Original article

The comparison of risky and ambiguity decision making and cool executive functions between patients with obsessive compulsive disorder and healthy controls

Buket Güngör[1], Ersin Budak[2], Ibrahim Taymur[2], Nabi Zorlu[3], Burcu Ucgun[2], Almila Akgul[2], Hakan Demirci[2]

[1] Istanbul Bakırköy Mental Health Training and Research Hospital – Psychiatry, Istanbul, Turkey.
[2] University of Health Sciences Bursa Yuksek Ihtisas Training and Research Hospital, Bursa, Turkey.
[3] Kâtip Çelebi University – Psychiatry, Izmir, Turkey.

Received: 02/24/2018 – **Accepted:** 08/27/2018

DOI: 10.1590/0101-60830000000170

Abstract

Background: Executive functioning has been evaluated in obsessive compulsive disorder (OCD). Cool and hot executive functioning discrimination provided a different way of conceptualising executive functions. **Objectives:** The aim of this study was to compare ambiguity and risky decision-making and cool executive functions in an OCD and a healthy control group. The relationship between decision-making and cool executive functioning was investigated. **Methods:** Sixty-two OCD patients and 48 healthy control participants were compared. Decision-making was measured using the Iowa Gambling Task. The cool executive functioning was assessed using the Stroop Test and the Wisconsin Card Sorting Task (WCST). **Results:** The OCD group completed the WCST and the Stroop Test statistically significantly with a lower score than that of the control group. The OCD group had impaired response inhibition and set-shifting that indicate impaired cool executive functioning. In contrast to a lack of a statistically significant difference, the risky decision-making performance was worse in the OCD group than in the healthy control group and in the unmedicated OCD patients than in the medicated OCD patients. **Discussion:** The OCD patients had a poorer performance in risky decision-making and cool executive functioning. There was a link between risky decision-making performance and impaired cool executive functions.

Güngör B et al. / Arch Clin Psychiatry. 2018;45(5):112-8

Keywords: OCD, risky decision making, ambiguity decision making, cool executive functioning.

Introduction

Obsessive compulsive disorder (OCD) is a debilitating common disorder that severely afflicts functionality. OCD is characterised by intrusive thoughts and compulsive behaviours. It has been removed from the anxiety disorders in the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition, and OCD and related disorders have been separated into a new category. OCD is the characteristic member of this group disorders.

The executive functions include planning, organisation, being able to behave flexibly, the ability to generate alternative responses according to changing conditions, decision-making and maintaining or being able to cease inappropriate or impulsive behaviour. It has been proposed that OCD was associated with broad impairment in executive functioning and these impairments were not associated with comorbid depression or general motor slowing[1]. It has been suggested that there are two distinct executive function systems[2,3]. A "cool" (cognitive) executive system is related to problem-solving abilities that require the organisation of working memory, planning and suppression or execution of a response. A "hot" (affective) executive system is related to processes that are connected with emotional cues, affect and motivation. The hot executive system involves emotional regulation and affective interference. The hot executive function impairment may cause affective biases on executive control. Hot and cool executive functioning discrimination underlies that cool executive functions include non-emotional cognitive processes whereas hot executive functions include emotional cognitive process. Response inhibition, working memory, set-shifting and planning are examples of cool executive functions. The meta-analysis regarding the cool executive functions in OCD support that OCD has been linked to impaired cool executive functioning[4,5].

Decision-making is a cognitive process that provides making appropriate selections for different situations. The Iowa Gambling Task (IGT) measures the decision-making ability. The IGT, developed by Bechara *et al.*[6], assess decision-making ability. It imitates real life in terms of ambiguity, reward and punishment. The task measures preferences, which would be chosen in the long term, namely, a low reward-low loss or a high reward-high loss. Decision-making capacity was primarily evaluated in cases with prefrontal cortex (PFC) lesions. Although these cases had a normal intellectual capacity and displayed intact executive functioning, they could not learn from previous experiences and had difficulty evaluating pros and cons thus eventually repeating similar mistakes[6,7]. Decision-making studies have been carried out not only for PFC lesions but also for alcohol and substance addiction[8] and pathological gambling[9].

Decision-making which is evaluated with the IGT, is conceptualised as an integration of both "hot" (affective) and "cool" (cognitive) systems[9]. Two different decision-making processes have been defined, namely, ambiguity and risky decision-making[10]. Ambiguity decision making is an example of a hot executive function. The selections are made via the emotions, affect and motivation in ambiguity decision making. On the other hand, risky decision making is an example of a cool executive function. The selections are made through previous experiences in risky decision-making. Both risky decision-making and cool executive functions are associated with a rational process[11].

Cool and hot executive function discrimination has been provided important implications. This study aimed to investigate the relationship between cool executive function and risky decision-making in an OCD group. There has been no study in the literature that has investigated this relationship in OCD and has examined these domains in one OCD sample. The ambiguity and risky decision-making were compared in the OCD group and a healthy control group. The relationship between the risky decision-making and the cool executive functions that were evaluated using the Stroop Test and the Wisconsin Card Sorting Task was investigated. In addition, it was investigated whether there was any decision-making performance difference between medicated and unmedicated OCD groups.

