Total	60.4±7.6	64.1±12.1	66.7±12.1	58.8±6.3	55.8±6.7	$F(4.7)=3.9$	AN-BP>HC; BN>HC; BN>BED

**Table 6.** TCI scores, descriptive analysis and post-hoc comparisons for each group

	AN-R (n=14)	AN-BP (n=13)	BN (n=14)	BED (n=10)	HC (n=28)	p<.05	Group differences (LSD post-hoc comparison)
	Mean/sd	Mean/sd	Mean/sd	Mean/sd	Mean/sd		
Novelty Seeking (NS)	15.3±4.9	4.9±6.9	18.9±5.0	21.1±7.1	18.3±5.1	$F(4.6)=1.4$	BED>AN-R
Harm Avoidance (HA)	23.4±6.0	6.0±8.7	23.9±5.7	20.8±5.5	18.5±7.4	$F(4.6)=1.7$	BN>HC
Reward Dependence (RD)	13.5±4.3	4.3±2.7	16.5±4.3	16.7±4.4	16.5±4.1	$F(4.6)=1.6$	HC>AN-R
Persistence (P)	6.2±1.4	1.4±2.3	4.6±1.8	5.3±2.1	5.2±1.5	$F(4.6)=1.2$	AN-R>BN
Self Directness (SD)	21.9±8.6	8.6±8.3	19.9±9.0	24.3±10.7	32.7±6.9	$F(4.6)=7.4$	HC>AN-R; HC>AN-BP; HC>BN; HC>BED
Cooperativeness (C)	29.0±5.8	5.8±8.9	28.3±6.8	32.2±7.6	34.1±6.3	$F(4.6)=2.5$	HC>AN-R; HC>AN-BP; HC>BN
Self Transcendence (ST)	12.4±5.8	5.8±7.1	14.0±6.9	12.8±5.6	9.4±6.5	$F(4.6)=2.0$	BED>HC

**Table 7.** FAB scores, descriptive analysis and post-hoc comparisons for each group

	AN-R (n=14)	AN-BP (n=13)	BN (n=14)	BED (n=10)	HC (n=28)	p<.05	Group differences (LSD post-hoc comparison)
	Mean/sd	Mean/sd	Mean/sd	Mean/sd	Mean/sd		
Conceptualization (Similarities)	2.9±0.3	2.7±0.4	3.0±0.0	2.8±0.3	2.9±0.2	F(4.6)=2.2	BN>AN-BP
Mental Flexibility/ Verbal Fluency	2.9±0.3	2.9±0.3	3.0±0.0	2.8±0.3	3.0±0.0	ns	-
Motor Programming/ executive control	2.4±0.9	2.7±0.4	2.9±0.3	2.8±0.3	3.0±0.0	F(4.6)=3.7	HC>AN-R; BN>AN-R; BED>AN-R
Conflicting Instructions	2.7±0.6	2.8±0.4	2.8±0.4	2.8±0.3	3.0±0.0	F(4.6)=1.5	HC>AN-R
Inhibitory Control (go- no go)	2.5±0.7	2.5±0.8	2.5±0.8	2.7±0.4	3.0±0.0	F(4.6)=2.7	HC>AN-R; HC>AN- BP; HC>BN
Prehension Behavior	3.0±0.0	2.9±0.3	3.0±0.0	3.0±0.0	3.0±0.0	F(4.6)=1.3	HC>AN-BP
FAB Total	16.4±2.4	16.6±1.9	17.2±1.2	17.3±1.3	17.9±0.2	F(4.6)=3.0	HC>AN-R; HC>AN-BP

**Table 8.** HAM-D scores, descriptive analysis and post-hoc comparisons for each group

	AN-R (n=14)	AN-BP (n=13)	BN (n=14)	BED (n=10)	HC (n=28)	p<.05	Group differences (LSD post-hoc comparison)
	Mean/sd	Mean/sd	Mean/sd	Mean/sd	Mean/sd		
HAM-D scores (21-items)	4.2±1.9	4.2±1.5	4.7±1.4	3.8±1.4	2.8±0.9	F(4.7)=5.2	HC < AN-R, AN-BP, BN

### 3.5. FAB

The FAB scores are summarized in **table 7**. Descriptive analyses between groups highlighted significant differences in total FAB scores and in a number of FAB sub-scales. The post-hoc analyses revealed that both AN groups (namely, AN-R and AN-BP) scored significantly lower than HC. The HC group performed significantly better than AN-R group in three different FAB sub-scales, namely: 'motor series', 'conflicting instructions' and 'go-no go'. They also scored higher in 'go-no go' and 'apprehension behaviors', when compared to AN-BP. Moreover, BN performed significantly worse than HC in 'go-no go'. Eating disorders (EDs) patients' intergroup differences were also found as follows: AN-BP scored lower than BN in 'similarities'; BN and BED scored better than AN-R in 'motor series'.

### 3.6. HAM-D

Patients with EDs did not reach the threshold for the diagnosis of a current major depressive episode (MDE), according to the HAM-D (AN-R: 4.2±1.9; AN-BP: 4.2±1.5; BN=4.7±1.4; BED: 3.8±1.4). As expected, also HC scored below the diagnostic threshold (2.8±0.9). Even if the mean HAM-D scores were all <7 both in EDs sample and in HC, we found a significant difference between AN-R, AN-BP and BN HAM-D scores when compared with HC, as summarized in **table 8** (F(4.7)=5.2; HC<AN-R, AN-BP, BN). No differences were found between BED and HC. Moreover, the post-hoc comparison between the overall EDs vs HC revealed a statistically significant difference (4.2±1.5 vs 2.8±0.9, respectively, T-value: 4.8; p<.01).

