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Intrusive Thoughts and Executive Functions in Obsessive Compulsive Disorder

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Abstract

Objectives: Our aim was to compare the effects of an unwanted intrusive thought on executive function in a group of people with Obsessive Compulsive Disorder (OCD) and in a healthy group. **Method:** The Behavior Rating Inventory of Executive Function Adult (BRIEF-A) was used to measure executive dysfunction in everyday life in people with OCD. The study participants underwent either an intrusive thought induction or neutral thought induction prior to the administration of three computer-based tests of executive function. **Results:** The BRIEF-A results confirmed the impairment of executive function in everyday life for patients with OCD. In the number-letter task, patients with OCD displayed a longer reaction time (relative to the controls). There were no intergroup differences in the local-global task. In the go/no-go task, there was a significant impairment ($p = 0.03$) in the OCD group (with more commission errors than controls). There was a non-significant trend towards an effect of thought induction in both groups in the number-letter task. However, intrusive thought induction did not have a greater effect than neutral thought induction on the OCD group in any of the tasks. **Conclusions:** Intrusive thought induction has no effect on executive function in the two groups. The two groups differed with regard to two executive tasks.

Keywords

Obsessive Compulsive Disorder, Intrusive Thought, Executive Function, Mental Flexibility, Inhibition Function

1. Introduction

Obsessive compulsive disorder (OCD) is characterized by intrusive obsessive thoughts, images or impulses (obsessions) that are perceived as the product of

one's own mind and/or repetitive compulsive behaviors or mental rituals (compulsions) [1]. Many studies have found that the intrusive thoughts experienced by "normal" (non-clinical) participants and the obsessions experienced by patients with OCD have the same content [2] [3] [4] [5]. The most common obsessions are doubts about previous actions (in "checkers") and fear of contamination (in "washers"). Intrusive thoughts related to doubt are more prevalent in non-clinical populations [4] [6]. Relative to intrusive thoughts in controls, obsessions in patients with OCD 1) occur more frequently, 2) interfere more with everyday life, 3) are perceived to be more important to get out of the mind, and 4) are more difficult to stop for patients with OCD. Neuropsychological studies have sought to gain a better understanding of the processes that underlie obsessive compulsive symptoms in people with OCD vs. non-clinical populations. Obsessive compulsive cognition can be conceptualized in terms of a failure to inhibit intrusive thoughts or a failure to shift attention away from intrusive thoughts [7]. It is now generally accepted that the impairments in memory tasks (and particularly visual memory tasks) observed in people with OCD are due to the failure of organizational strategies involving executive functions [8] [9]. In view of the contradictory results reported for several cognitive domains, Chamberlain, Blackwell, Fineberg, Robbins and Sahakain [10] suggested that OCD might be conceptualized as a "lateral orbitofrontal loop dysfunction" with impairments in cognitive and behavioral inhibitory processes. Several studies have observed impaired executive functions in patients with OCD [11]. Executive functions correspond to a set of processes involved in facilitating adaptation to novel situations—notably when habits or learnt cognitive skills are not sufficient [12]. These functions include "planning, goal-directed behaviors, self-regulation, maintenance of cognitive set and set-shifting ability, impulse control, motor inhibition, sustained attention, and working memory" (Evans and colleagues [11], p. 222). Set-shifting and response inhibition appear to be more specifically involved in the perseveration seen in obsessions and compulsions [9] [13]. Greisberg and McKay [14] reviewed 14 studies (performed between 1992 and 1999) of executive function and attention in patients with OCD. Relative to healthy participants, OCD tended to be linked to interference effects. However, none of the 14 studies controlled for depression. This is a concern as executive functioning deficits are observed in depression. Kueltz and colleagues [8] reviewed a number of studies performed between 1991 and 2002: there were 29 studies of set-shifting ability in patients with OCD, 19 studies on verbal and non-verbal fluency tasks in patients with OCD and in healthy controls, and 7 studies on conceptual thinking and planning ability in patients with OCD. The Wisconsin Card Sorting Test (WCST) is the most commonly used test of set-shifting abilities. On this basis, 4 studies reported impaired abilities in patients with OCD (compared with healthy individuals) and 8 studies did not. Furthermore, six other studies have found impairments in the Object Alternation Test (OAT) and the Delayed Alternation Test (DAT). Hence, the impairment of set-shifting abilities in patients

