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# Cognitive rigidity in unipolar depression and obsessive compulsive disorder: Examination of task switching, Stroop, working memory updating and post-conflict adaptation

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ABSTRACT

Obsessive compulsive disorder (OCD) and depressive rumination are both characterized by cognitive rigidity. We examined the performance of 17 patients (9 suffering from unipolar depression [UD] without OCD, and 8 suffering from OCD without UD), and 17 control participants matched on age, gender, language and education, on a battery covering the four main executive functions. Results indicated that, across both disorders, patients required more trials to adjust to single-task conditions after experiencing task switching, reflecting slow disengagement from switching mode, and showed abnormal post-conflict adaptation of processing mode following high conflict Stroop trials in comparison to controls. Rumination, which was elevated in UD and not in OCD, was associated with poor working memory updating and less task preparation. The results show that OCD and UD are associated with similar cognitive rigidity in the presently tested paradigms.



## 1. Introduction

Many psychological disorders are characterized, phenomenologically, by some form of cognitive rigidity. Two such disorders are obsessive compulsive disorder (OCD) and unipolar depression (UD, see also Pronin and Jacobs, 2008). In OCD, patients suffer from obsessions: recurrent, persistent and distressing intrusive thoughts, impulses, or images which are difficult to disengage from or suppress (American Psychiatric Association, 1994). In UD, patients tend to ruminate: repetitively think about the causes, consequences and symptoms of their negative affect (Nolen-Hoeksema, 1991). Understanding the nature of these two forms of rigid thinking may lead to important insights regarding these pathologies, especially given the rapidly growing body of knowledge regarding the cognitive and neurological underpinning of cognitive rigidity. The questions addressed in this study are, “What characterizes the cognitive rigidity found in these two psychopathologies?” and “Are there differences between these two disorders in terms of type or nature of cognitive rigidity?” Understanding rigidity in these two pathologies is important both theoretically and clinically. For example, if the pathologies are associated with similar rigidity, this would suggest that rigidity may be a general risk factor for these disorders. Clinically, incorporating recently developed training protocols that have been shown to improve flexibility may be indicated (e.g., Karbach and Kray, 2009).

In order to be able to address these questions, we had to use precise and rich measurements that would cover a wide variety of differential aspects of rigidity. Such an approach allowed us to address the question regarding whether the *profile* of rigidity is similar or different across indices. We also had to take into account the high co-morbidity of these two pathologies, which could potentially cause them to appear to be similar. For this reason, we excluded from the study patients exhibiting both OCD and depressive symptoms. In the next section we present the rationale for choosing our measurements, especially those based on the task switching paradigm.

The task switching paradigm (Meiran, 2010; Monsell, 2003, for reviews) is considered to be the most precise measure of cognitive rigidity to date. In this paradigm, participants are asked to rapidly switch between simple cognitive tasks, such as color judgment (e.g., green vs. red), shape judgment (e.g., circle vs. square) and size (e.g., small vs. large). This paradigm enables researchers to study the processes associated with forming and changing trains of thoughts, in this case “task sets”. It provides several advantages relative to classical neuropsychological tests such as the Wisconsin Card Sorting Test (WCST, Berg, 1948), in which participants need to find a sorting rule based on correct/incorrect feedback provided by the experimenter. The most notable

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advantage of the task switching paradigm is that it taps different aspects of rigidity, including the cost of actual switching, the cost of maintaining readiness for a switch, the degree of disengagement from a previous set, the rate of disengagement and others. In contrast, the WCST provides a single measure of rigidity: the number of perseverative errors. These are the errors associated with employing the previously relevant but no longer relevant sorting rule. Additionally, like the WCST, performance in the task switching paradigm is multifactorial, but unlike the WCST, the different factors are clearly distinguishable from one another. We will give just one example: Perseverative errors may result from poor memory of the previous choices, poor memory of the sorting rule or from difficulty in processing the correct/incorrect feedback. In the task switching paradigm, however, the classification rules appear on the screen and therefore require minimal if any memory and there is no need to keep track of past choices. Thus, measurements of rigidity are not contaminated by working memory and feedback processing (e.g., Miyake et al., 2000). Another notable advantage of this paradigm is that its indices have been linked to differential neurological substrates and processes (e.g., Derrfuss et al., 2005, Dosenbach et al., 2006; Sakai, 2008, for reviews), which we discuss further in the sections below.