Address for correspondence: Buket Güngör. Istanbul Bakırköy Mental Health Training and Research Hospital. Zuhuratbaba, Bakırkoy, Istanbul. Istanbul 34147. Turkey. E-mail: buket.gungor@yahoo.com

CC BY

Methods

Participants

The OCD group included 62 patients aged 18-65 years who were recruited for the study after meeting the Structured Clinical Interview for DSM-IV/Clinical Version (SCID-I)[12] diagnostic criteria for OCD. In addition, SCID-I was administered to determine other lifetime psychiatric comorbidities. Attention deficit hyperactivity disorder (ADHD) diagnosis was investigated using the Adult Attention Deficit Hyperactivity Rating Scale. The participants were asked about any presence of an organic mental disorder in a face-to-face interview. The patients who had psychotic disorder, affective disorder, anxiety disorder, somatoform disorder, eating disorder, ADHD and organic mental disorder and alcohol and substance use disorder except nicotine use disorder were excluded because of possible confounding effects. It was confirmed that there was no aforementioned psychiatric diagnosis other than OCD. Another exclusion criterion was a deficit in intellectual functioning. The patients and those in the control group had at least primary school education. Two cases were ruled out because of receiving high scores for ADHD according to the Adult Attention Deficit Hyperactivity Rating Scale. Three cases reported previous academic failure, and these cases were ruled out after an assessment of intelligence.

The OCD-diagnosed patients were treated with the following medications: 22 patients with sertraline, 14 with fluoxetine, 6 with paroxetine, 3 with escitalopram, 3 with clomipramine and 2 with fluvoxamine. Twelve cases were taking more than one drug. The augmentation medication was administered with risperidone in five cases, aripiprazole in four cases, olanzapine in two cases and haloperidol in one case. Eleven cases were newly diagnosed and were not receiving any medications.

The control group consisted of 48 healthy subjects. The control group was selected by age and their education matched up to the hospital staff participants (secretary, cleaning and security staff and nurse). The control group was interviewed using the SCID-I, and it was confirmed that there was no lifetime and current psychiatric diagnosis except nicotine use disorder. The participants in the control group who were recently and previously diagnosed with a psychiatric disorder or had a family history of OCD were ruled out. The subjects' ages were between 18 and 65 years.

The search was carried out in the Outpatient Department of Psychiatry of Bursa Yuksek Ihtisas Training and Research Hospital between September 2014 and December 2015. All of the participants who were confirmed to take part in the study provided a written informed consent. The study was approved by the local ethics committee.

Procedures

Patients who were referred to the Bursa Yuksek Ihtisas Education and Research Hospital Psychiatry Outpatient Clinic and were diagnosed with OCD were selected and gave an informed consent. The OCD diagnosis was confirmed by an SCID-I interview conducted by a psychiatrist. The OCD-diagnosed patients were enrolled in the study if there was no comorbid psychiatric diagnosis. The severity of the symptoms was evaluated by the Yale-Brown Obsessive-Compulsive Scale (YBOCS) in OCD group. YBOCS is a rating scale that assesses the severity of obsessions and compulsions over the previous week in patients with OCD. Executive function tests and intelligence scale Wechsler Adult Intelligence Scale Test (WAIS) were administered by a certified psychologist. WAIS was administered if there was a suspicion of an intellectual disability or alleged mental retardation. The intellectual disability was verified with WAIS. Healthy people were selected as the subjects of the control group, and it was confirmed that there was no psychiatric diagnosis by the SCID-I interview.

The Executive Function Tests

All of the participants completed the IGT, the Stroop Test and the WCST.

The IGT, developed by Bechara *et al.*[6], measures decision-making. It consists of four decks: two of them are advantageous and the other two of them are disadvantageous. The decision-making score is calculated by the difference between the advantageous and the disadvantageous selections. The gain and the loss are less in the advantageous decks, so they are more profitable than the disadvantageous decks in the long term. After making random selections, normal cases start to avoid the disadvantageous decks. The selections from the disadvantageous decks are not only related to gaining a large amount of money but also to losing as much, even much more than gaining. The IGT consists of 100 cards, which are split into five blocks of 20 cards. These five blocks correspond to four learning phases. The first 20 cards (0-20) represent pre-punishment (baseline), the second 20 cards (21-40) a pre-hunch, the third 20 cards (41-60) a hunch and the fourth (61-80) and fifth (81-100) blocks show conceptual knowledge. After making a small random selection, normal cases start to avoid the disadvantageous decks.

The first 40 cards have been conceptualised as decision-making under ambiguity, and selections between 41 and 100 cards have been classified as decision-making under risk[13,14]. The original paper used real cards were used for the assessment.

The Stroop Test, developed by Stroop[15], measures response inhibition by naming the colour of the ink used to print the word without the reading the actual word. The test has five stages and the fourth stage is a preparation for the fifth stage. The last stage includes cards written in different colour-meaned words. The time to complete while naming the colour of the word was measured in the last stage. The Stroop interference effect was measured in this last stage.

The WCST assesses cognitive flexibility and set-shifting abilities, which are evaluated by a number of trials, total errors, perseverative responses, perseverative errors, non-perseverative errors, completed categories and a failure to maintain the set[16]. The WCST consists of 128 cards version was utilized. The original paper used real cards were used both for the Stroop and the WCST assessment.