with OCD had not been unambiguously demonstrated. Only seven of 19 participants on fluency tasks have reported lower scores in patients with OCD than in non-clinical populations. Problem-solving and planning ability are usually evaluated with the Tower of Hanoi and Tower of London tasks. There is some evidence to suggest that planning and problem-solving (as addressed by the Tower of London task) is not affected in OCD. However, the findings in this domain are inconsistent. Kuelz and colleagues [8] concluded that there is some evidence of visuospatial memory dysfunction in patients with OCD, which in turn suggests the presence of impaired executive function. Studies of set-shifting, fluency, planning and problem-solving abilities have yielded contradictory results; this might could reflect methodological differences between studies (*i.e.* the materials, or the presence or absence of a control group), possible effects of comorbidities (such as depression and anxiety), heterogeneity in the OCD (*i.e.* checking vs. contamination/cleaning vs. sexual/religious obsessions) and/or the use of psychotropic medications by some participants [8]. Olley and colleagues [9] review focused on a subset of executive functions in OCD: set-shifting, response inhibition, verbal and non-verbal fluency, and decision-making. Most WCST-based studies have not found any difference between patients with OCD and non-clinical individuals. Some studies have reported an intergroup difference with the OAT but not with the WCST. In fact, the OAT (but not the WCST) can be seen as a measure of behavioral reversal: poorer performance might result from impaired response inhibition. The studies using the CANTAB battery's intradimensional/extradimensional (ID/ED) task have yielded more consistent impairments. The ID/ED task is considered to be a "purer" set-shifting task than the WCST or the OAT. Additional research in this domain is needed. Most studies of verbal fluency have found that the latter is unaffected in OCD. The few published studies of non-verbal fluency in OCD have used different tasks, making it difficult to interpret the results. The Iowa gambling task (a decision-making task) gave mixed results in OCD, and the study needs to be replicated [9]. The researchers concluded that patients with OCD had impaired executive functions, namely "increased responses latencies, perseveration of previous responses, and difficulties using feedback to adapt to change" (Olley and colleagues [9], p. 21). Lastly, Abramowitch and colleagues [15] performed the first meta-analysis of 113 neuropsychological studies in OCD populations (published between 1989 and 2012). Medium-sized effects were found for executive function and its various dimensions (planning, response inhibition and set-shifting/cognitive flexibility), with poorer overall performance in patients with OCD than in healthy controls. The Stroop test gave divergent findings for response inhibition, with respectively medium-sized and small effects for interference errors and commission errors. The researchers concluded that a comparison of several response inhibition tasks would be useful (Abramowitch and colleagues [15], p. 1168). Their final conclusion was that patients with OCD performed less well than healthy controls in neuropsychological tests in general and executive function tests in

particular. It also appears that certain cognitive tasks (e.g. the WCST) are not appropriate for psychopathologic testing and are not sufficiently specific for a particular function (e.g. set-shifting*).*

Hence, executive functions display both unity and diversity, and the available tasks are likely to measure more than one executive subfunction. In the literature, executive function has always been considered as a unitary system. Miyake and colleagues [16] were the first to challenge this concept by suggesting that executive function is based on three main independent (albeit interconnected) components: shifting of mental sets, monitoring and updating of working memory representations, and the inhibition of prepotent responses. To evaluate these three functions more specifically, the researchers selected nine tasks, including two tasks administered in the present study (the number-letter task [17]) and the "local-global" mental shifting task. It has been found that patients with OCD have impairments in mental set shifting [9] and in the inhibition of prepotent responses [13] [18]. In fact, these impairments seem to be related to intrusive thoughts in these patients [19]. The presence of intrusive thoughts may also have a role in the monitoring and updating of working memory representations. Hence, we decided to study the effects of intrusive thoughts on executive function. To the best of our knowledge, this question has not previously been addressed in patients with OCD.

