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Cognitive control of a simple mental image in patients with obsessive–compulsive disorder

Orhan Murat Koçak [a,*], Ayşegül Yılmaz Özpolat [b,2], Cem Atbaşoğlu [b,c,2], Metehan Çiçek [b,c,1]

[a] Kirikkale University, School of Medicine, Psychiatry Department, Turkey
[b] Ankara University, School of Medicine, Psychiatry Department, Turkey
[c] Ankara University, Brain Research Center, Turkey

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ABSTRACT

The nature of obsessions has led researchers to try to determine if the main problem in obsessive–compulsive disorder (OCD) is impaired inhibitory control. Previous studies report that the effort to suppress is one of the factors that increase the frequency of obsessive thoughts. Based on these results and those of the present study that suggest inferior parietal lobe (IPL) abnormality in OCD and findings of a recent study that reported the importance of the right posterior parietal cortex in cognitive control of a simple mental image, the present cognitive control paradigm study aimed to determine whether there is a difference in brain dynamics between OCD patients and non-obsessive controls while performing tasks that necessitate cognitive control of a simple mental image, and whether the right posterior parietal region is one of the regions in which a difference in activity between the OCD patients and controls would be observed. Functional brain imaging was performed while the participants attempted to suppress, imagine, or manipulate a mental image. The general linear model showed that there was a main effect of group and main effect of task. Accordingly, in all contrasts (suppression minus free-imagination, erasing minus free-imagination, and imagination minus free-imagination), the right IPL, right posterior cingulate cortex, and right superior frontal gyrus activity were lower in the OCD patients than in the healthy controls. These results and the observed correlations between activity levels, and symptom and subjective performance scores are discussed. In conclusion, the results of the present study and those of previous studies suggest that the main problem in OCD might be difficulty activating the right frontoparietal networks during tasks that require cognitive control, which might result in the intrusiveness of obsessive thoughts.

1. Introduction

Obsessions are recurrent and persistent thoughts, images, or impulses that are experienced as intrusive and cause marked anxiety or distress (DSM-IV, American Psychiatric Association, 1994). The intrusive nature of obsessions has led researchers to try to determine if OCD patients have impaired cognitive control. Studies that focused on cognitive control of mental content using a thought suppression (TS) paradigm reported that effort to suppress thoughts can cause a paradoxical increase in the thought's intrusiveness (Abramowitz, Tolin, & Street, 2001; Purdon, 1999; Rassin, Merckelbach, & Muris, 2000; Wenzlaff & Wegner, 2000;), and that the effort to suppress is one of the factors that increases the frequency of obsessive thoughts (Grisham & Williams, 2009; Marcks & Woods, 2007; Morillo, Belloch, & Garcia-Soriano, 2007). In the light of these findings it was thought that investigating the differences in brain dynamics between obsessive individuals and non-obsessive controls while performing tasks that necessitate cognitive control of simple mental content (such as a thought or an image) could yield findings important for understanding impaired cognitive control mechanisms that play a role in the occurrence of obsessions. The cognitive control paradigm used in the present study encompasses mechanisms involved in sustaining goal-directed action, processing task-relevant stimuli, and effective control of errors via inhibition of intrinsic/extrinsic interference.

Only a few functional imaging studies have examined which brain regions are involved in the control of simple mental content, and the results were insufficient for definitively indentify

* Corresponding author. Address: Kırıkkale Üniversitesi Tıp Fakültesi Psikiyatri Anabilim Dalı Süleyman Demirel Eğitim ve Araştırma Hastanesi, 71100, Kırıkkale/Turkey. Fax: +90 318 225 28 19.
E-mail addresses: orhanmuratkocak@gmail.com (O.M. Koçak), aysgulyilmaz@yahoo.co.uk (A.Y. Özpolat), E.Cem.Atbasoglu@medicine.ankara.edu.tr (C. Atbaşoğlu), metehan.cicek@medicine.ankara.edu.tr (M. Çiçek).
[1] Address: Ankara Üniversitesi Tıp Fakültesi Morfoloji Binasi Fizyoloji Anabilim Dalı, 06100 Ankara, Turkey. Fax: +90 318 225 28 19.
[2] Address: Ankara Üniversitesi Tıp Fakültesi Psikiyatri Anabilim Dalı Dikimevi, 06100 Ankara, Turkey. Fax: +90 312 319 21 60.

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particular mechanisms (Kocak, Cicek, Yagmurlu, & Atbasoglu, 2008; Mitchell et al., 2007; Wyland, Kelley, Macrae, Gordon, & Heatherton, 2003). Using different methods researchers have shown that the insular cortex (IC) (Kocak et al., 2008; Wyland et al., 2003), anterior cingulate cortex (Mitchell et al., 2007; Wyland et al., 2003), and posterior parietal region (intraparietal sulcus [IPS]) (Kocak et al., 2008) are activated while attempting to suppress a thought. These regions were also reported to be abnormally activated in OCD patients (Adler et al., 2000; den Braber et al., 2008; Gu et al., 2008; Henseler et al., 2008; Mataix-Cols et al., 2004; Nabeyama et al., 2008; Nakao et al., 2009; Remijnse et al., 2006; Remijnse et al., 2009; Roth et al., 2007; Van den Heuvel et al., 2005; Yucel et al., 2007). With the exception of the anterior cingulate cortex, which is thought to play a central role in action monitoring and conflict resolution (which are reported to be impaired in OCD patients), these regions have not been integrated into models that explain the etiopathogenesis of OCD (Menzies et al., 2007). The role of the parietal region is particularly intriguing in this respect. We previously observed anteroposterior distribution of activity in the right intraparietal sulcus while controlling a mental image. During thought suppression (TS) activity was observed in the IPS and during mental manipulation this activity shifted to the anterior region of the IPS (Kocak et al., 2008). The right posterior parietal region also seems to be essential for visuospatial ability, which is reportedly impaired in OCD. Findings indicating posterior parietal abnormalities in OCD (Carmona et al., 2007; Menzies et al., 2008; Szeszko et al., 2005; Valente et al., 2005), the role of the right IPS in controlling a simple mental image (Kocak et al., 2008), and visuospatial deficits in patients with OCD (Muller & Roberts, 2005; Penades, Catalan, Andres, Salamero, & Gasto, 2005; Purcell, Maruff, Kyrios, & Pantelis, 1998; Savage et al., 1999; Segalas et al., 2008; Shin et al., 2004; Zitterl et al., 2001) suggest that in OCD abnormal right posterior parietal region (surrounding the IPS) functioning might be associated with an increase in the frequency of obsessive thoughts.