Statistical analysis

Statistical analyses were carried out using SPSS version 21.0 for Windows. The Kolmogorov-Smirnov Test was used to check the normal distribution while the Chi-square Test for categorical variables. Numeric variables were compared based on their distribution patterns with the Mann-Whitney-U or the student t-test. The IGT consists of 100 cards that are divided into five groups with 20 cards in each group. The number of cards selected from the advantageous C and D decks was subtracted from the number of selected cards from the disadvantageous A and B decks. A Two-way Repeated Measures Variance Analysis was used to compare the IGT scores of the five decks among the groups and to compare ambiguity and risky decision-making. Greenhouse-Geisser Correction was used when the sphericity assumption was violated. Decision-making under ambiguity was evaluated by the first 40 cards, and decision-making under risk was measured by the cards between 41 and 100. The correlation between the IGT, the neuropsychological test scores, and the YBOCS score was evaluated by the Spearman correlation analysis. A p value of less than 0.05 was considered to show a statistically significant result.

Results

Sociodemographic and clinical characteristics

The demographic characteristics of the study are shown in Table 1. Sixty-two OCD patients and 48 healthy control participants were enrolled in the study. The OCD and the control groups did not differ according to gender (p = 0.946), age (p = 0.530), education year (p = 0.291), and marital status (p = 0.095). The severity of OCD was evaluated with the YBOCS in the patient group (20.91 ± 8.37). The rate of a family history of OCD in the OCD-diagnosed cases was 41.9%.

The results of the executive function tests are shown in Table 2. The comparisons revealed that the OCD group showed a significantly poorer response inhibition on the Stroop Test than the control group. In addition, the OCD group exhibited a poorer performance on the WCST. The OCD group executed a greater number of trials, total errors, perseverative responses, non-perseverative errors, a failure to maintain the set and a lower number of completed categories and conceptual responses.

Decision making evaluation

The comparison of the IGT performance change from the first to the last block which represents four learning phases, is shown in Figure 1 for the OCD group and the healthy control group and in Figure 2 for the medicated and the unmedicated OCD groups. No statistically significant differences were found between the OCD group and the control group from the first to the fifth block of the IGT ($F = 1.530$, $p = 0.193$). The IGT scores seemed to be higher initially in the ambiguity decision-making in the OCD group compared with the healthy group, but there was no statistically significant difference. The first block represents a baseline assessment and is associated with casual decisions[17]. Although there was no statistically significant difference, the initial IGT score was higher, but the final IGT score was lower in the OCD group than in the healthy control group (Figure 1). There was no statistically significant difference between the medicated and the unmedicated OCD groups for the IGT performance ($F = 0.121$, $p = 0.955$; Figure 2).

The comparison of ambiguity and risky decision-making is presented in Figure 3 between the OCD group and the healthy control group and in Figure 4 for the medicated and the unmedicated OCD groups. No statistically significant differences were found on the ambiguity and the risky decision-making performance between the OCD group and the healthy control group ($F = 1.811$, $p = 0.18$). Although there was no statistically significant difference, the mean of the ambiguity decision-making score was higher, while the mean of the risky decision-making score was lower in the OCD group compared with the healthy control group (Figure 3). There was no statistically significant difference between the medicated and the unmedicated OCD groups for ambiguity and risky decision making ($F = 0.014$, $p = 0.908$). Although not statistically significant, the mean of the risky decision-making score in the unmedicated OCD group was lower than in the medicated OCD group (Figure 4).

The correlation between clinical features, decision making and executive function in the OCD group

Spearman correlation analysis was performed between clinical features, decision-making and executive functions in the OCD group. Table 3 shows the results of the correlation analysis. There was a positive correlation between the IGT last block performance and the Stroop Test performance. Except for these findings, no significant association was determined between the IGT performance and other parameters.

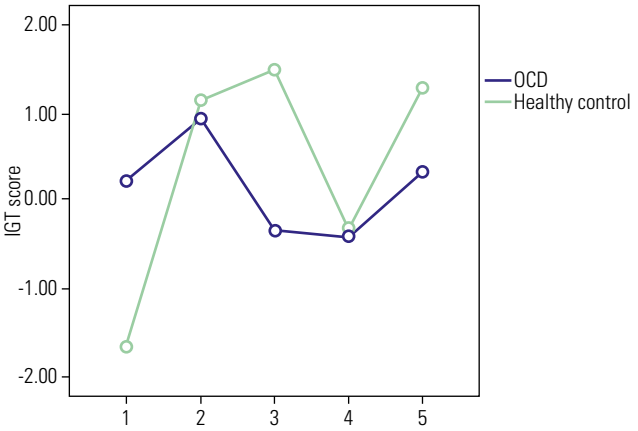

Figure 1. Comparison of IGT performance change from the first to the last block between OCD and healthy control group.