Our general purpose was that study participants with OCD would display a relatively greater impairment in executive function following the induction of their specific intrusive thoughts than non-clinical study participants. In a first step, we administered the International Intrusive Thoughts Interview Schedule (IITIS) [20] and determined each participant's the most distressing intrusive thought. Next, participants were assigned to the induction of an intrusive thought or the induction of a neutral thought prior to the executive function tasks. Three executive function tasks were administered: the number-letter task [16] [17] and the local-global task [16] [21] probed mental flexibility and the go/no-go task probed response inhibition. The objective was to compare the effect of the most distressing intrusive thought versus a neutral thought on executive function. We hypothesized that (i) OCD patients would present an executive deficit relatively to control participants, and (ii) the most distressing intrusive thought would have a greater impact on executive tasks in patients with OCD than in non-clinical control participants.

2. Materials and Methods

Participants

We assessed 22 patients with OCD (mean ± standard deviation age: 34.68 ± 9.50; range: 17 - 47) attending the Savoie Mont-Blanc University Psychological Consultation Center (Chambéry, France) and the Grenoble University Medical Center (Grenoble, France) during one year. The diagnosis of OCD was based on the DSM IV criteria, following a semi-structured Mini International Neuropsy-

chiatric Interview (MINI) with trained psychologists [22]. The Vancouver Obsessional Compulsive Inventory (VOCI) [23] was used to check for the presence of OCD. Individuals with past or current neurological disease (e.g. epilepsy, brain tumor, traumatic head injury or stroke) or past or current schizophrenia were excluded from the study. The demographic and clinical characteristics of the participants in the OCD and control groups are summarized in **Table 1**.

Furthermore, 22 control participants (mean ± standard deviation age: 37.86 ± 12.95; range 21 - 61) were recruited by advertisements in Savoie Mont-Blanc University and elsewhere, and were selected to match the patient groups for age, gender ratio and educational level (expressed as years of formal education, from primary school onwards) (**Table 1**). Again, we screened for exclusion criteria (notably the presence of any neurological disease, psychiatric disorder or medication use (e.g. antipsychotics and sedatives) that could affect cognition during the MINI.

We also administered the Beck Depression Inventory (BDI) [24] to control for depressive symptoms that might have interfered with cognitive performance. The IITIS (IITIS) [20] was used to identify each participant's most distressing intrusive thought (for more details, see [4]) from among seven categories: contamination/dirt/disease intrusions, harm/injury/aggression intrusions, doubting intrusions, unwanted religious or immoral intrusions, unwanted sexual intrusions, intrusions of being a victim of violence, and "other intrusions" not falling

Table 1. Demographic and clinical characteristics of the patients with OCD and the healthy control participants.

	Control participants	Patients with OCD	Group comparison (*p* value)
Gender ratio (M/F)	8/15	11/12	0.36
	Mean (SD)	Mean (SD)	
Age	37.86 (12.95)	34.68 (9.50)	0.36
Duration of illness (years)	/	12.86 (8.45)	
Years of formal education	14.86 (3.12)	13.5 (2.84)	0.14
Beck Depression Inventory score	6.64 (5.82)	21.27 (12.18)	<0.001
Vancouver Obsessive Compulsive Inventory			
Total score	33.27 (21.93)	95.09 (32.49)	<0.001
Factor 1 (checking)	9.59 (5.91)	25.23 (10.55)	<0.001
Factor 2 (contamination)	5.41 (6.26)	22.45 (12.44)	<0.001
Factor 3 (obsession)	5.50 (5.91)	6.77 (7.01)	0.52
Factor 4 (hoarding)	5.59 (5.21)	16.82 (10.46)	<0.001
Factor 5 (just right)	3.45 (2.89)	12.68 (7.92)	<0.001
Factor 6 (indecisiveness)	4.18 (3.05)	11.14 (5.70)	<0.001

into the other categories (Table 2). Written informed consent was obtained from each participant. The study was approved by the Savoie-Mont-Blanc University's investigational review board (reference: 20145).

