Reprinted from the German Journal of Psychiatry · http://www.gjpsy.uni-goettingen.de · ISSN 1433-1055

Cognitive Performance and Specific Deficits in OCD Symptom Dimensions: III. Decision-making and Impairments in Risky Choices

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Abstract

Objective: To investigate ambiguous and risky decision-making in obsessive–compulsive disorder (OCD) patients grouped according to established primary symptom dimensions. The difficulties of OCD patients in real-life quite often seem related to situations of decision-making, for example, whether to check the door or clean the house. Decision-making appears on the face of it impaired in the clinical OCD setting in the context of doubting and uncertainty.
Methods: The participants were administered the Iowa Gambling Task and the Cambridge Gambling Task, reputed to be established measures of ambiguous and risky decision-making respectively. Background measures included assessments with standard clinical and psychological questionnaires. The OCD patients (n=72) were grouped according to their primary symptom dimensions using the Dimensional Yale-Brown Obsessive–Compulsive Scale and compared with a healthy control group (n=66).
Results: Risky decision-making related to rationality was impaired for patients in the dimensions symmetry/order and sexual/religious, and the deliberation time to make a decision was particularly slow for patients in the dimensions safety and contamination. A deficit in ambiguous decision-making was found in patients showing aggressive and symmetry/order symptoms.
Conclusion: This study is believed to be the first to present selective deficits in different OCD symptom dimensions related to decision-making. The data confirm the necessary role of intact interactions between cognitive and emotional processing (German J Psychiatry 2011; 14: 13-25).

Keywords: Obsessive–compulsive disorder, symptom dimensions, decision-making, cognitive dysfunctions, anxiety

Received: 26.11.10
Revised version: 24.1.11
Published: 1.7.2011

Introduction

Recurrent and intrusive thoughts and rigid and stereotypical compulsive behaviors are core characteristics of obsessive–compulsive disorder (OCD; American Psychiatric Association, 2000). An ongoing debate about the nature of cognitive deficits thought to underlie the disorder's behavioral dysfunctions has elucidated few consistent findings (e.g, Kuelz et al., 2004). Decision-making, a cognitive process to evaluate environmental information in terms of rewards and punishments in order to select the right course of action for the benefit of the self and others, seems impaired in OCD. The role of uncertainty in decision-making has yet to be systematically investigated in OCD (Cavedini et al., 2006) and indecisiveness has even been posited to be a basic characteristic of OCD (Summerfeldt et al., 2004a). Worry is also thought to underpin difficulties making deci-

sions and there are attempts to conceptualize OCD as a disorder of decision-making (Sachdev & Malhi, 2005). Decision-making performance has revealed that OCD participants request more information about and spend more time deliberating over low-risk scenarios and OCD-relevant decisions compared to non-anxious controls (Foa et al., 2003). OCD patients request more information before making a decision and excessive worry and doubt could therefore mediate difficulties in decision-making (Foa et al., 2003; Milner et al., 1971). Several subjective experiences have been suggested to explain why OCD patients do not feel satisfied after a compulsive act is carried out and which seem important factors that trigger patients to perform the repetitive behaviors. For example, 'premonitory urges' (Leckman et al., 1993) and experiences of 'just right' (Leckman et al., 1994), 'not just right' (Coles et al., 2005), and 'incompleteness' (Summerfeldt et al., 2004b) are attempts to explain the dysfunctional behavior. The latter has recently been found to be most associated with patients in the dimension symmetry/order because they experience their actions and perceptions as incomplete (Ecker & Gönner, 2008). Prolonged deliberation before a decision is made and reward uncertainty in OCD have been linked to uncharacteristic orbitofrontal cortex (OFC) activity (Sachdev & Malhi, 2005). Therefore, why patients do not feel that their experiences and actions are right, lends itself readily to explain decision-making difficulties in OCD.

Traditionally, findings from neuroimaging studies show that decision-making irregularities in OCD are presumed to involve the OFC (e.g., Nielen et al., 2002). However, Cavedini et al. (2006, p. 12) rightly pointed out that different test techniques applied in decision-making demonstrated impaired functioning of the ventromedial prefrontal cortex (VMPFC). At present it remains unclear whether the OFC or the prefrontal cortex (PFC) is more involved in obsessive doubting and uncertainty as characteristics of decision-making in OCD. Therefore, studying decision-making behavior in OCD may stimulate further insight into the cognitive neurobiology of the disorder (Nielen et al., 2002). It is argued that a faulty information processing system in OCD (Dittrich et al., 2010a) can partly be explained by deficiencies in emotional processing associated with decision-making because of the strong involvement of the OFC in emotional processing. Consequently, two well established cognitive tasks assessing decision-making abilities in OCD, the Iowa Gambling Task (IGT; Bechara et al., 1994) and the Cambridge Gambling Task (CGT; Rogers et al., 1999), were employed in the present study. The former requires decisions that involve choices associated with different rewards and punishment and where the relevant outcomes remain hidden (ambiguous decision-making) whereas the latter relies on choices between contingencies that are presented in a readily comprehensible format (risky decision-making). However, recently it has been proposed that the IGT is thought to measure both ambiguous and risky decision-making (Brand et al., 2007; Lawrence et al., 2009) whereas the CGT probes decisions under risk only (Clark et al., 2008). The VMPFC is thought to mediate intact performance on the IGT (Bechara et al., 1998; Cavedini et al., 2006; Lawrence et al., 2009) whereas optimal performance on the CGT has been found to rely on the orbital PFC (Rogers et al., 1999). Furthermore, the possibility of probing OFC pathology in psychiatric disorders by administering decision-making tasks such as the CGT has also been suggested (Clark & Manes, 2004).

