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Think twice: Impulsivity and decision making in obsessive–compulsive disorder

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Background and aims: Recent studies have challenged the anxiety-avoidance model of obsessive–compulsive disorder (OCD), linking OCD to impulsivity, risky-decision-making and reward-system dysfunction, which can also be found in addiction and might support the conceptualization of OCD as a behavioral addiction. Here, we conducted an exploratory investigation of the behavioral addiction model of OCD by assessing whether OCD patients are more impulsive, have impaired decision-making, and biased probabilistic reasoning, three core dimensions of addiction, in a sample of OCD patients and healthy controls. *Methods:* We assessed these dimensions on 38 OCD patients and 39 healthy controls with the Barratt Impulsiveness Scale (BIS-11), the Iowa Gambling Task (IGT) and the Beads Task. *Results:* OCD patients had significantly higher BIS-11 scores than controls, in particular on the cognitive subscales. They performed significantly worse than controls on the IGT preferring immediate reward despite negative future consequences, and did not learn from losses. Finally, OCD patients demonstrated biased probabilistic reasoning as reflected by significantly fewer draws to decision than controls on the Beads Task. *Conclusions:* OCD patients are more impulsive than controls and demonstrate risky decision-making and biased probabilistic reasoning. These results might suggest that other conceptualizations of OCD, such as the behavioral addiction model, may be more suitable than the anxiety-avoidance one. However, further studies directly comparing OCD and behavioral addiction patients are needed in order to scrutinize this model.

Keywords: OCD, behavioral addiction, impulsivity, decision making, probabilistic reasoning, neuroeconomics

INTRODUCTION

The stereotypical portrait of an obsessive–compulsive patient is an excessively self-controlled, risk aversive individual that acts in order to avoid potential loss or punishments. Although this portrait fits well with several clinical studies showing increased harm-avoidance in obsessive–compulsive disorder (OCD) (Kim, Kang & Kim, 2009), more recent clinical, neuropsychological and neuroimaging studies challenged this idea and described a different portrait of OCD.

First of all, several clinical studies suggest that impulsivity may be a feature of OCD (Benatti, Dell'Osso, Arici, Hollander & Altamura, 2013; Ettelt et al., 2007). Moreover, a recent study demonstrated excessive self-control (the capacity to delay rewards) only in obsessive–compulsive personality disorder (OCPD) patients, but not in OCD patients (Pinto, Steinglass, Greene, Weber & Simpson, 2013). In addition, several neurocognitive studies report risky decision-making (preference for an immediate reward despite negative future consequences) in both adults and children with OCD (Cavedini, Gorni & Bellodi, 2006; Cavedini, Riboldi, D'Annucci & Bellodi, 2002; Cavedini, Riboldi, Keller, D'Annucci & Bellodi 2002; Cavedini et al., 2012; Cavedini, Zorci, Piccini, Cavallini & Bellodi 2010; da Rocha, Alvarenga, Malloy-Diniz & Correa 2011; da Rocha, Malloy-Diniz, Lage & Correa 2011; da Rocha et al. 2008; Kodaira et al., 2012; Kashyap, Kumar, Kandavel & Reddy, 2013; Starcke, Tuschen-Caffier, Markowitsch & Brand, 2010). Also, studies on probabilistic reasoning failed to find that OCD patients had less confidence in their choices, or needed more information before reaching a decision compared to controls (Fear & Healy, 1997; Pelissier and O'Connor, 2002; Reese, McNally & Wilhelm, 2011; Jacobsen, Freeman & Salkovskis, 2012). Finally, recent neuroimaging studies showed reward dysfunction in OCD (Figee et al., 2011; Admon et al., 2012), similar to findings in disorders that are characterized by reduced impulse control and risk-seeking behaviours such as pathological gambling and substance dependence (Feil et al., 2010; Miedl, Peters & Büchel, 2012). Extra evidences come from D2 dopamine receptor binding studies that show a pattern of binding reduction in OCD patients similar to that found by other studies in addicted patients (Blum et al., 2014; Denys et al., 2013; Lee et al., 2009).