Materials and Procedures

The Behavior Rating Inventory of Executive Function Adult version (BRIEF-A) [25] self-questionnaire was used to check for executive dysfunction in everyday life.

The executive function tasks were administered after intrusive thought induction or neutral thought induction. For the induction of intrusive thoughts, the participant was told to write down the most distressing intrusive thought determined in the IITIS. He/she was then told to close his/her eyes and concentrate on this phrase for 30 seconds. For the induction of neutral (control) thoughts, the participant was told to write down the name of a noise that he/she hears frequently in his/her favorite or local park. He/she was then told to close his/her eyes and concentrate on this phrase for 30 seconds. Control and OCD participants were assigned to both intrusive thought/neutral conditions.

Before the three executive function tasks, each participant had to score his/her levels of anxiety, worry and guilt on 10-point Likert scales ranging from 1 ("not at all") to 10 ("extremely"). All participants then performed three computer-based cognitive tasks assessing the executive functions of inhibition (the go/no go task) and mental flexibility (the number-letter task [16] and a local-global task [16] [21]. Superlab 2.0 software was used to present stimuli and record responses for all three tasks.

The order of the tasks was counterbalanced for each participant and each induction condition.

The Behavior Rating Inventory of Executive Function Adult version.

The BRIEF-A is designed to assess the executive behavior of adults in home and work environments [25] [26] for the French adaptation. This 75-item questionnaire yields a Behavioral Regulation Index (BRI), a Metacognitive Index (MI) and also an overall Global Executive Composite score (GEC). The BRI comprises four non-overlapping clinical scales (Inhibit, Shift, Emotional Control, and Self-Monitor), and the MI comprises five scales (Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials). Self-reported and informant-reported versions of the BRIEF-A are available; only the self-reported version was administered here. For each participant, *T* scores

Table 2. The most distressing types of intrusive thought in the two groups

	Contamination	Harm	Doubt	Unwanted religion	Unwanted immoral	Sexual	Being a victim	Other
Patients with OCD	8	1	7	1	2	/	/	3
Control participants	1	5	10	/	2	/	/	4

(based on comparisons with a normative sample) were calculated for each of the three main indices. Higher T scores reflect greater impairments in executive functions.

The go/no-go task.

This task examined the participant's ability to attend to relevant targets and to inhibit the motor response to distractors. Participants were instructed to (i) respond (by pressing on the mouse key) as quickly and as accurately as possible when a red rectangle appeared at the center of a computer screen (the "go" condition) and (ii) not respond (and wait for the next trial) when a green rectangle appeared at the center of the screen (the "no-go" condition). The two conditions were randomly distributed during the task. Omission errors (when the participant failed to respond in the "go" condition) and commission errors (when the participant responded in the "no-go" condition) were recorded. It is thought that commission errors reflect difficulties in motor inhibition.

The number-letter task (adapted from Rogers & Monsell [16] [17]).

A number-letter pair (e.g. "7G") was presented in one of four quadrants of a computer screen. Participants were instructed to indicate (by pressing a button) whether the number was odd or even when the pair was presented in either of the two top quadrants, and whether the letter was a consonant or a vowel when the pair was presented in either of the two bottom quadrants. The task was divided into three blocks, reflecting two main conditions. In the "no-switching" condition, a first block of 32 target trials appeared solely in the two top quadrants and a second block of 32 target trials appeared solely in the two bottom quadrants. The "switching" condition contained a third block of 64 target trials in which the number-letter pair was presented successively in all four quadrants in clockwise order; this required participants to shift between the two types of categorization every two trials.