The neuropsychological performance in OCD on the IGT and the CGT has so far not yielded any concrete result patterns. On the IGT, both impairments (Cavallaro et al., 2003; Cavedini et al., 2002) and intact performance have been demonstrated relative to healthy controls (Lawrence et al., 2006; Nielen et al., 2002). The severity of OCD as measured by the Yale-Brown Obsessive–compulsive Scale (Y-BOCS; Goodman et al., 1989) as well as anxiety did suggest a poorer performance in the patient group as reported in Nielen et al. (2002). Compromised performance on the IGT has also been displayed in OCD patients who fail to respond to pharmacotherapy (Cavedini et al., 2002). So far, OCD patients have not been impaired on the CGT (Chamberlain et al., 2007a, b; Watkins et al., 2005). Interestingly, Tourette's syndrome patients were impaired in rational decisions on the CGT relative to a group of OCD patients and healthy controls (Watkins et al., 2005). The question of comorbidity and similarities in clinical symptoms between OCD and other psychiatric conditions will be addressed in the current study and specifically how this might be related to patients in different symptom dimensions. OCD patients that present with comorbid motor tics are often associated with the symptom dimensions obsession/checking and symmetry/order (Leckman et al., 1997; Mataix-Cols et al., 2005). Specifically it was predicted that patients in the dimension safety are more impaired compared to other symptom dimensions and the healthy controls in time taken to make decisions on the CGT. This is expected considering that they are potentially slow in executing decisions in relation to situations they find potentially dangerous. For the CGT, it was hypothesized that the OCD group and the healthy controls would show differences in decision-making performance in relation to the variable rational decisions.

Methods

Participants

There were 72 OCD patients (44 female, 28 male) meeting criteria for a DSM-IV-TR (American Psychiatric Association, 2000) diagnosis and 66 healthy controls (45 female, 21 male) who participated. Mean age in the OCD group was 41.8 years (standard deviation (SD) = 12.5) compared to 37.6 years (SD = 14.4) in the healthy control group. At the time of testing 65 OCD patients received selective serotonin reuptake inhibitor (SSRI) medication. The healthy participants who volunteered to take part were recruited from the University of Hertfordshire and the general Hertfordshire population by newspaper and posted advertisements.

The OCD patients were grouped into their primary symptom dimensions on the basis of their current primary obsessions and/or compulsions assessed by the Dimensional Yale-Brown Obsessive–compulsive Scale (DY-BOCS; Rosario-Campos et al., 2006). Further details of the recruitment procedure and the participants are described in Dit-

trich et al. (2010a). The following obsessive–compulsive (OC) symptom dimensions were established from the patient sample:

(1) obsessions about harm due to aggression/injury/violence/natural disasters predominantly to themselves including an urge to feel safe and protect the self and related compulsions (safety, n = 23).

(2) obsessions about harm due to aggression/injury/violence/natural disasters predominantly to family members and others and related compulsions (aggression, n = 7).

(3) obsessions about symmetry/'just-right' perceptions and compulsions to count or order/arrange (symmetry/order, n = 14).

(4) contamination obsessions and cleaning compulsions (contamination, n = 22).

(5) obsessions concerning sexual/moral/religious obsessions and related compulsions (sexual/religious, n = 6).

The study was approved by the Hertfordshire Partnership NHS Trust Local Research Ethics Committee, UK. Data in this manuscript were obtained according to the Helsinki Declaration.

Design

The experimental study used a mixed design, with the between-subjects factor group (OCD or OC symptom dimensions/healthy controls). For the IGT, the within-subject factors were card selection by condition (advantageous/disadvantageous) and block (disadvantageous card selections in block 1 to 5). For the CGT, the within-subject factors were ratio of colored boxes (6:4/7:3/8:2/9:1) and condition (ascending/descending) as a function of deliberation time to make a decision, rational decisions and points gambled.

Materials

The clinical and psychological testing measures and the two neuropsychological tasks administered in the current study are separately described below.

Clinical and psychological testing

A range of tests was applied to assess the clinical and psychological status (see details described in Dittrich et al., 2010a): Montgomery-Åsberg Depression Rating Scale (MADRS; Montgomery & Åsberg, 1979); State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983); Cognitive Assessment Instrument of Obsessions and Compulsions (CAIOC-18, 18-item version; Dittrich et al., 2010a, 2011a); Compulsive Personality Assessment Scale (CPAS; Fineberg et al., 2007); Sheehan Disability Scale (SDS; Sheehan et al., 1996); Locus of Control (LoC; Rotter, 1966); National Adult Reading Test (NART; Nelson, 1982).

Neuropsychological tasks

On the IGT the ability to balance immediate rewards against long-term negative consequences is assessed. The participants are presented with four decks of cards on a computer screen, named A, B, C and D. The task is to maximize profit on a loan of 2000 play money. In total, 100 card selections are made but the participants are not informed of this. One card at a time is selected from any of the four decks and participants are told that they can switch between the decks at any time and as often as they wish. In the long run, the four decks of cards are associated with monetary losses (decks A and B) and gains (decks C and D). The reward from selecting a card from decks A and B is 100, but on every 10 cards a heavy loss of 1250 is encountered, so the total net loss is 250. From decks C and D the participant gets 50 for each card selected, but the loss at every ten cards is only 250, and therefore the gain at every ten cards is in fact 250. Dependent measures were total number of disadvantageous (A and B) and advantageous (C and D) cards selected and the pattern of responding over five blocks to establish whether the decision-making process was random or deliberate.

The CANTAB (Cambridge Cognition, 2006) CGT is a decision-making task that requires the participants to decide whether a yellow token is hidden behind a red or a blue box by using a touch screen and to bet a certain amount of their current points total. The proportion of red and blue boxes is varied over the course of the task between 6:4, 7:3, 8:2 and 9:1. For example, the 6:4 (red:blue boxes) ratio would indicate that there is a 60% chance for the yellow token to be hidden behind the red box. The bet options are either presented sequentially in an ascending or descending order. In the ascending order the bets are presented as 5%, 25%, 50%, 75% and 90% of total points collected whereas in the descending condition the order of bets presented is reversed. Participants play four game blocks, each consisting of eight betting trials in both the ascending and descending conditions. At the start of each block, the participants are given 100 points and if during the block the total points drop to one (1) the current block ends and the remaining blocks in that condition cannot be completed. The next block in the other condition (ascending or descending) is subsequently presented. Comparison of ascending and descending conditions enables impulsive behavior to be separated from genuine risk-taking behavior (genuine risk takers must inhibit motor responding for many seconds in the ascending condition waiting for the bets to increase and the opposite behavior must be displayed in the descending condition). Key measures include percentage of rational decisions, percentage of points gambled when the most likely outcome was chosen (rational decision) and deliberation time to choose the most likely outcome. The three variables may each interact with the ratio of red and blue boxes. At the 9:1 ratio, participants should pick the likely outcome more consistently, be more confident in the decisions and hence bet more, and may deliberate less, in comparison with trials at the 6:4 ratio. The presentation of the ascending and descending conditions was counterbalanced such that half the participants were given the ascending condition first and the other half started with the descending condition first.