Increased impulsivity, risky decision-making and reward-system dysfunction in these studies conflict with the stereotypical OCD portrait of doubtfulness and risk-aversiveness. In fact, these findings are prototypical for addiction and have led some authors in the last years to view OCD as a behavioural addiction (Denys, Zohar & Westemberg, 2004;

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Figee et al., 2011; Grant, Brewer & Potenza, 2006; Holden, 2001). In this perspective, comparable to addiction, OCD is perceived as process, in which patients with OCD develop over time a dependency upon their compulsive behaviours because of the rewarding effect when performed perfectly or when compulsions reduce obsession-induced anxiety or distress (Denys, 2011). However, this model has never been tested thoroughly in OCD and it is therefore still a theoretical paradigm.

Impulsivity and risky decision-making have been linked to the development of substance and behavioural addictions (Grant & Chamberlain, 2014; Balogh, Mayes & Potenza, 2013). Moreover, biased probabilistic reasoning has been observed in substance use disorder, pathological gamblers, Parkinson's patients with medication-induced behavioural addictions and recently also in subjects with elevated risk for the development of alcohol addiction (Morris et al., 2015; Voon et al. 2015). Thus, these cognitive facets could be also relevant for the development of a dependency upon compulsions. The studies mentioned above assessed impulsivity (Trough the Barratt Impulsiveness Scale), decision-making (Trough the Iowa Gambling Task) and probabilistic reasoning (Trough the Beads Task) separately (Benatti et al., 2013; Cavedini et al., 2010; Jacobsen et al., 2012); no study examined all these domains at once in one OCD sample. Moreover, they included only small patient samples and they did not exclude patients with episodic OCD or with comorbid Axis I or II disorders (Jacobsen et al., 2012; Reese et al., 2011). Thus, the aim of the present study was to investigate the role of impulsivity, decision-making and probabilistic reasoning, as core dimensions of addiction, in a single sample of patients with a primary diagnosis of OCD. According to a behavioral addiction model of OCD, our hypothesis is that OCD patients show increased impulsivity, risky decision-making and biased probabilistic reasoning compared to healthy controls.

METHODS

Participants

We recruited 40 outpatients with OCD from the OCD unit of the University of Florence. We included only patients with a primary diagnosis of OCD, without comorbid mental disorders (except for chronic tic disorders) and with good insight into their disorder. The latter inclusion criterion was selected in order to avoid a putative effect of delusional beliefs on the probabilistic reasoning task. Inclusion criteria were established based on: 1) presence of DSM-IV criteria for OCD, established by a psychiatrist and confirmed by the Structured Clinical Interview for DSM-IV Axis-I Disorders/Patient Edition (SCID-I/P) (First, Spitzer, Gibbon & Williams, 2002a); 2) good insight, established by a psychiatrist and rated with the Yale-Brown Obsessive–Compulsive Scale (Y-BOCS) (score of 0 or 1 on the insight item) (Goodman, Price, Rasmussen, Mazure, Delgado et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischman et al., 1989); 3) age between 18 and 65 years. We excluded potential patients with any of the following conditions: 1) current DSM-IV Axis I diagnosis other than OCD and/or lifetime DSM-IV diagnosis of bipolar I or II disorder, schizophrenia or other psychotic disorders, substance abuse/dependence, Tourette's disorder; 2) any Axis II clinical diagnosis (established by a clinical interview conducted in accordance to the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II) flow-chart) (First, Gibbon, Spitzer, Williams & Benjamin, 1997); 3) episodic OCD; 4) illness duration less than two years; 5) hospitalization in the last 6 months; 6) pharmacological treatment changes in the last 3 months; 7) mental disorder due to a general medical condition or history of mental retardation.

We enrolled 40 healthy controls matched for gender, age and educational attainment, recruited by advertisements and word of mouth, with an age between 18 and 65 years, without a history of OCD or any other mental disorder, as confirmed by the SCID-I/NP (Non-patient Edition) (First, Spitzer, Gibbon & Williams, 2002b). Demographic variables of all subjects are displayed in Table 1. All study procedures occurred in 1 day.