## 4. Discussion

The present study explored the relationships between decision-making, impulsiveness, temperamental features and frontal lobe functioning in a group of patients with EDs, compared with a group of healthy controls (HC). The main result of our study was that the decision-making processes, as assessed with the IGT, were significantly impaired in AN-BP, BN and AN-R patients, but not in BED patients, that scored similarly to HC. This finding was in line with previous observations: AN-R, AN-BP and BN patients might show persistence for IGT disadvantageous decks (Guillaume et al., 2010; Brogan et al., 2010; Davis et al., 2010; Danner, Ouweland, van Haastert, Hornsveld, & De Ridder, 2012; Matsumoto et al., 2015), whereas patients with BED might learn how to avoid them (Danner et al., 2012). This finding was confirmed in our study also by the multiple regression analysis, that grouped together AN-BP and BN and showed how the dimension 'perseverance' was correlated with the IGT total score. Interestingly, AN-BP and BN patients were fully aware of the consequences of their choices, as they answered correctly in 70% of cases when asked: «which desk was in your opinion advantageous? And which one was disadvantageous?». However, they were evenly unable to delay the reward, with a trend to return quickly and more often to the desks characterized by high immediate rewards and large future losses. This finding should be interpreted with caution, considering the small size of the sample, but we could speculate that AN-BP and BP patients might show a cognitive form of impulsiveness, maybe due to a pattern of emotion-related signals interfering with the cognitive processes at an unconscious level, as already suggested by Danner et al. (2016). The group of AN-R

patients showed a specific IGT profile, different from both AN-BP and BN patients, with an improvement from block 1 to block 3 (although lesser than HC) and a worsening in the last two IGT blocks. This pattern derived from the adoption of an impaired strategy characterized by poor reversal learning and set shifting, concordant with a 'rigid style of thinking' (Jäuregui-Lobera, 2013). Taken as a whole, the IGT scores suggested the existence of similarities in decision-making performances of AN-BP and BN patients (they both performed significantly different from HC starting from block 3), and differences between AN-BP/BN and AN-R patients (that performed differently from block 4). AN-BP and BN shared also similar temperamental and impulsiveness profiles, as demonstrated by the BIS-11 'motor impulsiveness' scores, and by the three TCI dimensions 'novelty-seeking', 'reward dependence', and 'persistence'. These results were in line with the hypothesis of a 'dimensional profile' shared by AN-BP and BN patients, as characterized by cyclothymic traits, whereas AN-R patients seemed to be characterized by obsessive-compulsive personality traits (Allen, King, & Hollander, 2003).

The overall BIS-11 assessment showed that AN-R, AN-BP and BN scored significantly higher than HC in the 'attentional' dimension, with no intergroup differences. The 'attentional impulsiveness' dimension was present in all ED groups except in BED, and was related to the 'attentional impairments'. This finding is in contrast with previous observations that described the 'food-related impulsiveness' as higher in BED patients than in HC (Hege et al., 2015) and in obese subjects without BED (Schag, Schönleber, Teufel, Zipfel, & Giel, 2013). In line with the literature, only BN and AN-BP patients (but not AN-R patients) scored significantly higher on the 'motor impulsiveness' subscale than HC, suggesting a proneness to 'behavioral impulsiveness' in bingeing/purging instead of restricting subjects (Hege et al., 2015). Again, the AN-BP patients shared more features in common with BN patients than with AN-R patients, namely a low response inhibition and the presence of frequent impulsive behaviors, as already described in previous studies (Adinoff et al., 2007; Waxman, 2009; Zalar, Weber, & Serneck, 2011).

Personality features, assessed with the TCI, showed that high levels of 'harm avoidance', and low levels of 'self directness' and 'cooperativeness' were equally represented among the four EDs groups, when compared to HC. Moreover, AN-R patients scored significantly higher than HC in the 'pessimism' and 'shyness' subscales of the 'harm avoidance' dimension, as already described in previous studies (the so-called 'anxious disposition') (Lindner, Fichter, & Quadflieg, 2012). The differences between AN-R and AN-BP/BN patients and the similarities between AN-BP and BN patients were confirmed by the TCI assessment. AN-R patients scored lower on 'novelty seeking' and higher on 'persistence' than BN patients. Again, the characteristics of AN-BP were intermediate between AN-R and BN. BED patients showed 'novelty seeking' total score significantly higher than AN-R patients, in line with previous observation (Krug et al., 2009).

To summarize, our study provided further support to the presence of decision-making deficits in the overall spectrum of EDs, except for BED. Poor decision-making in AN-R patients seemed mainly related to a cognitive style characterized by rigidity, meager ability in set-shifting and attentional impulsiveness. AN-BP and BN patients seemed to be impaired in decision-making by the tendency to novelty seeking, attentional impulsiveness, motor impulsiveness and non-planning

impulsiveness. Future studies should explore more thoroughly the connections of these different dimensions and temperaments with poor decision-making in ED patients, as they might inform therapeutic choices.

## Limitations

Main limitations of the study were the small sample size, and the cross-sectional design. Less relevant limitations were the differences between EDs and HC samples in terms of age, and the absence of a systematic assessment for psychopharmacological and psychotherapeutic treatments. These should be considered in future studies as possible confounding factors associated with decision-making deficits.

## Clinical Implications

The association between decision-making and impulsiveness with EDs suggests that they might represent clinically relevant phenomena and factors interfering with treatment outcome. This is raising question on the importance of specific tasks assessing such dimensions routinely in clinical settings, not only for research purposes. Thus, their potential uses might include the identification of patients at risk for future harmful behaviors leading to a better definition of specific psychological/psychopathological dimensions that could become treatment targets and response indicators.

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## Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee of the University of Pisa, Italy, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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