Procedure

On the day of testing during the clinical interview the patients were screened with the Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998) to exclude past and present history of mental problems. During the same session, ratings of OCD severity (Y-BOCS), depression (MADRS), OC personality (CPAS), predicted verbal IQ (NART) and the primary OC dimensional symptom profiles of the patients were established (DY-BOCS). The self-rated background questionnaires STAI, CAIOC, SDS and the LoC were either completed on the day of recruitment or at home and posted back using a pre-paid envelope. The healthy control participants were assessed with the MINI and rated on clinical measures (Y-BOCS, MADRS, CPAS) and the NART. The self-rated clinical and psychological measures (STAI, CAIOC, SDS, LoC) were completed on the day of testing. The neuropsychological tasks were administered in a quiet room in the hospital clinical or at the University of Hertfordshire.

Data Analysis

The data were analyzed using the Statistical Package for the Social Sciences version 16.0 (SPSS Inc., 2008). The categorical variables gender and handedness were subject to Pearson chi-square analyses. The data from the clinical and psychological measures were analyzed with independent-samples t tests (OCD and healthy control group) and one-way analysis variance (ANOVA; patients in OC symptom dimensions and healthy control group). The data from the neuropsychological task performance were submitted to repeated-measures ANOVA, one-way ANOVA and independent-samples t test. Post-hoc least significant difference tests were performed to follow up main effects. The partial eta squared (η^2_p) was used as an effect size measure, which indicates the proportion of total variability attributable to a factor. A η^2_p of .01 is considered a small effect size, .059 a medium effect size and ≥ .138 a large effect size (Cohen, 1988). The error bars in figures represent the standard error of the mean. In the OCD group, correlations between the Y-BOCS, MADRS, STAI-state, STAI-trait, CAIOC and the neuropsychological task measures were examined using Pearson product-moment correlation.

Results

Demographic, clinical, and psychological background measures

Patients in the symptom dimensions and the healthy control group did not differ in gender, handedness, age, years in formal education, and predicted verbal IQ, while, as expected, patients in all symptom dimensions had significantly higher scores on the clinical measures compared to the healthy controls ($p < .01$ for all, Table 1). On the LoC, the healthy control group selected fewer external control of event statements compared to patients in the dimensions aggression ($p = .016$), symmetry/order ($p = .032$), and sexual/religious ($p = .032$). In OCD severity, patients with aggression symptoms had significantly higher scores compared to patients in the dimensions symmetry/order ($p = .050$) and sexual/religious ($p = .015$) and marginally higher than patients with safety concerns ($p = .053$). On the CAIOC it was revealed that patients in the dimension sexual/religious were significantly less impaired compared to patients in the dimensions aggression ($p = .038$) and symmetry/order ($p = .037$). Psychosocial (SDS) impairment was significantly higher in patients with symmetry/order compared to sexual/religious symptomatology ($p = .046$).

IGT – OCD and healthy controls

The difference in the number of cards selected from the disadvantageous (A and B) and advantageous (C and D) card decks was compared between the OCD and the healthy control group. Results revealed that the two groups drew the similar number of cards from the disadvantageous (OCD: Mean (M) = 48.8, SD = 13.3; controls: M = 48.3, SD = 15.4) and advantageous card decks (OCD: M = 51.2, SD = 13.3; controls: M = 51.7, SD = 15.4). Further, the total of 100 cards selected was sub-divided into five blocks of 20 cards to examine the pattern of decision-making responses over time. For each block the number of disadvantageous card selections was used as the dependent variable. The mean number of disadvantageous card selections for each of the five blocks in the healthy control and OCD group is displayed in Figure 1.

The number of disadvantageous card selections per block revealed a main effect for block, $F (4, 133) = 8.247$, $p < .001$, $\eta^2_p = .199$, indicating that both groups shifted their preference from the disadvantageous to the advantageous card decks over time. A group and block interaction was also identified, $F (4, 133) = 2.810$, $p = .028$, $\eta^2_p = .078$. The group differences at each block were analyzed with independent samples t-tests. In block one, there was a trend towards a group difference because the OCD patients (M = 11.3, SD = 3.2) selected more disadvantageous cards compared to the healthy controls (M = 10.3, SD = 3.6), $t (136) = 1.710$, $p = .089$.

IGT – symptom dimensions and healthy controls

The mean numbers of disadvantageous card selections in the five blocks for patients in the symptom dimensions and the healthy control group are displayed in Table 2.

The performance over the five blocks revealed a main effect for block, $F (4, 129) = 8.444$, $p < .001$, $\eta^2_p = .207$ and a group and block interaction, $F (20, 528) = 1.714$, $p = .028$, $\eta^2_p = .061$. To examine the interaction one-way ANOVAs were conducted. The result for disadvantageous card selections in block 2 was approaching significance (see Table 2), $F (5, 132) = 2.144$, $p = .064$. Post hoc analysis revealed that patients in the dimension aggression selected significantly fewer disadvantageous cards compared to patients in the dimensions safety ($p = .014$), symmetry/order ($p = .011$) and contamination ($p = .016$) whereas the performance against the healthy control group was marginally significant ($p = .059$). Furthermore, paired-samples t tests were conducted separately for each symptom dimension to investigate

Table 1. Clinical and psychological characteristics for patients in the OC symptom dimensions (SA, safety; AG, aggression; SO, symmetry/order; CO, contamination; SR, sexual/religious) and the healthy control group (HC)