Procedures and assessments

Clinical assessments. OCD symptoms and severity were assessed by independent evaluators using the Y-BOCS (range 0–40 with higher scores representing greater severity) and the Y-BOCS symptom checklist (Y-BOCS-SC) (Goodman, Price, Rasmussen, Mazure, Delgado et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischman et al., 1989). On the basis of the Y-BOCS-SC patients' primary symptoms were classified as one of five a priori dimensions: 1) doubt/checking; 2) contamination/cleaning; 3) symmetry/ordering; 4) unacceptable/taboo thoughts; 5) hoarding. The sub-classification on these a priori five dimensions was

Table 1. Sociodemographic variables and Barratt Impulsiveness Scale (BIS-11) mean scores and standard deviation (sd) for OCD patients and healthy controls

	OCD	Controls	*p*
Sex	39.47% F, 60,53% M	51.28% F, 48.72% M	0.298
Age	36.29 (sd 12.73)	34.10 (sd 11.18)	0.469
Years of education	14.63 (sd 2.69)	15.64 (sd 2.92)	0.085
BIS-11			
Attentional Impulsiveness	16.92 (sd 4.55)	14.33 (sd 3.31)	0.005
Motor Impulsiveness	21.10 (sd 4.93)	20.56 (sd 3.91)	0.751
Nonplanning Impulsiveness	27.18 (sd 5.11)	24.92 (sd 4.11)	0.035
BIS-11 Total Score	65.21 (sd 12.49)	59.82 (sd 8.34)	0.026

based on factor analysis performed on previous studies (Brakoulias et al., 2013). We also performed a clinical interview in order to assess social and demographic variables, duration of illness, current or past history of tics (two patients had a history of chronic tic disorder and five patients a past history of transient tic disorder), current pharmacological treatments (32 out of 38 patients were using serotonin reuptake inhibitors and/or atypical antipsychotics) and history of treatment resistance (defined as non-response (< 25% improvement in baseline Y-BOCS scores) to at least one adequate serotonin re-uptake inhibitor (SRI) trial (maximum recommended dose for at least 12 weeks) and non-response to a 16 sessions cognitive behavioral trial) (Pallanti et al., 2002). Clinical variables of OCD subjects are displayed in Table 2.

Impulsivity. Impulsivity traits were assessed using the Barratt Impulsiveness Scale, version 11 (BIS-11). This scale consists of 30 self-descriptive items, with responses in a four-point Likert-type scale ranging from "Rarely/Never" to "Almost Always/Always." (Patton, Stanford & Barratt, 1995). It measures the total score (range: 30–120) of impulsivity and three factors: Attentional Impulsiveness (AI), Motor Impulsiveness (MI), and Non-planning Impulsiveness (NPI) with higher scores indicating higher impulsivity. BIS-11 was used in its Italian translation (Fossati, Di Ceglie, Acquarini & Barratt, 2001).

Decision-making. To assess decision-making we used the Iowa Gambling Task (IGT), a card game that is widely used to study decision-making under risk (the probability of different outcomes are known) and ambiguity conditions (the probability of different outcomes are unknown) (Brand, Labudda & Markowitsch, 2007; Brand, Recknor, Grabenhorst & Bechara, 2007). Decision making behaviors on the IGT can separate "risky-players" that prefer immediate reward despite negative future consequences, from "risky-avoidant" players that prefer small but long-term rewarding choices (Cavedini et al., 2012). In the IGT the subject must make 100 card selections from four decks (A, B, C, and D) and the objective is the maximum profit. At the beginning of the test the subjects receive a loan of play-money. After turning over each card, subjects are either given money or asked to pay a penalty according to a programmed schedule of reward and punishment. Gains and losses are different for each deck. Decks A and B (disadvantageous decks) are high paying but disadvantageous in the long run, because the penalties are even higher. Decks C and D (advantageous decks), on the other hand, are low paying but advantageous because the penalties are lower, resulting in an overall gain in the long run. In this study we used a computerized version of the original IGT (Bechara, Damasio, Damasio & Anderson, 1994; Cois, 2007; Struglia et al., 2011; Tommasini et al., 2012). The performance was measured using the net score, defined by choices from advantageous (C and D) minus disadvantageous (A and B) decks, with higher scores indicating a risk-avoidant pattern of decision making. The net score for each block of 20 cards was also considered in order to evaluate the choice behavior during the task. We considered the 1st and 2nd blocks as decisions under ambiguity, due to the fact that the probability of outcome is unknown during these blocks of choices. On the other hand we considered the 3rd, 4th and 5th blocks as decisions under risk, due to the fact that subjects learn how the decks work during the first and second block and thus the probability of outcome is known during these blocks of choices (Brand, Labudda et al., 2007; Brand, Recknor et al., 2007).