Table 1. Demographic and clinical characteristics of OCD patients and healthy control group

	OCD (*N* = 62)	Healthy Control (*N* = 48)	*Chi square/Z/t*	*P = Chi square/Mann Whitney-U/t test*
Gender Female/male	43(%69.4)/19(%30.6)	33(%68.7)/15(%31.3)	0.005	0.946*
Age	34.15 ± 10.32	32.27 ± 7.48	2.967	0.272***
Education year	10.69 ± 4.38	10.29 ± 3.14	-1.057	0.291**
Marital status Married/single-divorced	35(%56.4)/27(%43.6)	35(%72.9)/13(%27.1)	4.709	0.095*
YBOCS Family history of OCD Yes/No	20.91 ± 8.37 26(%41.9)/36(58.1)			

* Chi square. ** Mann Whitney U. *** t test.

Table 2. Comparison of neuropsychological assessment of the groups

	OCD (*N* = 62)	Healthy control (*N* = 48)	*Z/t*	*p* = Mann Whitney-U/t test
Stroop	28.85 ± 8.41	22.77 ± 4.98	4.865	**0.000****
WCST Number of trials	120.41 ± 17.22	110.93 ± 18.40	-3.306	**0.001***
Total errors	50.01 ± 18.54	35.15 ± 17.83	-3.601	**0.000***
Completed categories	3.62 ± 1.71	5.03 ± 1.35	3.818	**0.000***
Perseverative responses	31.37 ± 15.89	20.71 ± 11.47	0.921	**0.001****
Non-perseverative errors	27.37 ± 12.68	15.18 ± 8.63	3.456	**0.001****
Perseverative errors	22.72 ± 11.35	18.50 ± 9.54	1.178	**0.001****
Failure to maintain set	1.08 ± 1.21	0.93 ± 1.21	-0.672	0.502*

* Mann Whitney U. ** t test.

There was a positive correlation between the Stroop Test performance and the WCST performance (total errors, perseverative response and perseverative errors). A poor Stroop Test performance was correlated with a poor WCST performance.

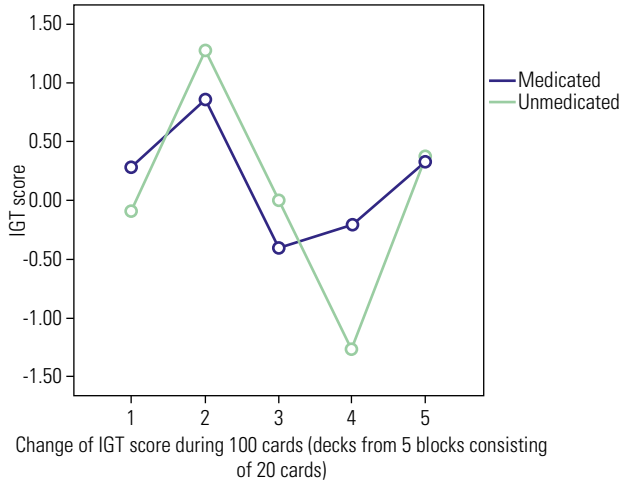

Figure 2. Comparison of IGT performance change from the first to the last block between medicated and unmedicated OCD group.

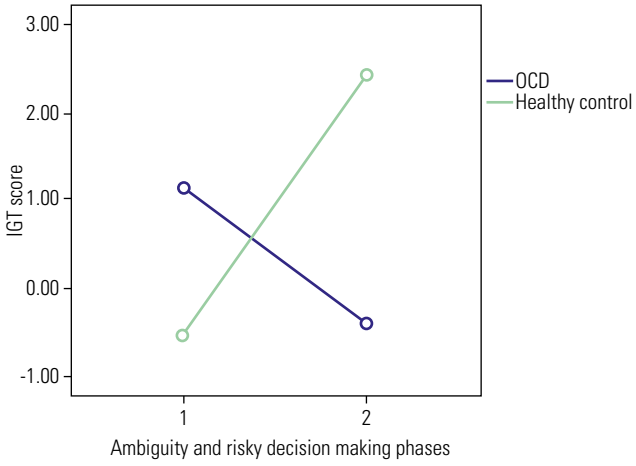

Figure 3. Comparison of ambiguity and risky decision making between OCD and healthy control groups.

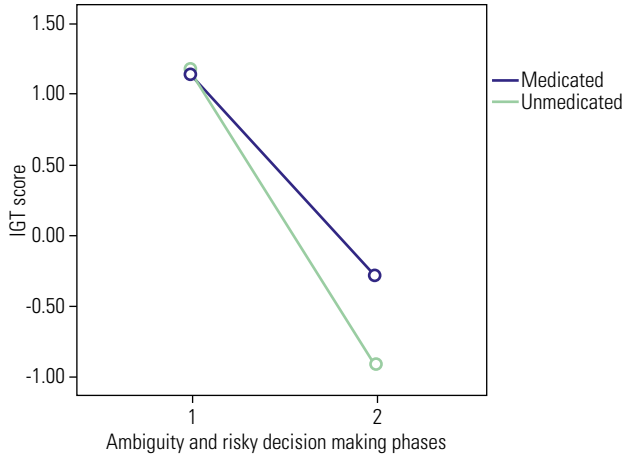

Figure 4. Comparison of ambiguity and risky decision making between medicated and unmedicated OCD groups.

There was a positive correlation between OCD severity that was evaluated with the YBOCS and the Stroop Test scores. The higher OCD severity was correlated with higher Stroop Test scores and an impaired response inhibition.