	SA (n = 23)		AG (n = 7)		SO (n = 14)		CO (n = 22)		SR (n = 6)		HC (n = 66)		
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F-value
Age	43.4	12.8	39.4	15.6	40.9	14.7	41.3	10.7	42.2	11.8	37.6	14.4	n.s.
Education	3.9	2.4	2.6	2.7	4.1	3.8	4.0	2.9	2.7	2.6	4.0	2.0	n.s.
Verbal IQ	114.2	2.7	115.4	4.0	115.0	6.3	116.6	6.4	115.0	3.9	115.8	5.9	n.s.
Y-BOCS	18.7	6.3	23.3	8.2	18.3	8.2	20.0	8.3	15.8	3.6	2.3	2.0	67.560***
MADRS	13.0	7.4	17.1	8.4	15.8	8.6	12.9	6.8	11.2	5.1	3.3	2.9	24.697***
STAI-state	51.7	15.3	52.0	13.9	50.4	15.7	51.2	13.4	51.8	10.6	32.5	10.0	15.843***
STAI-trait	56.0	11.6	58.7	11.1	54.6	14.9	56.2	9.8	55.3	3.4	36.7	9.5	23.357***
CAIOC	60.7	16.4	66.9	14.8	64.4	23.3	61.3	21.3	47.0	13.6	28.4	14.4	26.511***
CPAS	13.3	5.5	17.0	5.2	15.9	5.4	14.8	6.5	11.7	4.2	6.0	3.3	24.392***
SDS	15.8	6.8	16.1	7.2	17.5	8.5	16.3	8.0	11.3	3.1	3.6	4.8	27.816***
LoC	12.7	3.7	15.0	4.1	13.9	3.1	13.1	4.1	14.8	3.2	11.7	3.1	2.646*

Note. CAIOC-18, Cognitive Assessment Instrument of Obsessions and Compulsions; CPAS, Compulsive Personality Assessment Scale; LoC, Locus of Control; MADRS, Montgomery-Åsberg Depression Rating Scale; SD, Standard Deviation; SDS, Sheehan Disability Scale; STAI, State-Trait Anxiety Inventory; Y-BOCS, Yale-Brown Obsessive–Compulsive Scale; df (one-way ANOVA) = 5,132; ***p < .001; *p < .05

Table 2. Means (M) and standard deviations (SD) in the OC symptom dimensions (SA, safety; AG, aggression; SO, symmetry/order; CO, contamination; SR, sexual/religious) and the healthy control group (HC) for disadvantageous card selections by block on the IGT

	SA (n = 23)		AG (n = 7)		SO (n = 14)		CO (n = 22)		SR (n = 6)		HC (n = 66)			
Variable	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	F-value	η^2_p
Block 1	11.7	4.2	11.4	2.8	11.3	1.9	11.4	2.4	9.5	4.9	10.3	3.6	<1	.036
Block 2	11.2	4.9	6.1	5.2	11.7	4.6	11.1	3.8	8.0	6.9	9.7	4.6	2.144	.075
Block 3	10.1	5.5	6.6	3.3	8.1	4.0	8.1	3.7	7.3	4.5	9.4	4.3	1.317	.048
Block 4	10.4	4.8	11.9	5.7	10.6	3.8	8.6	3.7	9.2	3.9	9.5	4.2	<1	.034
Block 5	8.4	5.3	7.6	5.3	8.7	4.1	8.0	4.3	10.7	6.5	9.5	4.6	<1	.026

Note. df (one-way ANOVA) = 5,132

Table 3. Means (M) and standard deviations (SD) in the OC symptom dimensions (SA, safety; AG, aggression; SO, symmetry/order; CO, contamination; SR, sexual/religious) and healthy control group (HC) for the CGT task measures

	SA (n = 22)		AG (n = 6)		SO (n = 13)		CO (n = 21)		SR (n = 5)		HC (n = 64)			
Variable	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	F-value	η^2_p
Rational 6:4 (%)	87.2	21.0	90.6	11.0	80.3	30.7	89.9	16.0	81.3	28.3	94.1	9.4	2.066	.076
Rational 7:3 (%)	89.8	17.0	91.7	17.5	80.3	35.0	92.0	12.5	78.8	31.1	94.7	9.6	2.264*	.083
Rational 8:2 (%)	94.3	15.7	89.6	20.0	88.9	23.8	94.1	13.0	77.5	37.1	96.4	7.3	2.075	.077
Rational 9:1 (%)	97.5	5.6	97.3	5.0	91.7	16.7	97.4	5.8	89.1	10.9	98.4	3.3	3.436**	.121
Deliberation 6:4 (ms)	2861	1100	2266	775	2323	987	2794	958	2661	580	2351	859	1.633	.061
Deliberation 7:3 (ms)	2667	753	2144	512	2434	1083	2710	941	2597	786	2213	691	2.069	.076
Deliberation 8:2 (ms)	2490	909	2199	400	2118	610	2529	827	2598	792	1989	579	3.280**	.116
Deliberation 9:1 (ms)	2394	706	1986	242	2304	684	2351	760	2343	539	1949	658	1.911	.073
Points gambled 6:4 (%)	36.0	18.6	55.2	20.1	47.2	26.1	52.8	18.1	48.4	13.7	47.7	13.7	2.608*	.094
Points gambled 7:3 (%)	46.9	16.3	62.9	17.7	53.4	27.0	58.8	17.0	52.0	11.8	58.2	14.2	1.998	.074
Points gambled 8:2 (%)	57.2	17.9	67.4	21.1	67.6	18.9	66.2	14.2	58.6	13.4	67.0	14.2	1.604	.060
Points gambled 9:1 (%)	66.6	19.1	66.5	19.1	75.2	19.2	72.5	15.0	66.0	24.6	71.6	15.9	<1	.025

