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Iconic Memory in Obsessive Compulsive Disorder

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SUMMARY

Objective: In this study, we aimed to investigate whether there is a fast decay in the iconic memory of patients with Obsessive Compulsive Disorder (OCD) compared to healthy individuals by taking into consideration the clinical OCD subtypes.

Method: The study included 74 patients diagnosed with OCD on the basis of the DSM 5 criteria and 63 healthy individuals. The OCD patients were grouped as washers, checkers, both washers and checkers, and non-washers and non-checkers. All participants took a partial report test (PRT) to compare iconic memory performance between the healthy control group and the OCD group as a whole and in OCD subgroups.

Results: Loss of iconic memory did not differ between OCD group and the controls. The iconic memory scores, expressed as the d' values, at specified time points correlated negatively with age and positively with education duration in all groups.

When the subgroup data were analyzed by controlling for age, the d1'value showing formation of iconic information was lower in the washers subgroup in comparison to the checkers subgroup and the non-washers and non-checkers subgroup. The d7' value was also lower in the washers subgroup than in the the non-washers and non-checkers subgroup and the healthy control group.

The iconic decay rate of the washers subgroup between the time points d6' and d7' was significantly higher in comparison to the healthy control group. The scores of OCD patients on the washing subscale of the Maudsley Obsessive Compulsive Inventory (MOCI) showed negative correlations with the iconic memory scores at all time points.

Conclusion: This study showed that washer OCD patients may have impaired iconic formation and fast iconic decay, which could significantly affect the amount of information transferred to visual memory.

Keywords: Obsessive compulsive disorder, iconic memory, short-term memory, working memory, washers

INTRODUCTION

Obsessive Compulsive Disorder (OCD) is a disorder characterised with symptoms of obsessions and/or compulsions, generally on a chronic course with occasional flare-up that significantly affect the functionality of the individual (Goodman et al. 1990). Symptoms of washing or checking by the patients on not being sure of the information last viewed, such as having clean hands or whether the cooker is turned off are frequently reported observation. Probably in an effort to relieve the anxiety induced by the uncertainty, individuals with OCD check repeatedly the visual information associated with the obsession in order to regain or to sustain it.

Visually checking if the cooker is on, the door is closed or washing the hands repeatedly while keeping the eyes on them, being uncertain about having washed them properly, are examples of reported compulsions (Rasmussen and Eisen 1992). OCD patients explain this as having seen the object or the activity but becoming very soon unsure of the information (Sadock and Sadock 2016, Tukel 2017). These findings suggest that OCD patients could have problems with the ability to obtain sufficient information during the visual perception or in preserving the information over time.

In parallel with the above-mentioned clinical observations, problems related to remembering complex visual stimuli are one of the most frequently experimentally reported neuropsychological problems in these patients (Benzina et al. 2016). For example, several studies have reported that OCD patients are not successful in the Rey-Osterrieth Complex

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Figure Test when compared to healthy individuals (Jang et al. 2010, Park et al. 2006, Rampacher et al. 2010). This test involves seeing a complex shape and drawing it from memory after it has been removed. The reason for the failure of OCD patients in drawing this shape from memory is thought to be a coding strategy dysfunction (Savage et al. 1999). However, the dysfunction may be related to the decay of the encoded visual information in a shorter time than the normal resulting in less information transfer to the short-term memory. The cognitive function that normally provides this transfer is called the iconic memory.

According to the generally accepted views, the iconic memory is a memory structure that transfers raw information of objects seen momentarily to the short-term-working memory on the pathway to becoming permanent. It is thought that the iconic memory has a high capacity to receive information which, however, decreases rapidly within milliseconds (Brelsford et al. 1968, Sperling G 1960). When received by the iconic memory, the part of the sensory information which is important for the individual is selected through a process involving activated attention and is included in the short-term memory-working memory system (Barban et al. 2013). Thus, at the moment the visual material is lost from the visual field, the stage of forming the rich iconic information with the details of the visual material decays with passing of time and is transferred to the working memory in this decayed form. The visual information received while the eyes are focussed on a point is believed to be preserved by the iconic memory system during the momentary saccadic eye movements (Thomas and Irwin 2006, Barban et al. 2013). The visual information received at a momentary focusing of the eyes can only be combined with the information received in a subsequent focussing by this maintenence mechanism operating during saccadic eye movements. It is thought that humans make a meaningful synthesis about the entirety of a visual material by combining the limited visual information received by focusing on only certain areas of the material. A dysfunction related to the formation or faster than normal loss of iconic information can cause impairment in the combining and understanding of this information by transfer to short-term memory-working memory (Hahn et al. 2011, Quak et al. 2015). Such a dysfunction related to the iconic memory will impair particularly the perception of moving objects since the information on the continuously changing images will have interruptions preventing the perception of the movement (Nikolić et al. 2009, Urakawa et al. 2010, Talaslı 1993). There are studies with OCD patients reporting dysfunctions in the perception of several bodies moving simultaneously (Tezcan and Tümkaya 2018, Tümkaya et al. 2013). Furthermore, it is generally accepted that visual memory and visual working memory deficits are seen in these patients (Shin et al. 2014, Abramovitch et al. 2013). One other reason for the dysfunctions of visual memory, working memory and moving object perception seen in OCD patients may be iconic memory dysfunction, because of which the amount of visual information transferred to the visual memory or the visual working memory is initially less than in healthy individuals, and may result in the dysfunctions in visual working memory and moving objects perception.