Probabilistic reasoning. To assess biases in probabilistic reasoning, participants completed the beads task, an experimental task designed to examine individuals' reasoning style under conditions of uncertainty (Phillips & Edwards, 1966). Decision making behaviors on the beads task can separate normal subjects from "rash-decision makers" that are confident in their decisions, despite not having enough information. This task has a standard paradigm in which participants are required to judge from which jar (out of two) different colored beads are being drawn. One jar might contain 85 beads of one color (green) and 15 beads of another color (purple). The second jar contains the same number of beads, but with the reverse distribution (15 green and 85 purple). Participants – knowing a priori the distribution of beads in the jars – are shown a series of beads that are drawn one at a time from one of the two jars, with each bead being replaced in its original jar after the participant has seen it. Participants are required to indicate when they are confident enough to make a judgment on which jar the beads are being drawn from. A maximum of 20 beads were presented to each participant in each trial. If participants did not make a decision after 20 beads, the computer prompted them to do so. We implemented a computerized version of the beads task (Stratta et al., 2013) on the basis of literature evidence recommendations (Huq, Garety & Hemsley,

Table 2. OCD patients' clinical data

	Clinical data
YBOCS Total Score	21.79 (sd 6.48)
Illness duration (years)	18.24 (sd 12.76)
History of tic disorder (number of patients)	7/38 (18.42%)
Patients taking medications (SRIs or SRIs+ antipsychotics)	32/38 (84.21%)
Patients taking SRIs or SSRI+antipsychotics	5/38 (13.6%)–27/38 (71.05%)
History of treatment resistance (number of patients)	27/38 (71.05%)
Symptoms dimensions (number of patients per symptom dimension)	doubt/checking: 16/38 (42.1%)
	contamination/cleaning: 8/38 (21.05%)
	symmetry/ordering: 6/38 (15.79%)
	unacceptable/taboo thoughts: 7/38 (18.42%)
	hoarding: 1/38 (2.63%)

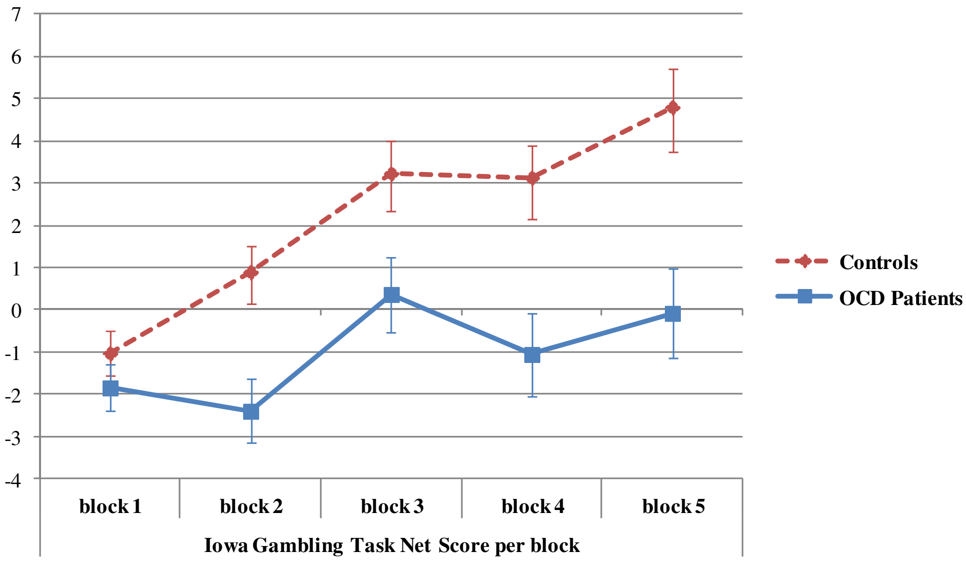

Figure 1. Net score's mean and standard error for each block for OCD patients and healthy controls