To the best of our knowledge the literature does not contain any functional imaging studies that examined how a simple thought or image is controlled in OCD. The present study aimed to determine if there were any differences between OCD patients and healthy controls, in terms of brain activity during cognitive control tasks associated with a simple mental image. In the present study cognitive control was assessed during three mental tasks: 1. suppression of an image (suppression); 2. mental manipulation of an image (erasing); 3. maintaining the image in mind (imagination). We hypothesized that activity patterns during the cognitive control tasks would differ between the two groups. In addition, it was hypothesized that the right posterior parietal region would be one of the regions in which a difference in activity between the OCD patients and controls would be observed.

2. Materials and methods

2.1. Participants

The study included 12 right-handed (six male and six female) OCD patients (OCD group) and 12 right-handed healthy volunteers matched for gender and level of education (control group). None of the participants in the control group had a neurological disorder or DSM-IV Axis I psychiatric disorder. Among the OCD patients, eight were cleaners, three were checkers (one of the checkers also had contamination obsessions), and one had harming obsessions. None of the OCD patients had another DSM-IV Axis I psychiatric disorder.

Disease duration in the OCD group ranged from 6 months to 7 years. All the participants were, at minimum, high school graduates. Written informed consent was obtained from all the participants, and sociodemographic data, medical history, and current health status were determined using a detailed questionnaire. SCID-I was administered to all the participants and the Yale-Brown Obsessive Compulsion Scale (Y-BOCS) (Goodman, Price, Rasmussen, Mazure, Delgado, et al., 1989; Goodman, Price, Rasmussen, Mazure, Fleischmann, et al., 1989), which was reported to be valid and reliable for use in the Turkish population (Tek et al., 1995), was used to measure disorder severity in the OCD patients. After completing the questionnaires all of the participants completed the Chapman and Chapman Handedness Inventory (1987) (its validity and reliability for use in the Turkish population was reported by Nalcaci, Kalaycioglu, Gunes, and Cicek (2002)).

Just before the experimental paradigm was explained to the participants they each completed the State-Trait Anxiety Inventory (STAI) (Spielberger, 1983), which was reported to be reliable and valid for use in Turkey by Öner and Le Compte (1985). Group means and standard deviations for age, handedness, STAI score, and Y-BOCS score, and *P* values for the comparisons of these variables are presented in Table 1. There were not any significant differences in the variables between the groups, except trait anxiety score, which was significantly higher in the OCD group.

2.2. The experimental paradigm procedure

The participants performed five tasks while undergoing functional magnetic resonance imaging (fMRI): imagination, suppression, erasing, free-imagination, and resting. The imagination, suppression, and erasing tasks were cognitive control tasks, the free-imagination task was used as the baseline condition, and the resting task was used to facilitate recovery of hemodynamic response to baseline levels. The content of the cognitive control tasks was a non-specific geometric shape drawn on an A4 sheet of paper (Fig. 1). While the participants were given instructions they were shown this sheet of paper. The instructions given to the participants for these tasks were as follows: 1. Imagination task: imagine the shape on the paper continuously until another command is given; 2. Suppression task: imagine the paper with the shape on it immediately after the command is given, and then immediately suppress the image of the shape (try to see the paper as blank) until another command is given; 3. Erasing task: imagine the paper with the shape on it, and then erase the shape by tracing its outline it until another command is given (Fig. 1); 4. Free-imagination task; imagine whatever comes to mind and change it with any other intrusive image – a type of free-association task of mental images (this task was used as the baseline condition task); 5. Resting condition: rest while in the scanner.

Most studies in the literature that investigated cognitive control focused on inhibitory cognitive control. In this regard the suppression task used in the present study can be thought of as the main cognitive control task. Even though inhibition is a core construct (Banich et al., 2009; Davidson, Amso, Anderson, & Diamond, 2006), there is a consensus among researchers that cognitive

Table 1
Mean and standard deviation (SD) for age, handedness, state anxiety, trait anxiety, and Yale-Brown obsessive compulsive scale (Y-BOCS) scores in both groups. P values for the comparisons of these variables are based on Student's *t* test.

	OCD		Control		*P*
	Mean	SD	Mean	SD	
Age	27.00	5.80	25.08	3.32	0.331
Handedness	13.33	0.65	13.67	0.89	0.306
State anxiety	35.17	9.93	31.75	7.66	0.356
Trait anxiety	49.25	8.79	34.50	8.50	0.000
Y-BOCS	20.25	6.24	–	–	–