Despite all the findings cited above, there is not, to the best of our knowledge, any investigation reported in the literature on the subject of iconic memory in OCD patients. Therefore, it has been aimed in this study to compare the iconic memory functions in OCD patients and healthy individuals. The hypothesis at the outset of the study was that the OCD patients would demonstrate a worse performance in the iconic memory test than the control group showing that there could be iconic memory impairment in OCD, which could explain the visual memory-working memory impairments seen in the patients.

METHOD

Participants

This study included 74 patients aged 18-65 years consulting the Psychiatry Hospital polyclinics of Pamukkale University Medical Faculty with OCD diagnoses according to the DSM-5 diagnostic criteria (American Psychiatry Association), who agreed to participate in the study. The control group consisted of 63 hospital personnel or their relatives without any history of psychiatric disorders and age, gender and educationally matched with the patients.

The exclusion criteria of the study comprised refusal to participate in the study, education level below primary school, having intellectual disability, neurocognitive disorders, psychotic disorder, bipolar disorder, alcohol or substance use disorder diagnosed according to the DSM-5, a 6-month history of electroconvulsive therapy (ECT) or transcranial magnetic stimulation (TMS) or a score of ≥17 on the Hamilton Depression Rating Scale (HAM-D).

In the second stage of the study, the OCD patients were placed in 4 subgroups according to the clincially evident washing symptoms, checking symptoms, both the washing and checking symptoms, and neither washing nor checking symtpoms for the comparative assessment of the iconic memory performance between the groups and with the fifth group of healthy control subjects.

The OCD washers subgroup comprised patients with ≥5 scores in the Maudsley Obsessive Compulsive Inventory (MOCI) washing subscale and the patients in the checkers subgroup had ≥5 scores in the MOCI checking subscale. The participants in the washers and checkers subgroups had ≥ 5 scores in both MOCI subscales (Irak and Tosun 2008; Karadag et al, 2005). The OCD subgroup without clinical

symptoms of either washing or checking had <5 scores in the MOCI washing and checking subscales. Only the washing and checking subscales of the MOCI were used in forming the OCD subgroups.

Data Collection Tools

The Yale Brown Obsessive Compulsive Scale (Y-BOCS): The Y-BOCS, used for measuring OCD severity and to evaluate the clinical course and treatment outcomes in the diagnosed individuals, is graded on the basis of 0-4 scores by questioning the degree of obsessive and compulsive symptoms, the time spent by the patient per day on a different symptom, the extent of the disease effect on daily life, the extent of the discomfort felt and the ability to resist and control the behaviour (Kim et al. 1990). The practitioner calculates the scores on the three categories of general obsession, general compulsion and the total scores. The maximum total score is 40, with 20 maximal scores in both the obsession and compulsion subdimesnions. The validity and reliability studies on the Turkish language version of the Y-BOCS was carried out by Tek et al. (1993).

The Maudsley Obsessive Compulsive Inventory (MOCI): This self-report inventory is used to evaluate the type and severity of obsessive compulsive symptoms in patients diagnosed with OCD and in healthy individuals. The original scale includes subscales of checking, washing, slowness and suspicion, and the Turkish language version also includes the subscale of rumination (Hodgson and Rachman 1977, Özsoylar et al. 2008). The scale is completed by marking each correct/wrong response. A score of 1 is given per correct response and the total score is calculated by adding the subscale scores.

The Hamilton Depression Rating Scale (HAM-D): Developed in 1960 to measure the level of depression, the HAM-D contains 17 items with a maximum of 53 scores. A cutoff value of 14 scores indicates depression. The validity-reliability study on the Turkish language version of the scale was conducted by Güleç et al. (2005).