Discussion

Determining decision-making and executive function in an OCD group and a healthy control group demonstrated that the OCD group had impaired response inhibition, cognitive flexibility and set-shifting abilities compared with the healthy control group. Although there was no statistically significant difference between the OCD group and the healthy control group for decision making performance, the mean score of the IGT tended to decrease from the beginning to the end point of the task and from the ambiguity decision-making phase to the risky decision-making phase in the OCD group. The healthy control group showed improvement in decision making performance from ambiguity to risky decision-making over time but OCD group performed worse over time and at risky decision-making in the IGT (Figures 1 and 2).

OCD has been considered to be responsible for a broad range of executive function deterioration. Inhibitory control has been found to be impaired in OCD[18], which could be linked to an inability to inhibit repetitive thoughts and behaviours. Existing literature denote that set-shifting and response inhibition, which are components of the executive function and performed by the WCST and the Stroop Test, respectively, have been impaired in OCD[19]. Response inhibition has been proposed as an endophenotype of OCD[18]. Abramovitch reported that a medium weighted mean effect size was found for response inhibition in the metaanalysis of 23 studies[4]. Consistent with previous studies[19-23], we detected that the OCD group completed the WCST and the Stroop Test poorer than the control group. The OCD group was significantly impaired on set-shifting, which was measured with the WCST. The OCD group responded perseveratively to the previously rewarded stimulus. The OCD-diagnosed group showed a significantly poorer response inhibition on the Stroop Test than the control one; they needed more time to complete the test. In other words, the OCD group required a greater effort for a response inhibition.

The studies in the literature related to decision-making in OCD have accumulated in recent years. Lawrence and Nielen found no difference between the OCD group and the healthy control group for decision-making performance[21,24]. However, the studies that have evaluated decision-making in OCD presented controversial results. The studies suggested that OCD originated from[25] and is related to impaired decision-making[26]. Some of the studies that ascertain

Table 3. Relationship between decision making, WCST and Stroop in OCD group

	YBOCS	Stroop	Total errors	Completed categories	Perseverative responses
Stroop	0.323 $p < 0.05$				
Total errors	-	0.273 $p < 0.05$			
Completed categories	-	-	-0.773 $p < 0.01$		
Perseverative responses	-	0.272 $p < 0.05$	0.775 $p < 0.01$	-0.578 $p < 0.01$	
Non-perseverative errors	-	-	0.644 $p < 0.01$	-0.588 $p < 0.01$	-
Perseverative errors	-	0.307 $p < 0.05$	0.772 $p < 0.01$	-0.627 $p < 0.01$	0.989 $p < 0.01$
IGT (81-100) (last block)	-	-0.441 $p = 0.01$	-	-	-

decision-making in OCD determined that the OCD group performed significantly poorer on the IGT than the control group[26-28]. Previous studies that used IGT evaluated the task as a whole and did not discriminate IGT as an ambiguity and a risky phase and if there was a difference between the OCD and control groups, it was interpreted as a difference at the ambiguity decision making[29]. However, according to a new paradigm, IGT has been conceptualised as an integration of both ambiguity and risky decision-making processes.

The studies that assessed decision-making under ambiguity and risk have been using two different methods. One of the methods uses only the IGT. The decision making under ambiguity is measured via the first blocks of the IGT and decision-making under risk via the last blocks[9,13,14]. The other method uses the IGT for evaluating decision-making under ambiguity and the Game of Dice Task (GDT) for decision-making under risk[3,10,30]. It was observed that the IGT last block performance and the GDT performance was correlated[10]. According to the first method which was used in our study, the first blocks of the IGT refer to decision-making under ambiguity. The probabilities of reward and loss are unknown when selections are made in the first blocks. The last blocks refer to decision-making under risk. The probabilities of reward and loss are known in the last blocks[10]. Decision-making under ambiguity is an example of a hot executive function; the selections are made via the emotions, affect and motivation. While decision-making under risk is an example of a cool executive function, the selections are made via previous experiences. The cool executive function has been associated with a rational process and has been related to the knowledge of the risk/benefit ratio[11]. The IGT has been conceptualised as an integration of both "hot" (affective) and "cool" (cognitive) systems. The former part of the IGT, the first blocks, are related to hot executive functions, and the latter part of the IGT, the last blocks, are related to cool executive functions. Brand reported that impaired cool executive functioning with intact hot executive functioning was associated with a better performance in decision-making under ambiguity than decision-making under risk[31]. However, impaired hot executive functioning with intact cool executive functioning was associated with both a lowered performance of decision-making under ambiguity and risk[32,33]. The relationship between hot and cool executive functions has been conceptualised in a pattern. It has been suggested that emotional reactions should be regulated primarily, and after that, problem-solving abilities and cognitive processes can be enacted[34].