Note. ms, milliseconds; df (one-way ANOVA) = 5,125; **p < .01; *p < .05

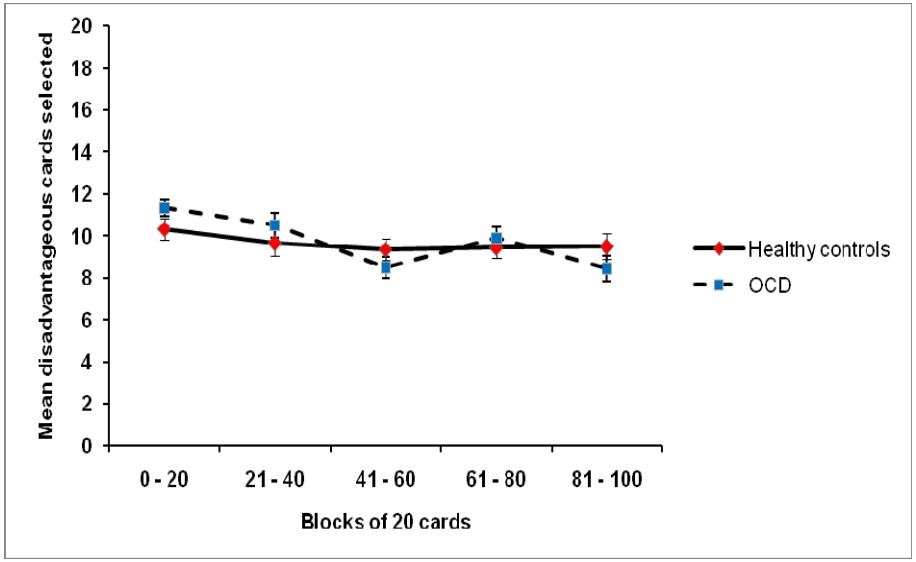

Figure 1. Mean number of disadvantageous card selections for each block in the healthy control and OCD group

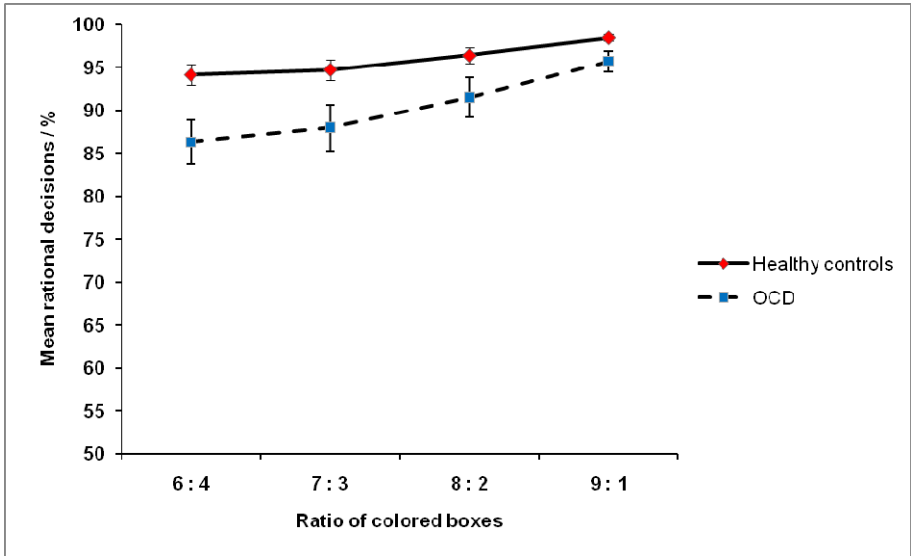

Figure 2. Mean percentage of rational decisions as a function of the ratio of red and blue boxes in the healthy control and OCD group

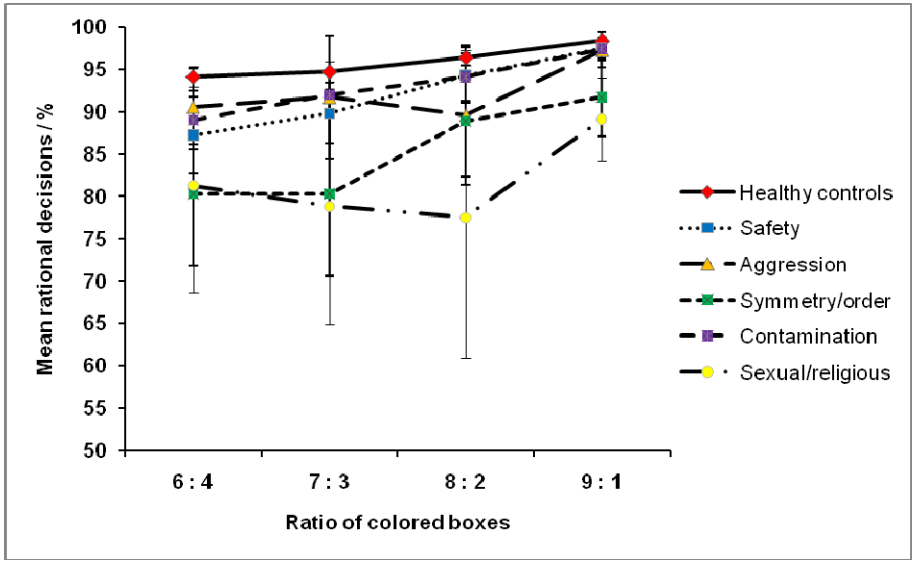

Figure 3. Mean percentage of rational decisions as a function of the ratio of red and blue boxes in the healthy control group and patients in the OC symptom dimensions