The Hamilton Anxiety Rating Scale (HAM-A): Developed to determine the severity of anxiety and the distribution of symptoms, the 14-item HAM-A is evaluated by the clinician by giving 0-4 scores on each item. A total score of 0-5 indicates absence of anxiety, 6-14 scores indicate mild-moderate anxiety and >15 scores indicate severe anxiety. The validity-reliability study on the Turkish language version of the HAM-A was reported by Aksu and Hocaoğlu (2004).

The Partial Report Test (PRT): The PRT, included by the Psychology Experiment Building Language (PEBL)- 0.14 version test battery by Mueller and Piper (2014) and used by Lu et al (2005), was also used in this study. For each item in the PRT, the participants are shown 8 letters simultaneously on a computer screen for 105 milliseconds (ms). The letters are selected randomly from D/F/J/K sets, and are shown on the screen within a circle (radius, 3.50°) with a fixed point at its centre, at 1.29° horizontal and 1.29° and 0.11° vertical visual angles. As the first stimulus, 8 letters are shown simultaneously for 105ms on a screen. After varying time intervals between each stimulus an arrow appears in the circle pointing at the place of a letter previously shown, which the participant is asked to state (Figure 1) In this study 7 different time intervals were used between the successive stimuli The arrow appeared at 11, 32, 74, 221, 516 or 1.105ms after the disappearance of the letters from the screen or at 116, 137, 179, 326, 621 veya 1,210 ms after the duration of the first stimulus is added. The arrow sign remained on the screen until the participant gives an answer. The Design Balanced Sampling function was used to be able to use each time interval in the test battery with approximately equal frequency. Thus, the distribution of the most frequently used time interval among the questions, between stimuli exceeds the distribution of the least frquently used time interval at the most by 1. The test is formed of 9 blocks of 50 questions each. The first block is a practice block for the participant to become familiar with the test.

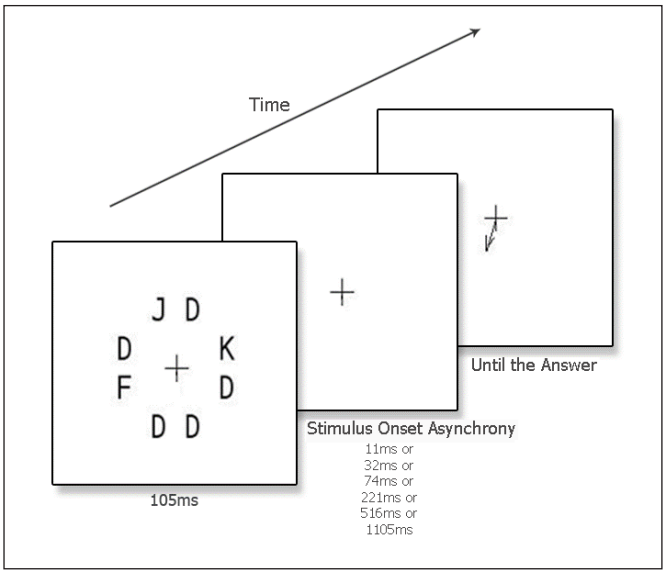

Figure 1. Successive Stages of the Partial Report Test Included in the PEBL battery
When there was onset asynchrony between the two stimuli, the arrow was seen 11, 32,74, 221, 516 and 1105 ms after the letters, in other words when the duration of vision of the first stimulus was prolonged, the stimulus onset asynchrony was 116, 137, 179, 326, 621 or 1210 ms.

Procedure

This study was approved by Non-Interventional Clinical Research Ethics Committee of Pamukkale University with the decision numbered 60116787-020/58754 and dated 13.10.2015. After completion of the clinical interviews, the mental status examinations and the psychometric tests, the participants took the computerised neurocognitive Partial

Report Test (PRT) in a quiet room. For the purposes of the PRT (Meuller and Piper, 2014), an HP Pro One 400 series personal computer with a 15.4-inch touchscreen and 1440 x900 pixel screen resolution was used under the supervision of the researcher. A distance of 25 cm was determined between the subject and the screen. To evaluate the iconic memory, the PRT was translated to the Turkish language by the researchers. Short breaks were given between the blocks of the PRT which lasted 45 mins on average.