In our study, the comparison of the OCD group and the healthy control group did not show a statistically significant difference according to the decision-making performance from the beginning to the end of the fifth phase of the task. Although there was no statistically significant difference, the mean of the IGT score at the initial phase was higher, but the mean of the IGT score at the last phase was lower in the OCD group than in the healthy control group. The mean of the ambiguity decision-making scores was higher, but the mean of the risky decision-making scores was lower in the OCD group compared with the healthy control group. In summary, the mean scores of the IGT in the OCD group tended to decrease from the ambiguity decision-making process to the risky one. Although not statistically significant, the mean of the IGT score was higher in the ambiguity decision-making phase but lower in the risky decision-making phase in the OCD group than in the healthy control group. It was considered that a small sample size could prevent detection differences between the groups. A study with a larger sample size may improve the study power and help identify the differences. The measurement of decision-making in the healthy control group showed an unexpected result and was different from Bechara's control group[6]. The healthy control group had gradually shifted their preferences towards the advantageous decks as the task progressed in Bechara's study. However, the healthy control group continued to select disadvantageous decks at the beginning of the conceptual phase in this study. The absence of a nonsignificant difference between the OCD and the healthy control groups may be due to a poor performance of the control group. In line with our results, Grassi reported that there was no significant difference between the OCD patients and the controls in the single blocks of IGT or in the performance of ambiguity and risky decision-making. Furthermore, similar with our results, Grassi reported that the IGT performance improved over time from the first block to the last block of IGT in the control group, while patients' performance did not improve. This result was considered as an indicator for impaired risky decision-making for OCD[35]. Additionally, Kodaira found the same results in a child sample, the OCD-diagnosed group selected disadvantageous cards towards the end of the IGT task. Although these studies underlie the impaired trend over time in IGT, they did not associate the results with ambiguity and risky decision-making and did not investigate the relationship between decision-making and executive functioning from this perspective[36]. Contradictory to our findings, Starcke[3] and Zhang[30] reported that the OCD patients demonstrated a poorer performance on decision-making under ambiguity than the control subjects, while the decision-making under risk performance was similar.

In addition to previous findings, there was no statistically significant difference between the medicated and the unmedicated OCD groups for a complete IGT task comparison (Figure 2) and for an ambiguity and risky decision-making performance comparison (Figure 4). Although not statistically significant, the mean of the risky decision-making score in the unmedicated OCD patients was lower than in the medicated OCD ones. Contradictory to our results, Kuelz reported that medicated OCD patients had a poorer executive function test performance compared with unmedicated OCD ones. However, this finding in that study was interpreted as an effect of confounding variables, such as comorbidity or psychotropic medication[37]. On the other hand, Cavedini investigated the decision-making function on the treatment response. It has been proposed that a poor decision-making performance is correlated with a poor response to treatment[27]. Zhang recently reported that the refractory OCD patients presented significant improvements in the IGT performance after anterior capsulotomy[38].

There was a positive correlation between the IGT last block performance and the Stroop Test performance, of which there were reported examples of cool executive functions in the OCD group[11]. In line with our results, Noel claimed that there was a relationship between cool executive function and the last part of decision-making. Therefore, it was suggested that the IGT last block performance might be involved in cool executive functions[13]. Inhibitory control could be more important during the last blocks of the task because the participant was aware of the risk of each deck after the former part of the IGT. The performance of the latter stages of the IGT has been associated with the performance of response inhibition[13]. Norman reported that patients with OCD showed activation deficits during a decision-making task in the fronto-striato-insular-cerebellar regions responsible for inhibitory control. The OCD group had increased choice impulsivity in that study[39]. However, Goudrian and van Holst reported that there was no association between impairments in cool executive functions and decision making in pathological gambling[40,41]. The review concerning the relationship between decision-making and cognitive abilities including inhibition, a working memory, set-shifting and verbal and nonverbal IQ revealed that there was no relationship between them and suggested that these findings highlighted the separability between decision-making and cognitive abilities. However, this review evaluated both clinical and nonclinical samples[42]. Except for the significant correlation between response inhibition measured with the Stroop Test and the IGT last block performance, no significant association was determined between the former part of the IGT and the response inhibition and set-shifting function in our study.

There was a positive correlation between the YBOCS score and the Stroop Test score. High Stroop Test scores show an impaired response inhibition. High YBOCS scores have been associated with an impaired Stroop Test performance in this study. Our result is consistent with the study of Peles, which declared that a Stroop Test interference was correlated significantly with the OCD severity score[43]. Contradictory to this finding, Nielen reported that cognitive impairments could be

a trait feature because they detected that cognitive symptoms were not secondary to symptoms[22]. There was no correlation between the decision-making and YBOCS score in our study. Aranovich reported that decision-making under risk correlated with OCD symptomology[44]. Nielen *et al.* determined that IGT performance and OCD severity were positively correlated with each other[24].

The study has several limitations. One of them is that, the assessment of decision-making under risk could be made with the GDT at the same time. The assessment of intelligence was performed to provide exclusion of intellectual disability if only there was a suspicion. If we had evaluated intellectual capacity in the whole sample, this could have provided a comparison between intellectual performance and the other executive function tests. A small sample size could be an effect that could limit the statistical significance for decision-making comparison between the groups.

In conclusion, we found evidence that the OCD group have impaired cool executive functioning and altered and impaired risky decision-making than the healthy control groups. The OCD group exhibited a poorer performance on the WCST and the Stroop Test, which are examples of cool executive function. There was a positive correlation between another example of a cool executive function, namely, the IGT last block performance and the Stroop Test performance. Although not statistically significant, the IGT scores were lower in the risky decision-making phases in OCD. It has been considered that OCD may have an accompanying cool executive function impairment. An impairment in risky decision-making may be a part of an impaired cool executive functioning in this context. In this study, ambiguity decision-making seems to be intact in OCD.