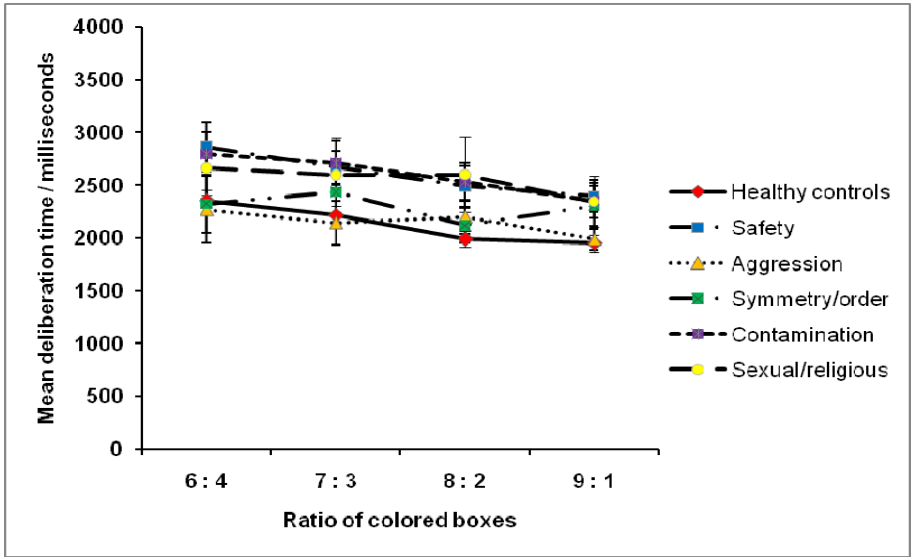

Figure 4. Mean deliberation time (milliseconds) as a function of the ratio of red and blue boxes in the healthy control group and patients in the OC symptom dimensions

whether the number of disadvantageous card selections differed between the blocks (Table 2). Results indicated that patients in the dimension safety selected a significantly higher number of cards from the bad card decks in block 1 compared to block 5, t (22) = 2.812, p = .010; patients in the dimension aggression chose a significantly higher number of cards from the bad card decks in block 1 compared to blocks 2, t (6) = 2.438, p = .050 and 3, t (6) = 3.232, p = .018; patients in the dimension symmetry/order selected a significantly higher number of cards from the bad card decks in block 1 compared to 3, t (13) = 2.990, p = .010 and 5, t (13) = 2.665, p = .019 as well as in block 4 compared to 5, t (13) = 2.535, p = .025 and patients in the dimension contamination chose a significantly higher number of cards from the bad card decks in block 1 compared to blocks 3, t (21) = 4.035, p = .001, 4, t (21) = 3.369, p = .003 and 5, t (21) = 3.876, p = .001.

Rational decisions, CGT – OCD and healthy controls

For this type of analysis data for five OCD and two healthy control participants were either not collected or were unusable due to technical errors.

Rational decisions are characterized by the ability of participants in choosing the most likely outcomes. The percentage of rational decisions in the ascending and descending conditions at the different color ratios revealed a main effect for color ratio, F (3, 127) = 11.874, p < .001, η^2_p = .219 indicating that participants made more rational decisions at the more favorable ratios of red and blue boxes. The OCD patients made significantly fewer rational decisions than the healthy control group at the color ratios 6:4, (t (129) = 2.692, p = .008, 7:3, t (129) = 2.291, p = .024 and 9:1, t (129) = 2.194, p = .030 and marginally fewer at the color ratio 8:2, t (129) = 1.906, p = .059 (see Figure 2).

Deliberation time, CGT – OCD and healthy controls

Deliberation time is associated with how long time the participants need to decide whether the yellow token is hidden behind a blue or a red box. The deliberation time in the ascending and descending conditions at the different color ratios revealed a main effect for color ratio, F (3, 127) = 14.857, p < .001, η^2_p = .260 indicating that participants had shorter deliberation times at the more favorable ratios of colored boxes. The OCD patients deliberated significantly longer than the healthy controls before making a decision at the color ratios 7:3 (OCD: M = 2583 milliseconds (ms), SD = 865; controls: M = 2213 ms, SD = 691), t (129) = 2.695, p = .008, 8:2 (OCD: M = 2412 ms, SD = 786; controls: M = 1989 ms, SD = 579), t (129) = 3.496, p = .001 and 9:1 (OCD: M = 2290 ms, SD = 671; controls: M = 1949 ms, SD = 658), t (129) = 2.938, p = .004 and marginally longer at the color ratio 6:4 (OCD: M = 2667 ms, SD = 981; controls: M = 2351 ms, SD = 859), t (129) = 1.960, p = .052.

Points gambled, CGT – OCD and healthy controls

The amount of points risked in order to increase the total amount of scores is associated with points gambled. The percentage of points gambled in the ascending and descending conditions at the different color ratios revealed a main effect for color ratio, F (3, 127) = 67.841, p < .001, η^2_p = .616, indicating that participants placed higher bets on more likely outcomes, and a main effect for condition, F (1, 129) = 134.828, p < .001, η^2_p = .511, indicating that participants placed higher bets in the descending condition compared to the ascending (Figure not shown). Independent-samples t tests confirmed that the groups did not differ in the percentage of points gambled at the different color ratios (6:4 - OCD: M = 46.1, SD = 20.8; controls: M = 47.7, SD = 13.7; 7:3 - OCD: M = 53.7, SD = 19.2; controls: M = 58.2, SD = 14.2; 8:2 - OCD: M = 63.1, SD = 17.2; controls: M = 67.0, SD = 14.2; 9:1 - OCD: M = 70.1, SD = 18.2; controls: M = 71.6, SD = 15.9).

Rational decisions, CGT – symptom dimensions and healthy controls

The means and standard deviations for rational decisions, deliberation time and points gambled for patients in the symptom dimensions and healthy control group are displayed in Table 3. For rational decisions (see Figure 3 and Table 3), results revealed a main effect for color ratio, F (3, 123) = 7.950, p < .001, η^2_p = .162, indicating that participants made more rational decisions at the more favorable ratios of red and blue boxes. A one-way ANOVA for the 6:4 ratio was approaching significance, F (5, 125) = 2.066, p = .074. Post hoc analysis revealed that patients in the dimension symmetry/order were less rational than the healthy controls (p = .007). The ANOVA for the 7:3 ratio was marginally significant, F (5, 125) = 2.264, p = .052 and post hoc tests revealed that the healthy controls were significantly more rational compared to patients in the dimensions symmetry/order (p = .005) and sexual/religious (p = .042) and in addition patients in the dimension contamination performed significantly better than patients in the dimension symmetry/order (p = .050). The ANOVA for the 8:2 ratio was also approaching significance, F (5, 125) = 2.075, p = .073, and post hoc analysis revealed that patients in the dimension sexual/religious were significantly less rational compared to patients in the dimensions safety (p = .021), contamination (p = .023) and the healthy control group (p = .006). The ANOVA for the 9:1 ratio was significant, F (5, 125) = 3.436, p = .006 and post hoc tests revealed that patients in the dimensions sexual/religious and symmetry/order made significantly fewer rational decisions compared to patients in the dimensions safety (p = .015 and p = .017 respectively), contamination (p = .017 and p = .021 respectively) and the healthy controls (p = .004 and p = .002 respectively).