Only two studies have examined task switching performance in OCD. Moritz et al. (2004), who examined two widely studied task switching-related parameters (switching cost and backward inhibition), did not find any abnormality among OCD patients. *Switching cost* is believed to reflect the difficulty associated with actual switching. It is reflected in a decrement in performance (reaction time, RT, and proportion of errors, PE) in trials involving a task switch as compared to trials in which the task is repeated from the preceding trial. *Backward inhibition* reflects a hypothetical process responsible for suppressing the previously relevant task set when switching to a new task set, so that the previous task set does not interfere with performance. Gu et al. (2008), on the other hand, did find increased PE in switch trials, but not in task repetition trials, among OCD patients compared to controls. This pattern suggests that OCD is related to increased task switching cost, seen for some reason only in errors and not in RT. Only one study investigated task switching in depression. Whitmer and Banich (2007) found that depression and rumination scores correlated with both task switching cost and backward inhibition in a college sample. The results of these three studies suggest that there is a differential profile of rigidity in the two pathologies. OCD seems to be related to a relatively mild increase in switching cost while depression seems to be related to both increased switching cost and impaired task-set inhibition. Research based on classical neuropsychological tests has reached a similar conclusion, at least regarding set switching. Such research has found a relatively consistent pattern of set switching difficulties in UD (see Austin et al., 2001; Rogers et al., 2004, for review) whereas the picture regarding OCD (Chamberlain et al., 2005; Greisberg and McKay, 2003; Kuelz et al., 2004; Menzies et al., 2008; Olley et al., 2007, for review), is mixed, with some studies finding impairment and some not, suggesting that the impairment is rather mild.

We examined cognitive flexibility in these two patient groups using a task switching paradigm (described below). Because set shifting ability (measured with task switching) is considered to be an executive function, we also measured other executive functions for completeness sake. To choose these functions, we relied on Miyake et al.'s (2000) taxonomy including three fundamental executive functions: shifting, inhibition, and working memory updating. We also studied a fourth, widely mentioned executive function — conflict monitoring (e.g., Botvinick et al., 2001). Functional imaging studies have linked problems with monitoring to abnormal functioning of the anterior cingulate cortex in patients suffering from OCD and depression (e.g., Elliot, 1998; Ullsperger, 2006). Another motivation to include additional executive functions in this study was their conceptual link to rigidity. Specifically, successful monitoring is required in order to detect a need to change processing mode. Failing to adjust processing mode according to changing contextual demands would count as rigidity. Likewise, successful inhibition is required in order to suppress one's tendency to operate based on the old, no-longer-relevant mode (see especially Friedman and Miyake, 2004). Accordingly, habitual behavior in situations requiring non-habitual responses would also count as rigidity. Finally, when there is a context change and an accompanying goal change, this information needs to be updated in working memory. Failure to update working memory with the new goal would result in perseverative and rigid behavior.

To study inhibition, we employed the Stroop (1935) test in which participants are asked to name the ink color of congruent (e.g., the word RED written in red ink, and requiring "red" response) and incongruent (e.g., the word GREEN written in red ink and requiring "red" response) words. The critical index of inhibition is the Stroop effect, which is the difference in performance between congruent and incongruent trials. To study working memory *updating* we used Oberauer's (2002) paradigm (see description below). To study monitoring, we examined an index called post-conflict adaptation — also known as the Gratton effect (Gratton et al., 1992; see also Freitas et al., 2007; Kerns et al., 2004). Post-conflict adaptation refers to the sharpened focusing on task-relevant information following high conflict trials. In the case of the Stroop task, it is evidenced by a smaller Stroop effect following incongruent trials as compared to congruent trials.

### *1.1. Predictions*

Results from prior studies, reviewed above, tentatively support the hypothesis that OCD and UD have differential rigidity profiles. Yet, to date, there is no study that has directly compared OCD and UD in task switching. Given the immense variability among task switching paradigms, any cross-study comparison is seriously limited. Moreover, previous studies have focused on only two measurements: switching cost and backward inhibition. In the present investigation we decided to broaden the exploration and include several additional parameters conceptually related to set perseveration and switching, especially to aspects that are likely to differentiate between the two pathologies. This is in accordance with the current Zeitgeist proposing that there is a differential underlying neurology, expressed as differential types of rigidity. Specifically, OCD has been linked to basal ganglia and prefrontal impairments (e.g., Kuelz et al., 2004; Menzies et al., 2008) whereas UD has been linked to cortical impairments, especially the anterior cingulate cortex and the dorso-lateral prefrontal cortex (e.g., Rogers et al., 2004). Moreover, the basal ganglia have been shown to be related to very distinct aspects of rigidity (e.g., Yehene et al., 2008). Below we explain the indices which we used in the present study and how they may be linked to UD and OCD.

When computing switching cost, the performance measure (e.g., reaction time, RT) in task switch trials is subtracted from that in task repetition trials. Note that task switch trials and task repetition trials occur in contexts in which a task switch *could* take place. Hence, in both conditions, participants need to maintain some readiness for a task switch. To assess the cost associated with maintaining readiness to switch tasks, we included a context in which task switching *could not* take place since only one task was required, "single-task". The comparison between performance in task repetition trials and single-task trials provides an index of the cost associated with maintaining readiness to switch tasks, called "mixing cost" (e.g., Braver et al., 2003; Rubin and Meiran, 2005). We also focused on the period of transition from the condition in which task switching could occur to the single-task condition, in which task switching could not occur. Specifically, we examined how RT became shorter in the course of this single-task block. Previous results by Mayr and Liebscher (2001; see also Meiran et al., 2001) indicate that aging is related to a very slow adaptation to single-task conditions following task switching. This "fadeout" effect reflects the rate of disengagement from a switching mode and, thus, indicates rigidity because it shows that the person maintains readiness for a task switch despite the change in context to one in which switching is no