1988). The performance was measured, recording the number of beads requested before reaching a decision ("draws to decision"), as a measure of the amount of information needed to make a decision. According to previous studies we considered 1 or 2 draws to decision as the threshold for a biased probabilistic reasoning (Ormrod et al., 2012). In order to minimize the effects of a miscomprehension of both tasks (IGT and Beads Task), each trial was preceded by a pre-explanation of the task after which the participants had to prove their understanding of the tasks.

Statistical analyses

Normality of variables was evaluated using Shapiro-Francia W' test. Normally distributed variables in OCD and control group were: years of education, IGT Net Score1, IGT Net Score2, Net Score3, Net Score4, Net Score5, IGT final Net Score, BIS-11 Attentional factor, BIS-11 Non-planning factor subscores. Age and Number of draws in Beads task were non-normally distributed in both groups, BIS-11 Motor factor subscore was non-normally distributed in control group while BIS-11 Scale score and duration of illness were non-normally distributed in OCD group. In order to compare the two groups on socio-demographic and clinical variables, a $\chi 2$ test was used for gender and for proportion of subjects that made only 1 or 2 draws to decision in Beads task; *t*-test was used to compare continuous or interval normally distributed variables. Wilcoxon–Mann–Whitney test was used to compare continuous or interval non-normally distributed variables. Repeated measures ANOVA was used to assess IGT performance over time.

Pearson's correlation test was used to test the interaction between clinical variables (natural logarithm of duration of illness, presence of pharmacological treatment and history of treatment resistance, Y-BOCS score, symptom dimensions, history of tics) and natural logarithm of BIS-11 total score, IGT final Net Score, natural logarithm of Beads task draws to decision in the clinical group; we used natural logarithm due to non-normality of the variables 'BIS-11 total score' and 'Beads task draws to decision'.

Statistical tests were two-tailed. Level of significance was set at $p = 0.05$. Considering that we tested multiple hypotheses using the same variables with Pearson's correlation test, Hochberg's correction was applied. We used Hochberg's adjustment because it is less conservative and has more power than Bonferroni's (Blakesley et al., 2009). All analyses were carried out using STATA statistical software V.12.1 (StataCorp, Texas).

Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki. The study was approved by the Institutional Review Board of the University of Florence and all participants had to sign the informed consent to be included in the study.

RESULTS

The final sample was composed of 38 OCD patients (2 of the 40 recruited patients did not complete the assessment, 1 due to onset of headache during the assessment and 1 because he decided to quit the experiment after signing informed consent) and 39 healthy controls (1 of the 40 recruited healthy controls decided not to complete the assessment).

Impulsivity

Compared to healthy controls, patients had significantly higher total BIS-11 scores ($p = 0.0258$) and Non-planning ($p = 0.0354$) and Attentional ($p = 0.0055$) BIS-11 subscores (see Table 1).

Decision-making

Patients' performance on IGT (IGT final Net Score) was significantly worse than controls (–5 (sd 40.45) vs 11.03 (sd 27.71); $p = 0.046$) (see Table 3), indicating a preference for immediate gains despite future negative consequences in

Table 3. IGT net score per block, IGT Final net score and Beads Task draws to decision, mean and standard deviation (sd) in OCD patients and healthy controls. Percentage of subjects who drew 1 or 2 beads in OCD group and healthy controls group

	OCD	Controls	*p*
IGT (Iowa Gambling Task)			
IGT Net Score block 1	−1.84 (sd 6.68)	−1.02 (sd 6.68)	0.593
IGT Net Score block 2	−2.39 (sd 9.29)	0.90 (sd 7.83)	0.097
IGT Net Score block 3	0.37 (sd 10.96)	3.23 (sd 9.64)	0.227
IGT Net Score block 4	−1.05 (sd 12.16)	3.13 (sd 9.74)	0.099
IGT Net Score block 5	0.08 (sd 13.09)	4.79 (sd 11.40)	0.085
IGT Final Net Score	−5 (sd 40.45)	11.03 (sd 27.71)	0.046
Beads Task			
Draws to decision	3.76 (sd 4.54)	7.79 (sd 5.90)	0.000
Number of subjects who made 1 or 2 draws to decision	22/38 (57.89%)	8/39 (20.51%)	0.001