Deliberation time, CGT – symptom dimensions and healthy controls

For deliberation time (see Figure 4 and Table 3), results revealed a main effect for color ratio, F (3, 123) = 6.016, p =

.001, η^2_p = .128, indicating that participants deliberated shorter at the more favorable ratios. Post hoc analysis (6:4 ratio) revealed that patients in the dimension safety deliberated significantly longer compared to the healthy control group (p = .027) and patients in the dimension contamination deliberated marginally longer than the healthy controls (p = .058). The ANOVA for the 7:3 ratio was approaching significance, F (5, 125) = 2.069, p = .074, the ANOVA for the 8:2 ratio was significant, F (5, 125) = 3.280, p = .008 and the ANOVA for the 9:1 ratio was approaching significance, F (5, 125) = 1.981, p = .086. Post hoc analysis for all three color ratios revealed that patients in the dimensions safety and contamination deliberated significantly longer prior to choosing the most likely outcome compared to the healthy controls (7:3 - p = .021 and p = .013 respectively; 8:2 - p = .004 and p = .002 respectively; 9:1 - p = .039 and p = .019 respectively).

Points gambled, CGT – symptom dimensions and healthy controls

For points gambled (see Table 3), a main effect for color ratio was identified, F (3, 123) = 28.295, p < .001, η^2_p = .408, indicating that participants placed higher bets on more likely outcomes, and a main effect for condition, F (1, 125) = 73.515, p < .001, η^2_p = .370, indicating that participants placed higher bets in the descending condition compared to the ascending. A one-way ANOVA for the 6:4 ratio was significant, F (5, 125) = 2.608, p = .028 and the ANOVA for the 7:3 ratio was approaching significance, F (5, 125) = 1.998, p = .083. Post hoc analysis revealed that patients in the dimension safety gambled significantly fewer points compared to the patients in the dimensions aggression, contamination and the healthy controls (6:4 - p = .016, p = .002 and p = .006 respectively; 7:3 - p = .038, p = .020 and p = .007 respectively). Post hoc tests (8:2 ratio) revealed that patients in the dimension safety risked significantly fewer points compared to the healthy controls (p = .012).

Correlation analysis

In the OCD group, correlations were performed to examine the relationship between the performance on the decision-making tasks and the clinical variables. On the CGT, there was a significant positive correlation between Y-BOCS and points gambled at the 9:1 color ratio, r (67) = .27, p = .028 and a significant negative correlation between CAIOC and rational decision at the 9:1 color ratio, r (67) = - .27, p = .037. Significant negative correlations were also found between deliberation times at all the color ratios and rational decisions at all the color ratios (range: - .29 (p = .019) to - .57 (p < .001), n = 67).

Discussion

The results of this study demonstrated that the OCD patients were impaired in rational decision-making and deliberation time to make a decision, whereas the number of points risked on the decisions was intact. Patients in the dimensions symmetry/order and sexual/religious were impaired in rational decision-making and patients in the dimensions safety and contamination were impaired in time taken to make a decision. Patients with safety concerns bet significantly reduced amounts of points on their decisions. Deliberation time in patients with safety concerns was impaired as predicted.

The impairment in rational decision-making in the OCD group is in contrast to Watkins et al. (2005), reporting intact performance in OCD patients but confirmed impairments in rational decision-making in Tourette's syndrome patients. Inhibitory control mechanisms appear dysfunctional in both disorders (Watkins et al., 2005) and may explain why these patients are unable to make rational decisions. Intact performance on the CGT in OCD was also found in Chamberlain et al. (2007a, b). Therefore, in extension to the previous studies the current findings indicate impairments in decision-making related to rational gambling behavior in OCD. Most of the patients were on selective serotonin reuptake inhibitor medication and the difficulties in decision making could even have been worse if the present investigation had been performed with unmedicated patients (e.g., Cavedini et al., 2002).

Furthermore, it was found that the OCD patients were not impaired on the IGT, which confirms previous results (Lawrence et al., 2006; Nielen et al., 2002). However, there were indications that patients in the dimension aggression performed superior in block 2 compared to patients in the dimensions safety, symmetry/order and contamination, but in block 4 patients in the dimension aggression seem to have switched their response pattern away from the good decks. However, when examining in more detail the frequency of disadvantageous card selections in all five blocks in the different symptom dimensions, it becomes evident that only patients in the dimensions safety and contamination similar to the healthy control participants appear to shift the selection of cards deliberately from bad decks to good decks over the course of the task. In contrast, patients in the dimensions aggression, symmetry/order and sexual/religious seem to draw cards randomly from different card decks, switching between good and bad decks, without a strategic preference over time for the good decks. Therefore, the performance in these patients (in particular symmetry/order and aggression) does not appear to be deliberate and conscious but more as a results of trial and error. The intact performance in patients with contamination fear on the IGT confirms an earlier finding and hoarders remain therefore the only patient dimension demonstrating deficits (Lawrence et al., 2006).

The impairment for patients in the dimension sexual/religious in rational decision-making on the CGT appeared to be particularly unusual, because of the impaired performance at the different color ratios. The obsessional thoughts in these patients often revolve around making judgments about morally and ethically right and wrong behaviors. The current deficit for rational choices seem to reflect impairments in affective cognitive decision-making, which may explain the faulty information processing related to these patients' obsessional fears. The patients in the dimension symmetry/order did also display deficits in rational decision-making behavior for almost all color ratios. It may

well be that symmetrical and perfectionist responses could have influenced the detrimental performance because of an inability to focus on the right aspect of the task. Their cognitive style appears therefore dysfunctional and these patients together with patients in the dimension sexual/religious may not have been aware of the different contingencies due to deficits in attention for particular details of the task.