Statistical Analysis

When calculating the PRT results, firstly the mean correct value was found for each time interval between the stimuli and their respective percentage values were determined separately. To reduce skewness to a minimum and obtain the highest level of normality, these percentages were then changed to sensitivity index d´ values. In these calculations, the special exponential decay function [$d'(UAM)=a_0+a_1e^{-UAM/\tau}$] was applied to each result. In this multiparameter function, UAM represents the time interval between stimuli, a1 represents the sensitivity of the fast loss of iconic information, τ represents the time constant of the iconic information loss, and a0 the information transferred to the short-term memory in the absence the arrow (Hahn et al, 2011). In this study the rate of iconic information decay, which is the ratio of the difference between sucessive d' values to the first d' value, were compared between the participant groups. For example, the ratio of iconic decay between d1' and d2' is (d1'- d2') / d1'.

The data obtained in the study were statistically analysed using the SPSS (Statistical Package for Social Sciences) version 22.0 software for Windows. The Chi-square test was used to compare the categorical variables between the groups and the t-test was used to compare the continuous variables. Correlations between different clinical variables were assessed with the Pearson's Correlation test. The One-Way ANOVA test was used for comparing the d´ values between the OCD and the control group in the first stage of the study, and for comparing the rates of iconic decay between the d´values. Covariance analysis (ANCOVA) was used with the control of the age variable for comparing the d´values between the OCD subgroups in the second stage of the study. One-Way ANOVA was used in comparison of the rates of iconic decay between the subgroups. The Bonferroni test was used in all post hoc paired comparisons. A value of $p<0.05$ was accepted as statistically significant.

RESULTS

The data of the OCD group

Statistically significant differences were not determined in the sociodemographic data on age, gender and education levels of the OCD group participants and the healthy control group. The Y-BOCS, MOCI, HAM-A, and the HAM-D scores were significantly higher in the OCD group than in the control group (Table 1). Evaluation of the treatment protocols showed that 32 patients were on antidepressants only, 29 were taking antidepressants together with antipsychotic drugs and 13 patients were not yet receiving any treatment. The mean daily drug doses were 145.83±64.12mg for sertraline; 41.05±15.59 mg for fluoxetine; 206.25±86.34 mg for fluvoxamine; 36.66±15.05 mg for paroxetine; 30±14.14 mg for citalopram; 135±62.74 mg for clomipramine; 137.5±53.03 mg for venlafaxine;15±0 mg for mirtazapine, 8.87±6.46 mg for aripiprazole; 250±86.6 mg for quetiapine; 3.75±1.76 mg for olanzapine; 1.66±1.25 mg for risperidone and 200±0 mg for amisulpride.

Statistically significant differences were not determined between the PRT d´scores of the OCD group and the control group (Table 2). The d´scores of the groups are shown in graph form in Figure 2. Statistically significant differences were not determined between the OCD and the control groups with respect to the consecutive d´values and the rates of iconic delay between d1' and d7' (Table 3).

Correlation analyses on the data of all study participants showed statistically significant positive correlation of the PRT d' scores with education level (r=0.550-0.316, $p<0.001$), and negative correlation with age (r=0.606-0.364, $p<0.001$). In the OCD group, the MOCI total score showed negative correlation with the d7' scores only (r=0.287, p=0.013). Negative correlations were determined between the MOCI washing scores and all the d´values from d1 to d7 (r=0.444, $p<0.001$; r=0.278, p=0.016; r=0.314, $p<0.007$; r=0.337, p=0.003; r=0.315, p=0.006; r=0.317, p=0.006; r=0.399, $p<0.001$, respectively). Significant correlations were not found between the scores of the other MOCI sub-tests and any of the d´values ($p>0.05$ for all).

The data of the OCD subgroups

At this stage of data analysis, the study participants consisted of 4 OCD subgroups including those with evident washers symptoms (n:16; 13 females, 3 males), with evident checkers symptoms (n:14; 8 females, 6 males), with both washers and checkers symptoms (n:24; 16 females, 8 males) and without washers and checkers symptoms (non-washers and non-checkers) (n:20; 9 females, 11 males) and the control group (n:63; 37 females, 26 males). These groups did not differ significantly on the basis of gender ($\chi^2=5.428$, df=4, p=0.246) or education durations (respectively, 12.13±3.96, 13.86±2.85, 11.13±5.18, 13.40±4.08 and 12.00±5.28) (F=1.066, df=4, p=0.376). Statistically significant differences were determined between the group mean ages in years (respectively, 31.75±8.86, 24.14±7.04, 33.75±10.95,

Table 1. Socio-demographic Characteristics of the OCD and the Healthy Control Groups