OCD patients compared to healthy individuals. We did not find a significant difference between patients and controls in the single blocks of choices or in performance under ambiguity (considering jointly the performance on the 1st and 2nd block of choices) or under risk (considering jointly performance on the 3rd, 4th and 5th block of choices), indicating that patients' performance was not influenced by the knowledge of outcomes' probability. We also compared IGT performance over time in each group in order to analyze decision pattern changes over the task: controls' performance significantly improved from the 1st block of choices to the last block ($F4, 152 = 3.00$, $p = 0.021$, η^2partial = 0.073), while patients' performance did not improve ($F4, 148 = 0.84$, $p = 0.501$, η^2partial = 0.022), indicating a lack of learning from negative outcomes (see Figure 1).

Probabilistic reasoning

Patients made significantly fewer draws to decision than healthy controls on the Beads Task (3.76 (sd 4.54) vs 7.79 (sd 5.90); $p = 0.0002$) and the proportion of subjects that made only 1 or 2 draws to decision (considered as the threshold for a biased probabilistic reasoning by previous studies) (Ormrod et al., 2012) was significantly higher in the OCD group (22/38: 57.89% vs 8/39: 20.51%; $p = 0.001$) (see Table 3 and Figure 2), indicating an overconfidence in decisions in patients.

Correlation analysis

Pearson product-moment correlation coefficients between clinical variables (symptom severity, illness duration, presence or history of tics, presence of medications, history of treatment resistance, symptom dimensions), natural logarithm of BIS-11 total score, IGT final Net Score and natural logarithm of Beads task draws to decision were not statistically significant.

DISCUSSION

In this study we conducted an exploratory investigation of the behavioral addiction model of OCD, by assessing three core dimensions of addiction in OCD patients. OCD patients demonstrate increased impulsivity, risky decision-making and biased probabilistic reasoning compared to healthy controls.

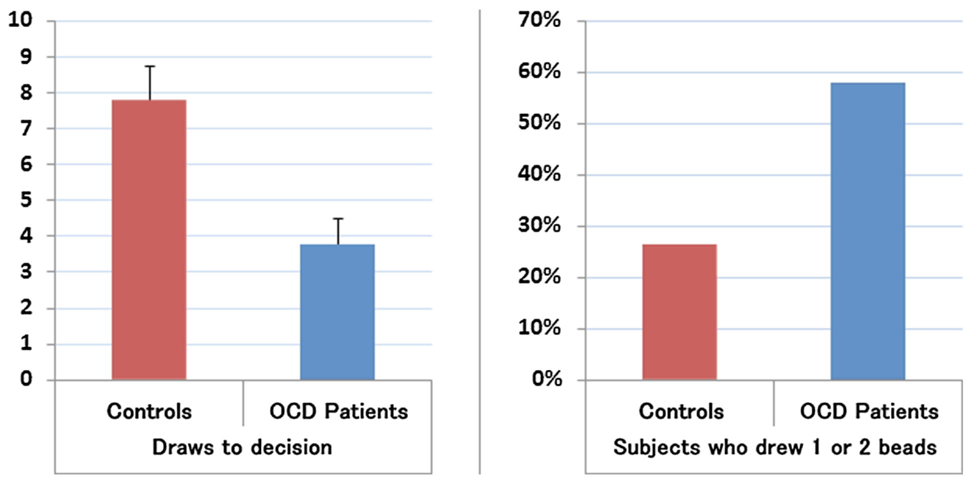

Figure 2. On the left the mean beads draws (and standard errors) for OCD patients and healthy controls. On the right the percentage of subjects who drew 1 or 2 beads in the OCD and the control group

A higher degree of impulsivity on the BIS-11 in OCD is consistent with other studies, showing that OCD patients are more impulsive than healthy controls (Benatti et al., 2013; Ettelt et al., 2007) and is in line with studies showing that disinhibition, which is a core dimension of impulsive behaviors, is central to OCD and may even represent a separate endophenotype (Fineberg et al., 2010). We found increased impulsivity score in particular in the BIS-11 Non-planning and Attentional domains, which is in line with previous studies (Benatti et al., 2013; Ettelt et al., 2007), confirming the predominance of cognitive impulsivity in OCD.