Vandenbroucke suggested that the decision-making process might be an endophenotype that could have important implications for OCD treatment[45]. Additional studies are needed to confirm these results in a large sample. Further studies that evaluate ambiguity and risky decision-making processes in OCD and the unaffected relatives of OCD patients would highlight, whether risky decision-making could be an endophenotype candidate or an epiphenomenon in OCD.

References

1. Synder HR, Kaiser RH, Warren SL, Heller W. Obsessive-compulsive disorder ıs associated with broad ımpairments in executive function: a meta-analysis. Clin Psychol Sci. 2015;3(2):301-30.
2. Zelazo PD, Müller U. Executive function in typical and atypical development. Handbook of Childhood Cognitive Development. Goswami: Oxford Blackwell; 2002. p. 445-69.
3. Starcke K, Tuschen-Caffier B, Markowitsch HJ, Brand M. Dissociation of decisions in ambiguous and risky situations in obsessive-compulsive disorder. Psychiatry Res. 2010;175(1-2):114-20.
4. Abramovitch A, Abramowitz JS, Mittelman A. The neuropsychology of adult obsessive-compulsive disorder: a meta-analysis. Clin Psychol Rev. 2013;33(8):1163-71.
5. Shin MS, Park SJ, Kim MS, Lee YH, Ha TH, Kwon JS. Deficits of organizational strategy and visual memory in obsessive-compulsive disorder. Neuropsychology. 2004;18(4):665-72.
6. Bechara A, Damasio AR, Damasio H, Anderson SW. Insensitivity to future consequences following damage to human prefrontal cortex. Cognition. 1994;50(1-3):7-15.
7. Bechara A, Tranel D, Damasio H. Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. Brain. 2000;123(Pt 11):2189-202.
8. Bechara A, Dolan S, Denburg N, Hindes A, Anderson SW, Nathan PE. Decision-making deficits, linked to a dysfunctional ventromedial prefrontal cortex, revealed in alcohol and stimulant abusers. Neuropsychologia. 2001;39(4):376-89.
9. Brevers D, Bechara A, Cleeremans A, Noël X. Iowa Gambling Task (IGT): twenty years after – gambling disorder and IGT. Front Psychol. 2013;4:665.
10. Brand M, Recknor EC, Grabenhorst F, Bechara A. Decisions under ambiguity and decisions under risk: correlations with executive functions and comparisons of two different gambling tasks with implicit and explicit rules. J Clin Exp Neuropsychol. 2007;29(1):86-99.
11. Sequin JR, Arseneault L, Tremblay RE. The contribution of 'cool' and 'hot' components of decision-making in adolescence: implications for developmental psychopathology. Cogn Dev. 2007;22:530-43.
12. First MB, Spitzer RL, Gibbon M, Williams JBW. Structured Clinical Interview for DSM-IV Clinical Version (SCID-I/CV). Washington: American Psychiatric Press; 1997.
13. Noël X, Bechara A, Dan B, Hanak C, Verbanck P. Response inhibition deficit is involved in poor decision making under risk in nonamnesic individuals with alcoholism. Neuropsychology. 2007;21(6):778-86.
14. Sinz H, Zamarian L, Benke T, Wenning GK, Delazer M. Impact of ambiguity and risk on decision making in mild Alzheimer's disease. Neuropsychologia. 2008;46(7):2043-55.
15. Stroop JR. Studies of interference in serial verbal reactions. J Exp Psychol. 1935;18:643-62.
16. Heaton RK, Chelune GJ, Talley JL, Kay GG, Curtiss G. Wisconsin Card Sorting Test manual: revised and expanded. Odessa: FL Psychological Assessment Resources; 1993.
17. Bechara A, Damasio H, Tranel D, Damasio AR. Deciding advantageously before knowing the advantageous strategy. Science. 1997;275(5304): 1293-5.
18. Chamberlain SR, Blackwell AD, Fineberg NA, Robbins TW, Sahakian BJ. The neuropsychology of obsessive compulsive disorder: the importance of failures in cognitive and behavioural inhibition as candidate endophenotypic markers. Neurosci Biobehav Rev. 2005;29(3):399-419.
19. Zhang J, Yang X, Yang Q. Neuropsychological dysfunction in adults with early-onset obsessive-compulsive disorder: the search for a cognitive endophenotype. Rev Bras Psiquiatr. 2015;37(2):126-32.
20. Cavedini P, Ferri S, Scarone S, Bellodi L. Frontal lobe dysfunction in obsessive-compulsive disorder and major depression: a clinical-neuropsychological study. Psychiatry Res. 1998;78(1-2):21-8.
21. Lawrence NS, Wooderson S, Mataix-Cols D, David R, Speckens A, Phillips ML. Decision making and set shifting impairments are associated with distinct symptom dimensions in obsessive-compulsive disorder. Neuropsychology. 2006;20(4):409-19.
22. Watkins LH, Sahakian BJ, Robertson MM, Veale DM, Rogers RD, Pickard KM, et al. Executive function in Tourette's syndrome and obsessive-compulsive disorder. Psychol Med. 2005;35(4):571-82.
23. Nielen MM, Den Boer JA. Neuropsychological performance of OCD patients before and after treatment with fluoxetine: evidence for persistent cognitive deficits. Psychol Med. 2003;33(5):917-25.
24. Nielen NM, Veltman DJ, de Jong R, Mulder G, den Boer JA. Decision making performance in obsessive compulsive disorder. Neuropsychology. 2006;20:409-10.
25. Kim S, Lee D. Prefrontal cortex and impulsive decision making. Biol Psychiatry. 2011;69(12):1140-6.
26. de Rocha FF, Alvarenga NB, Malloy-Diniz L, Correa H. Decision making impairtment in obsessive compulsive disorder as measured by the Iowa Gambling Task. Arq Neueopsiquiatr. 2011;69(4):642-7.
27. Cavedini P, Riboldi G, D' Annucci A, Belotti P, Cisima M, Bellodi L. Decision making heterogenity in obsessive compulsive disorder: ventromedial prefrontal cortex function predicts different treatment outcomes. Neuropsychologia. 2002;40(2):205-11.
28. Zhang L, Dong Y, Ji Y, Zhu C, Yu F, Ma H, et al. Dissociation of decision making under ambiguity and decision making under risk: a neurocognitive endophenotype candidate for obsessive-compulsive disorder. Prog Neuropsychopharmacol Biol Psychiatry. 2015;57:60-8.
29. Martoni RM, Brombin C, Nonis A, Salgari GC, Buongiorno A, Cavallini MC, et al. Evaluating effect of symptoms heterogeneity on decision-making ability in obsessive-compulsive disorder. Psychiatry Clin Neurosci. 2015;69(7):402-10.
30. Zhang L, Yi D, Ji Y, Taov R, Chen X, Ye J, et al. Trait related decision making impairtment in obsessive compulsive disorder: evidence from decision making under ambiguity but not decision making under risk. Sci Rep. 2015;5:17312.
31. Brand M, Kalbe E, Labudda K, Fujiwara E, Kessler J, Markowitsch HJ. Decision-making impairments in patients with pathological gambling. Psychiatry Res. 2005;133(1):91-9.
32. Bechara A, Damasio H, Tranel D, Damasio AR. Deciding advantageously before knowing the advantageous strategy. Science. 1997;275(5304): 1293-5.
33. Weller JA, Levin IP, Shiv B, Bechara A. Neural correlates of adaptive decision making for risky gains and losses. Psychol Sci. 2007;18(11):958-64.