	OCD Group n (%) or Mean± SD	Control Group n (%) or Mean±SD	χ^2/t	df	p
Gender					
Male	28 (%37)	26 (%41)	0.168	1	0.728
Female	46 (%63)	37 (%59)			
Marital Status					
Married	27 (%36)	37 (%58)	6.764	1	0.011*
Single	47 (%64)	26 (%42)			
Age	30.95±10.51	32.95±9.25	-1.175	135	0.242
Duration of Education	12.47±4.32	12±5.28	0.576	135	0.566
Onset Age of OCD	21.75±7.33	-	-	-	-
Y-BOCS-Obsession	10±4.25	0.63±1.19	16.91	135	≤0.001
Y-BOCS-Compulsion	8.66±5.08	0.42±0.91	12.67	135	≤0.001
MOCI total	20.86±6.27	9.07±5.19	11.85	135	≤0.001
MOCI Checking	4.74±2.09	1.26±1.42	11.14	135	≤0.001
MOCI Cleaning	5.27±2.80	2.65±2.07	6.12	135	≤0.001
MOCI Slowness	3.47±1.51	1.26±1.11	9.54	135	≤0.001
MOCI Doubt	4.90±1.52	2.52±1.29	9.75	135	≤0.001
HAM-D	4.77±2.69	2.23±2.29	5.87	135	≤0.001
HAM-A	7.21±7.33	3.47±2.90	3.79	135	≤0.001

OCD: Obsessive-Compulsive Disorder, Y-BOCS: The Yale–Brown Obsessive Compulsive Scale, MOCI: The Maudsley Obsessive-Compulsive Inventory, HAM-D: The Hamilton Depression Rating Scale, HAM-A: The Hamilton Anxiety Rating Scale

Table 2. Comparison of the Partial Report Test d 'values of the Study Groups

	OCD Group		Control Group		One-Way ANOVA		
	Accuracy	d'	Accuracy	d'			
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	F	d.f.	p
0 ms	0.73±0.21	2.26±0.98	0.74±0.18	2.21±0.76	0.134	1	0.715
116 ms	0.55±0.16	1.47±0.48	0.55±0.14	1.48±0.42	0.040	1	0.843
137 ms	0.55±0.17	1.48±0.51	0.54±0.13	1.44±0.38	0.236	1	0.628
179 ms	0.53±0.15	1.44±0.49	0.54±0.12	1.44±0.37	0.011	1	0.915
326 ms	0.50±0.15	1.34±0.49	0.51±0.12	1.35±0.35	0.049	1	0.826
621 ms	0.47±0.12	1.23±0.35	0.46±0.11	1.21±0.35	0.188	1	0.665
1210 ms	0.43±0.12	1.09±0.39	0.48±0.09	1.12±0.29	0.168	1	0.683

OCD: Obsessive-compulsive disorder

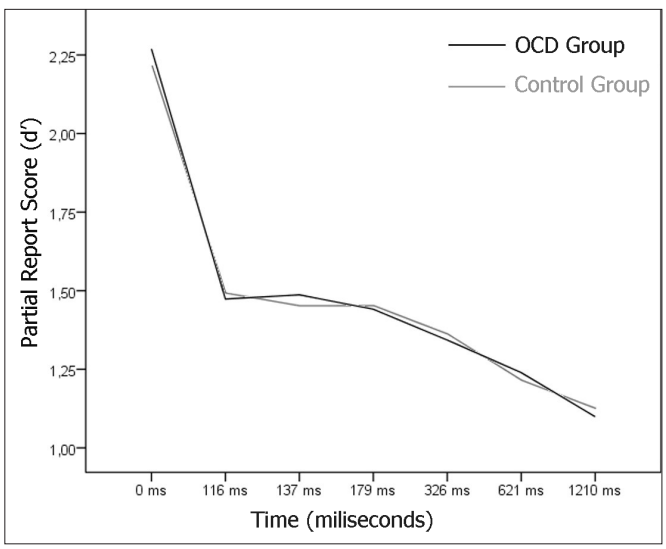

Figure 2. Graphical Representations of the Iconic Memory Scores of the OCD and Control Groups

31.70±11.77 and 32.95±9.25) (F=2.621, df=4, p=0.038). In the paired comparisons, the washers subgroup was found to be younger than the washers and checkers subgroup and the control group (p=0.027 and p=0.040, respectively).