Our second finding, risky decision making on the Iowa Gambling Task in OCD patients compared to controls, is consistent with other studies showing an impaired performance on this task in patients with OCD relative to healthy controls (Cavedini et al., 2006; Cavedini, Riboldi, D'Annucci et al., 2002; Cavedini, Riboldi, Keller et al., 2002; Cavedini et al., 2012, Cavedini et al., 2010; da Rocha, Alvarenga et al., 2011; da Rocha, Malloy-Diniz et al., 2011; da Rocha et al. 2008; Kashyap et al., 2013; Kodaira et al., 2012; Starcke et al., 2010). Our OCD sample showed a preference for immediate rewards despite negative future consequences and did not learn from losses. Healthy controls at the beginning of the IGT usually are likely to choose from the disadvantageous decks, due to their higher rewards. However, they progressively switch to the advantageous decks after having learnt that avoiding the higher losses of disadvantageous decks results in obtaining greater long-term gains. This pattern of behavior, in which losses are more effective than rewards in orienting choices, has been extensively described as loss aversion and loss avoidance (Kahneman & Tversky, 1984, 1979). Accordingly, we found loss avoidance also in our healthy controls. However, OCD patients did not show any significant improvement during the task, implying that their choices were not oriented by loss avoidance. In contrary to some studies that used a different decision-making task (Starcke et al., 2010; Starcke, Tuschen-Caffier, Markowitsch & Brand, 2009) we did not find evidence for an impairment of decision making in ambiguous conditions relative to risky conditions. On the contrary, patients had greater impairments under risky conditions, which is consistent with some studies that used the IGT in OCD (Kodaira et al., 2012), suggesting that decision-making in OCD may be not related to the presence of an ambiguous situation. However, these observations are limited by the fact that the dissociation of decision-making process under ambiguity and risky conditions through the IGT is still debated and recent studies demonstrated different performances under risk in OCD, using different decision-making tasks (Kim et al., 2015).

Our third finding of biased probabilistic reasoning in OCD, e.g. fewer draws to decision on the Beads Task may reflect overconfidence and reflection impulsivity (Voon et al., 2015). Although this finding sounds paradoxical when thinking of the doubtfulness of a patient with checking symptoms, overconfidence and reflection impulsivity are two cognitive facets consistent with our and other studies that found increased cognitive impulsivity in OCD (Benatti et al., 2013, Ettelt et al., 2007). Moreover, more than 70% of patients included in the final sample had a history of treatment-resistance that has been linked to the presence of a higher degree of impulsivity traits in OCD patients by previous studies (Kashyap et al., 2012). Previous studies did not find different performance between OCD and healthy controls using this task (Fear and Healy, 1997; Pelissier and O'Connor, 2002; Reese et al., 2011). However, the present work differs from these studies as we included only pure OCD without co-morbidity (except for 2 patients with chronic tic disorder) and without an episodic illness course, since these characteristics may be related to disorders within the bipolar spectrum (Mahasuar, Janardhan & Math, 2011). In fact, OCD in bipolar-spectrum patients seems to occur significantly more often in the depressive phases of the disorder and anxiety disorders comorbidities (panic, agoraphobia, social anxiety and avoidant personality) are two times more frequent than in non-bipolar OCD (Amerio et al., 2014; Shashidhara, Sushma, Viswanath, Math & Janardhan Reddy, 2015). Thus, we can hypothesize that these facets of episodic-OCD could affect cognitive performances in a different direction with respect to chronic OCD.