A "reaction time (RT) shift cost" was calculated from the difference between the average RT in the third block of trials (in which mental shifting was required) and the average RT in the first two blocks of trials (in which mental shifting was not required). Likewise, an "error shift cost" was also calculated from the number of errors in the third block vs. the first two blocks.

The local-global task (adapted from Miyake and colleagues, [16]).

A geometric, local-global "Navon figure" was presented on a computer screen. The "global" element (such as a triangle) was composed of other much smaller "local" elements (such as squares) [21]. Four different geometric figures (a square, a triangle, a circle and a cross) were used as the global or local elements. The figures were displayed in black or in blue. Participants were instructed to state the name of the global figure if the figure was displayed in black and to state the name of the local figure if the figure was displayed in blue. As the color of the stimuli changed from black to blue or vice versa during the series of trials, the participants had to shift from examining the local features to the global features or vice versa. Ninety-six pre-randomized target trials and 36 practice trials

were presented. Half the trials required a switch from local to global features or vice versa, and the RTs were measured. A "shift cost" was calculated from the difference between the mean RT in the trials requiring a shift in mental set (*i.e.* when the color of the stimulus changed) and the mean RT in the trials in which no shift was required (*i.e.* when the color of the stimulus did not change). A "shift cost" was also calculated for the number of errors in the local-global task.

Statistical analyses

We used Statistica software (version 10) for all analyses. Intergroup differences in demographic and clinical characteristics were analyzed in independent *t* tests. The effect of gender as a categorical variable was examined in a chi-squared test. All tests were two-tailed, and the threshold for significance was set to $p < 0.05$. Univariate analyses of variance were used to assess intergroup differences in the questionnaire scores (Table 1). Effect sizes were calculated by using the partial η^2 method.

3. Results

Demographic and clinical characteristics

In the OCD group, 18 of the 22 participants (82%) presented with comorbid disorders (according to the MINI). Seven of these 18 participants had only one disorder associated with the primary diagnosis of OCD, 8 presented with two related disorders, 2 participants had three related disorders, and 1 had five comorbid disorders. The most common disorders were generalized anxiety disorder (n = 13), panic disorder (n = 6), agoraphobia (n = 5) and social phobia (n = 5). Fourteen of the 22 OCD participants were taking antidepressants or other medications. None of the non-clinical participants presented with disorders or were taking medications.

The two groups did not differ in terms of sociodemographic characteristics, gender distribution ($X^2 = 0.83$, $p = 0.36$), age ($t(42) = 0.92$, $p = 0.36$) or educational level ($t(42) = 1.52$, $p = 0.14$) (Table 1).

The VOCI total score differed significantly when comparing patients with OCD and control participants ($F(1, 42) = 54.70$, $p < 0.001$, $\eta^2 p = 0.57$). Furthermore, univariate tests on each of the 6 VOCI factors revealed significant intergroup differences for checking ($F(1, 42) = 36.78$, $p < 0.001$, $\eta^2 p = 0.47$), contamination ($F(1, 42) = 32.97$, $p < 0.0001$, $\eta^2 p = 0.44$), hoarding ($F(1, 42) = 20.30$, $p < 0.001$, $\eta^2 p = 0.33$), "just right" ($F(1, 42) = 26.36$, $p < 0.001$, $\eta^2 p = 0.39$), and indecisiveness ($F(1, 42) = 25.45$, $p < 0.001$, $\eta^2 p = 0.38$). No intergroup difference was found for obsessions ($F(1, 42) = 0.42$, $p = 0.52$, $\eta^2 p < 0.01$). With the exception of the latter factor, patients with OCD had significantly higher VOCI factor scores than control participants. The main effect of *group* was also significant for the BDI ($F(1, 42) = 25.86$, $p < 0.001$, $\eta^2 p = 0.38$), with higher total scores for patients with OCD than for control participants (Table 1). The most distressing type of intrusive thought for patients with OCD was contamination (n = 8, 36%), followed by doubt (n = 7; 32%). The most distressing type of intrusive

thought for non-clinical participants was doubt (n = 10; 45%) (see Table 2).