In the One-Way ANOVA, significant differences were not determined between the 4 OCD subgroups with respect to duration of illness (F=1.657, df=3, p=0.189), the Y-BOCS obsession subscale scores (F=1.706, df=3, p=0.174) and the HAM-D scores (F=2.294, df=3, p=0.085). Statistically significant differences were determined between the OCD subgroup scores on the Y-BOCS compulsion subscale scores (F=5.285, df=3, p=0.002) and the HAM-A scores (F=2.962, df=3, p=0.038). In the paired comparisons, the washers and checkers subgroup, and the washers subgroup were determined to have higher scores on the Y-BOCS compulsion subscale than the OCD non-washers and non-checkers subgroup (p=0.003, p=0.016, respectively). The HAM-A

Table 3. Comparison Between the OCD Group and the Control Group of the Decay Rates in Iconic Information

	OCD Group		Control Group		One-Way ANOVA		
	Mean	SD	Mean	SD	F	df	P
(d1'- d2' / d1)	0.79	0.63	0.72	0.52	0.504	1	0.479
(d2'-d3' / d2)	-0.01	0.23	0.04	0.27	1.499	1	0.223
(d3'-d4' /d3)	0.04	0.28	0.00	0.24	1.011	1	0.316
(d4'-d5' / d4)	0.09	0.32	0.08	0.24	0.028	1	0.866
(d5'-d6' / d5)	0.10	0.30	0.14	0.26	0.755	1	0.387
(d6'-d7' /d6)	0.14	0.23	0.08	0.33	1.083	1	0.300
(d1'-d7' / d1')	0.47	0.20	0.45	0.17	0.378	1	0.540

OCD: Obsessive-compulsive disorder

scores of the OCD subgroups did not significantly differ in the paired comparison analyses.

With respect to drug therapy, 9 of the 16 washers subgroup participants were on antidepressants, 5 were on antidepressants and antipsychotic drugs while 2 were not receiving treatment. In the checkers subgroup, 6 of the 14 participants were on antidepressants, 5 were on antidepressants and antipsychotic drugs while 3 were not receiving treatment. In the washers and checkers subgroup, 9 of the 24 participants were on antidepressants, 8 were on antidepressants and antipsychotic drugs and 7 were not receiving treatment. In the non-washers and non-checkers subgroup, 9 of the 20 patients were on antidepressants, 10 were on antidepressants and antipsychotic drugs and 1 was not receiving treatment. Statistical analyses including data of all the OCD subgroups did not demonstrate significant group differences with respect to being or not being on drug therapy (χ^2=4.839, df=3, p=0.184), using or not using antidepressants (χ^2=1.787, df=3, p=0.618) or being or not being on combination therapy (χ^2=1.761, df=3, p=0.624).

Given the the significant differences of age between the OCD subgroups and the correlation between age and all the d´values, the age variable was controlled in the comparisons of the d´values of the subgroups. Thus, ANCOVA analysis was carried out with the age variable as the control variable, the OCD subgroups and the control group as the independent variables, and all the d´scores as the dependent variables. The group effect was significant at d1' and d7' (F=4.179; df=4, p=0.003 and F=5.358, df=4, p<0.001, respectively) but not significant at other d´ times (p>0.05). Therefore, paired comparisons were made on the d1' and d7' values of the subgroups. The d1' values of the washers subgroup were significantly lower than those of the checkers subgroup and the non-washers and non-checkers subgroup; and also tended to be lower than the d1' values of the healthy control group. In the paired comparisons, the d7' values of the washers subgroup were significantly lower than the d7' values of the non-washers and non-checkers subgroup and also lower at borderline significance level from the control group values.