34. Giancola PR, Godlaski AJ, Roth RM. Identifying component-processes of executive functioning that serve as risk factors for the alcohol-aggression relation. Psychol Addict Behav. 2012;26(2):201-11.
35. Grassi G, Pallanti S, Righi L, Figee M, Mantione M, Deny D, et al. Think twice: impulsivity and decision making in obsessive-compulsive disorder. J Behav Addict. 2015;4(4):263-72.
36. Kodaira M, Iwadare Y, Ushijima H, Oiji A, Kato M, Sugiyama N, et al. Poor performance on the Iowa gambling task in children with obsessive-compulsive disorder. Ann Gen Psychiatry. 2012;11(1):25.
37. Kuelz AK, Hohagen F, Voderholzer U. Neuropsychological performance in obsessive-compulsive disorder: a critical review. Biol Psychol. 2004;65(3):185-236.
38. Zhang C, Chen Y, Tian S, Wang T, Xie Y, Jin H, et al. Effects of anterior capsulotomy on decision making in patients with refractory obsessive-compulsive disorder. Front Psychol. 2017;8:1814.
39. Norman LJ, Carlisi CO, Christakou A, Chantiluke K, Murphy C, Simmons A, et al. Neural dysfunction during temporal discounting in paediatric attention-deficit/hyperactivity disorder and obsessive-compulsive disorder. Psychiatry Res Neuroimaging. 2017;269:97-105.
40. Goudriaan AE, Oosterlaan J, de Beurs E, Van den Brink W. Pathological gambling: a comprehensive review of biobehavioral findings. Neurosci Biobehav Rev. 2004;28(2):123-41.
41. van Holst RJ, van den Brink W, Veltman DJ, Goudriaan AE. Why gamblers fail to win: a review of cognitive and neuroimaging findings in pathological gambling. Neurosci Biobehav Rev. 2010;34(1):87-107.
42. Toplak ME, Sorge GB, Benoit A, West RF, Stanovich KE. Decision-making and cognitive abilities: A review of associations between Iowa Gambling Task performance, executive functions, and intelligence. Clin Psychol Rev. 2010;30(5):562-81.
43. Peles E, Weinstein A, Sason A, Adelson M, Schreiber S. Stroop task among patients with obsessive-compulsive disorder (OCD) and pathological gambling (PG) in methadone maintenance treatment (MMT). CNS Spectr. 2014;19(6):509-18.
44. Aranovich GJ, Cavagnaro DR, Pitt MA, Myung JI, Mathews CA. A model-based analysis of decision making under risk in obsessive-compulsive and hoarding disorders. J Psychiatr Res. 2017;90:126-32.
45. Vandenbroucke CL, Gabriëls L. The decision-making process in obsessive compulsive disorder. Tijdschr Psychiatr. 2012;54(1):39-49.