Our results seem to support the conceptualization of OCD as a disorder of behavioral addiction. Indeed, many studies showed that addicted patients have higher impulsivity scores on the BIS-11 (Kjome et al., 2010; Verdejo-Garcia, Lawrence & Clark, 2008) and several studies showed that substance-addicted and pathological gamblers have the same pattern of risky decision making, i.e. a preference for immediate reward, despite negative future consequences on the IGT (Cavedini, Riboldi, D'Annucci et al., 2002; Cavedini, Riboldi, Keller et al., 2002; Lemenager et al., 2011; Tommasini et al., 2012) (but see also Choi et al., 2014; Dannon, Schoenfeld, Rosenberg, Kertzman, & Kotler, 2010). Furthermore, recent studies showed that detoxified-alcoholic patients and stimulant-dependent subjects showed a biased probabilistic reasoning on the Beads Task, similar to our results in OCD patients (Stratta et al., 2013; Voon et al., 2015).

Preference for immediate reward and impulsivity have been linked to substance addiction by neuroeconomic studies because of their capacity to motivate the behavior toward a substance (the immediate reward) despite its future negative consequences (Monterosso, Piray & Luo, 2012). Nevertheless, also compulsions represent an immediate reward (relieving anxiety) with future negative consequences (both in terms of time consuming and distress). Thus, in a behavioral addiction perspective, preference for immediate reward, cognitive impulsivity and overconfidence could also be relevant in the development of a dependency toward compulsions.

Several limitations are worth mentioning. One potential limitation is that we did not assess the Intelligence Quotients (IQs) of patients and controls. However, a large majority of the studies on IGT in both clinical and non-clinical samples showed a non-significant relationship between IQ and IGT performance (Toplak, Sorge, Benoit, West & Stanovich, 2010). Moreover, IQ did not affect Beads task's performance in other clinical samples (Ormrod et al., 2012). Finally, every participant of the study had to prove his comprehension of the tasks before starting the experiment and we excluded subjects with intellectual disability. Thus, it is unlikely that differences in IQs affected our results.

Another potential limitation is that we used a clinical interview to exclude the presence of personality disorders and not the SCID-II (First et al., 1997). Thus, we cannot rule out the hypothetical presence of some sub-threshold Axis II symptoms, mainly obsessive–compulsive personality traits, and its putative effect on the decision-making tasks. Moreover, our study is lacking of a behavioral measure of impulsivity that could detect more specifically than BIS-11 the presence of impulsive traits.

Regarding our inclusion/exclusion criteria, the exclusion of co-morbid psychiatric conditions may compromise the generalizability of the findings to the whole population of OCD patients. Thus, further studies including comorbid-patients are needed.

Finally, 32 out of 38 patients were using serotonergic and/or dopaminergic agents which might have influenced their performances since these neurotransmitters have been related to impulsivity and decision making (Cools, Robert & Robbins, 2008; Simon et al., 2013). However, our results on decision-making and impulsivity are consistent with previous studies on un-medicated OCD patients (Boisseau et al., 2012; Cavedini et al., 2012) and our regression analysis confirmed that medications did influence neither neurocognitive performances nor impulsivity scores.

Lastly, we can not directly clarify which component of the economic choice process is impaired in OCD, because we did not include in our methods a neurophysiological measure, such as transdermal conductance, during the decision-making task. Of note, other OCD models can account for our results on decision-making and probabilistic reasoning. Indeed, our results could be interpreted in terms of deficits of the inhibitory control system (mainly involving the medial parts of the frontal cortex structures) and of the executive functions (mainly involving the dorsal parts of the frontal cortex structures), respectively, as proposed by some authors (Friedlander & Desrocher, 2006).

CONCLUSIONS

In conclusion, OCD patients are more impulsive than healthy controls and demonstrate risky decision-making and biased probabilistic reasoning. These results might corroborate the novel conceptualization of OCD as a behavioral addiction and highlight the need of further systematic studies directly comparing behavioral addicted patients and OCD patients.

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Authors' contributions: GG and PS: study concept and design; SP, MF, DD, MM, AR: study supervision, paper writing and revising; LR: statistical analyses; DP: data collecting and database.

Conflict of interest: The authors declare no conflict of interest.

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