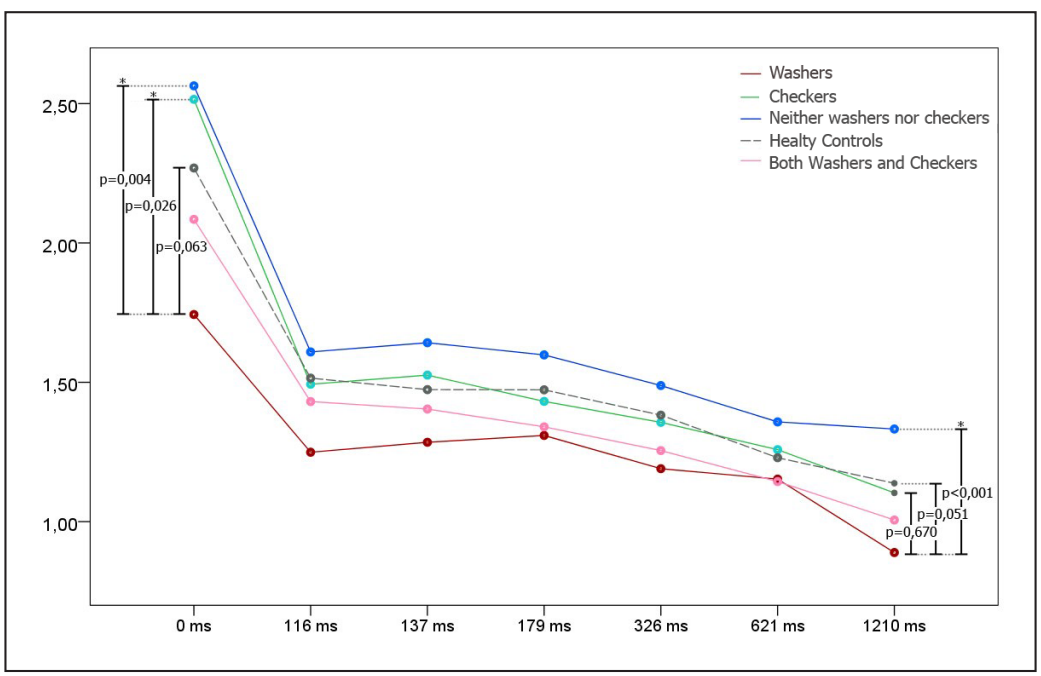

Figure 3. Estimated Marginal Average d' Values of the Study Groups According to Age at 31.87 years

Table 4. Comparisons Between the Study Subgroups and the Controls of the Decay Rates of Iconic Information

	Washers		Checkers		Both Washers and Checkers		Non-Washers-Non- Checkers		Healthy Controls		One-Way ANOVA		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	df	p
(d1'- d2' / d1')	0.26	0.15	0.39	0.11	0.26	0.17	0.32	0.17	0.29	0.17	1.587	4	0.181
(d2'-d3' / d2')	-0.03	0.24	-0.02	0.14	-0.01	0.18	-0.03	0.18	0.00	0.24	0.232	4	0.920
(d3'-d4' / d3')	-0.07	0.27	0.05	0.14	0.02	0.25	0.00	0.21	-0.02	0.20	0.841	4	0.501
(d4'-d5' / d4')	0.06	0.29	0.03	0.19	0.00	0.36	0.04	0.19	0.03	0.22	0.138	4	0.968
(d5'-d6' / d5')	-0.01	0.31	0.04	0.23	0.00	0.36	0.05	0.18	0.09	0.20	1.082	4	0.368
(d6'-d7' / d6')	0.25	0.20	0.12	0.19	0.08	0.40	0.00	0.18	0.01	0.32	2.446	4	0.050
(d1'-d7' / d1')	0.47	0.23	0.56	0.10	0.48	0.16	0.40	0.26	0.45	0.17	1.514	4	0.202

Significant differences were not determined in the other paired comparisons (p>0.05 for all). The significant difference seen between the checkers and the washers subgroups at the d1' stage decreased and lost its statistical significance at the d7' stage (p=0.670) (Figure 3).

A borderline significance in the rates of iconic information loss was seen at the d6' and d7' stages (Table 4). In the paired comparisons of the subgroups, a significantly greater rate of iconic decay was seen in the washers subgroup as compared to the control group (p=0.049). Significant differences were not determined in the paired comparisons of the other subgroups. (p>0.05).

DISCUSSION

The results of this study gave the impression that there were not significant differences in the rates of iconic memory and iconic information loss in comparison to the control group when the OCD participants were taken as a single group. However, when the OCD subgroups were evaluated separately, the washers subgroup showed a greater iconic information loss between 621 ms and 1210 ms than the healthy control group. Moreover, at the 1210 ms time point, the information transfer to the working memory of the washers subgroup was less compared to the non-washers and non-checkers subgroup. At each time point measured from 0 ms to1210 ms, the amount of iconic information showed consistent correlations with the MOCI washing scores. During the iconic information formation, the amount of information in the iconic memory of the OCD washers subgroup was less as compared to the healthy control group and the OCD non-washers and non-checkers subgroup (Figure 3); and it decreased further between 621ms and 1210 ms in comparison to the healthy control group.