The current study seems one of the first to comprehensively assess different aspects of decision-making behavior in OCD. The lack of differences on the IGT between groups and selective impairments on the CGT highlight specific characteristics of each task. The IGT is thought to measure decision-making related to ambiguous choices despite that it was originally launched as a measure of risky decision-making (Bechara, 2007), whereas the CGT is related to risky gambling behavior only (Clark et al., 2008). Recently, the IGT has been criticized for the ambiguities of what aspects of decision-making it measures (risky, ambiguous or both) and it is unclear how personality and state mood could affect performance (Buelow & Suhr, 2009). In line with these arguments it has been claimed that the early card selections on the IGT are associated with ambiguous decision-making whereas the last half of the blocks relates to decision-making under risk (Brand et al., 2007). This is suggested because during the early stages of the task participants have not had the time to experience the win/loss contingencies for the deck choices and this is in contrast to the last half of the task where these contingencies should have been picked up through winning (good decks) and losing (bad decks). Brand and colleagues (2007) further argue that the dividing line between where ambiguous card selections become risky during the game is not clear-cut. In addition, poor performance on the IGT may be due to a preference for immediate high rewards (impulsivity), a preference for reward irrespective of punishment (losses) or it could be due to problems with reversal learning, set-shifting or working memory (Clark & Manes, 2004). Recently, a group of OCD patients was found to be impaired on the IGT (Starcke et al., 2010) but not the Game of Dice Task, developed by Brand et al. (2005), which assesses risky decision-making. Risky decision-making has been found to correlate with executive task performance (Wisconsin Card Sorting Test) both in OCD patients and in healthy controls whereas in healthy participants only the IGT performance seemed to correlate with executive task performance and dorsolateral PFC activity (Starcke et al., 2010). In the current study the proposed problem between ambiguous and risky choices on the IGT seems to have been accounted for because decision-making by block performance was investigated and a dysfunctional strategy of card selections was indeed found for patients in the dimensions aggression and symmetry/order. This finding highlights the fact that the specific characteristics of the symptom dimension performance cannot be revealed if overall summary results for each task are analyzed and which are often reported in the literature (e.g., Chamberlain et al., 2007a, b). The present findings confirm that only a detailed analysis of result patterns will indicate these differences which can be interpreted as the evidence for different cognitive specificity according to specific task characteristics (e.g., Dittrich et al., 2011b; Henderson & Dittrich, 1993).

An important question seems the extent to which the performance on the IGT and the CGT depends on executive processes such as planning, cognitive flexibility and working memory (Clark & Manes, 2004). The IGT also taps the executive processes of working memory and strategy learning (Clark & Manes, 2004; Hinson et al., 2002) and neuroimaging and lesion studies have revealed widespread involvement of frontal regions (Manes et al., 2002). In contrast, the CGT seems to be a more one-sided task without implicating working memory as in each trial exclusive information is available, and mainly depending on ventral PFC involvement (Clark & Manes, 2004). However, here it is proposed that in the case of a gain/loss scenario (CGT) the decision-making process is also strongly affected, if any of the memory elements are dysfunctional. For example, it can be assumed that participants will consider computer based gain/loss tasks in a visual sense and not only through the verbal mode (high value bet/card and low value bet/card). In terms of Baddeley's model (1992), the activation state for the verbal mode corresponding to the articulatory rehearsal would be lower than the activation level for the sketchpad corresponding to the visual mode (Baddeley, 1986) and deficits in visual processing is thought to underlie many of the dysfunctional behaviors in OCD (Gonçalves et al., 2010; Rubies et al., 2001). Therefore, selective visual processing deficits related to risky decision-making (CGT) may be specific to patients in all symptom dimensions except for those with aggression concerns who were the only patients not showing selective deficits on the CGT.

Following the concept of information processing it has been suggested that OCD behavior stems from a failure to specifically process emotional signals adequately (Dittrich et al., 2010a) and detect one's own behavioral output (Szechtman & Woody, 2004). OCD patients seem unable to generate a normal 'feeling of knowing' experience that would signal task completion (Szechtman & Woody, 2004). The authors relate this to a dysfunctional security motivational system where emotion-based feedback processes are assumed to be impaired. Similar deficient emotional processes that accompany the experiences of impaired 'feeling of knowing' or of a feeling of 'incompleteness' may be closely linked to the often reported 'not just right' experience (Coles et al., 2005; Ecker & Gönner, 2008). These experiences would have implications for decision-making tasks such as the CGT as impaired rational decision-making may signal dysfunctional 'feeling of knowing' and 'not just right' experiences in patients with symmetry/order and sexual/religious concerns. It still remains an open question why a decision is not completed because OCD patients find it difficult to make the decision to shift a response pattern when that is required (Dittrich et al., 2010b; Veale et al., 1996). Alternatively to the role of uncertainty and ambiguity, impaired decision-making can be seen as a result of difficulties in processing information adequately in the light of strong emotional activation (e.g., Williams et al., 1997). Similarly, it has been shown that during decision-making, bodily states are associated with previous choice options as described in the somatic marker hypothesis (Damasio, 1996). On both the IGT and the CGT each decision seems to be related to a positive or negative emotion depending on the outcome and they can therefore be assumed to measure emotional decision-making, but the

question of cognitive factors in decision-making is not resolved because the integrity of the executive process seems important in emotional decision-making.

The important message from the current study is the evidence for selective deficits according to patients in different symptom dimensions related to risky decision-making of rationality (symmetry/order, sexual/religious), deliberation time (safety, contamination) and risk assessment (safety) and support the symptomatological approach to study OCD. Therefore, the heterogeneity in the findings on decision-making in OCD (CGT and IGT) is likely to be explained by OCD group sizes and neglecting performances by patients in different symptom dimensions.

Acknowledgements

We greatly appreciated the time and effort devoted by all participants to this study. The authors also wish to thank the staff at the QE II Hospital, Mental Health Unit, South-East England, UK and especially Kim Fox for the valuable administrative/technical support. Thanks to Mahrufa Choudhury and Gabriela Garrett for data processing and Professor David Winter for his support. The support of Cambridge Cognition Limited and especially David Hart is gratefully acknowledged. Conflict of interest: none.

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