These results suggest the possibility of dysfunctions in the mechanisms of both the formation of iconic information and its transfer to the working memory. To the best of our knowledge, this is the first study in the literature on the investigation of iconic memory in OCD patients. Considering that both the formation of iconic information and the fast decay of the acquired information could affect the amount of visual information transferred to the working memory, and the working memory dysfunctions reported in the OCD patients (Kashyap et al. 2017) could be related to iconic memory. It can therefore be speculated that these dysfunctions could conribute to the factors causing the uncertainty in these patients about becoming clean when washing hands or having a bath. There are some indirect data in the literature that could support the association between the washers symptoms and iconic memory-related dysfunctions seen in OCD patients. Similarly to the current study, the previous study on an eastern population by Kashyap et al. (2017) showed an association between visual working memory scores, washing symptoms and impaired attention. Another study also reported the association of both the washers symptoms and visual perception as well as the impairments in the areas of cognitive flexibility, planning, organisation and processing speed (Pedron et al, 2015). Although it could be speculated that these reports on visual processing dysfunction could be related to the impairment of iconic information formation or the fast decay of iconic information in patients with the washers symptoms, there is need for further research employing tests relevant to visual processing together with the iconic memory test in OCD patients.

In the current study, the difference in forming iconic information between the washers subgroup and the non-washers and non-checkers subgroup continued up to 1210 ms, which is known to be the endpoint of iconic memory. This indicated a significant differentiation of the washers subgroup and the non-washers and non-checkers subgroup in the formation of iconic information and the subsequent cognitive functions (Figure 3). In so far as we know, this important finding is reported for the first time in the literature, and needs must be biologically confirmed by further research where electrophysiological studies may be useful. The previously made studies on electrophysiological investigation of early visual perception functions in OCD patients, not

differentiated on the basis of clinical symptoms, had reported conflicting results. Di Russo et al. (2000) recorded the visually evoked potentials of OCD patients during the "go/no go" test and reported that the N1 wave, thought to emerge approximately 100 ms after the visual stimulus, was delayed in the OCD patients incomparison to the control group and the amplitude of this wave was greater in the OCD patients than in the control group. Although this result supports the impairment of early visual processing in OCD patients, Savage et al. (1994) could not demonstrate a similar difference in the visually evoked potentials between OCD patients and the control group. However, neither of these two studies evaluated OCD patients subgrouped according to the heterogeneity of symptoms, which may underlie the difference between their results. Future studies evaluating the early visually evoked potentials of subgrouped OCD patients could provide valuable information related to early perception functions. A previous meta-analysis reported that visual memory and working memory performances were more impaired in OCD patients with checkers symptoms as compared to those with washers symptoms (Leopold and Backenstrass 2015). As discussed earlier, if the trigger of the visual proccessing dysfunctions, observed in OCD patients with washers symptoms, is an iconic memory dysfunction causing less information transfer to the subsequent cognitive functions, it becomes difficult to explain why iconic information formation disorder or fast iconic decay is not seen in OCD patients with checkers symptoms who can show more severe visual processing disorders than OCD patients with washers symptoms. Moreover, the symptoms seen in these patients are generally in the form of uncertainty whether there is a view which can be visually perceived.

Although the results match on the uncertainty of correct perception of visual stimuli by the OCD patients with washers or checkers symptoms, it has been frequently reported in the literature that these two OCD subgroups differ from each other biologically (Mataix-Cols et al. 2004, Nakao et al. 2014, van den Heuvel et al. 2009) and on cognitive mechanisms (Bragdon et al. 2018, Hashimoto et al. 2011) suggesting that the feelings of uncertainty are based on different mechansms in these two OCD subgroups. On the other hand, the current study has demonstrated in these two OCD subgroups the disappearance over time of the significant difference in the amount of information transferred to the working memory or the visual memory.

The principal limitation of this study is the low number of participants in the subgroups after subgrouping of the OCD group. Another limitation arises from including participants some of whom were on therapy with antidepressant and antipsychotic medication. As far as we know, there is not a study on the relationship of these type of drugs and iconic memory. However, no significant difference was determined between the subgroups of this study in respect of the treatments used, suggesting that this potential limitation did not affect the study results. In subgrouping the OCD particpants, only the washing and checking subscales of the MOCI were used. Since the MOCI cannot evaluate other OCD subtypes, the results of the study should be evaluated with this limitation in mind. Also, not having carried out intelligence test on the participants may be considered a further limitation. Despite these limitations, however, this study has demonstrated that in comparison to healthy individuals and OCD patients without evident washers or checkers symptoms, the OCD patients with clinically evident washers symptoms have dysfunctions in the mechanisms of formation and decay of iconic information which could significantly affect the amount of information transferred to visual memory and visual working memory.

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