As can be seen in Table 3, overall T scores in the BRIEF-A were higher for patients with OCD than for control participants. The main effect of *group* was significant for all three indexes, *i.e.* the BRI: $F(1, 42) = 21.76$, $p < 0.001$, $\eta^2 p = 0.34$; the MI: $F(1, 42) = 4.74$, $p = 0.04$, $\eta^2 p = 0.10$; and the GEC: $F(1, 42) = 12.57$, $p < 0.001$, $\eta^2 p = 0.23$).

We measured the effect of thought induction on the mean anxiety, worry and guilt scores in the two groups. Significant effects of *group* and *thought induction* were observed for anxiety ($F(1,40) = 9.51$, $p < 0.01$, $\eta^2 p = 0.19$ for *group* and $F(1,40) = 6.53$, $p < 0.05$, $\eta^2 p = 0.14$ for *thought induction*), worry ($F(1,40) = 5.69$, $p = 0.02$, $\eta^2 p = 0.12$ for *group* and $F(1,40) = 16.13$, $p < 0.001$, $\eta^2 p = 0.29$ for *thought induction*), and guilt ($F(1,40) = 4.89$, $p = 0.03$, $\eta^2 p = 0.11$ for *group* and $F(1,40) = 4.89$, $p = 0.03$, $\eta^2 p = 0.11$ for *thought induction*). None of the interactions was significant. In both groups, intrusive thought induction yielded higher anxiety, worry and guilt scores than neutral thought induction did. However, the overall effect size was greater in patients with OCD (Table 4).

Executive tasks

According to the BDI, patients with OCD were more depressed than healthy controls. Given that depression might have influenced the dependent variables (*i.e.* the executive function scores), the BDI total score was used as a covariate in the analyses. For each executive task, a two-way analysis of covariance was performed with *group* (OCD, healthy) and *thought induction* (intrusive, neutral) as between-participants factors and the BDI total score as a covariate. Effect sizes were also calculated, using the partial η^2 method. Table 5 summarizes the executive task scores for patients with OCD and control participants as a function of

Table 3. Mean ± standard deviation T-scores for control participants and patients with OCD in the self-reported BRIEF-A

	Control participants	Patients with OCD	Group comparison (*p* value)
BRIEF-A	Mean (SD)	Mean (SD)	
Behavioral Regulation Index	50.36 (9.18)	66.45 (13.32)	<0.001
Metacognitive Index	55.59 (11.92)	65.59 (17.95)	0.035
Global Executive Composite score	53.55 (10.83)	67.95 (15.69)	<0.001

Table 4. Means ± standard deviation anxiety, worry and guilt scores (range: 1 to 10) as a function of the group and the type of thought induction

Group	Type of thought induction		Anxiety score	Worry score	Guilt score
Control participants	neutral	Mean (SD)	1.48 (0.67)	1.42 (0.75)	1.00 (0.00)
Control participants	intrusive	Mean (SD)	3.52 (2.51)	4.30 (2.61)	3.00 (2.62)
Patients with OCD	neutral	Mean (SD)	3.9 (3.28)	3.12 (3.06)	3.00 (2.91)
Patients with OCD	intrusive	Mean (SD)	5.70 (2.65)	6.06 (2.52)	4.24 (2.89)

Table 5. Mean ± standard deviation executive task scores for control participants and patients with OCD, as a function of the type of thought induction

Thought			Local-global flexibility score (RT)	Local-global flexibility score (errors)	Go/no-go omission errors	Go/no-go commission errors	Number-letter flexibility score (RT)	Number-letter flexibility score (Errors)
Control participants	Neutral	Mean (SD)	169.58 (149.27)	0.55 (0.93)	0.18 (0.40)	2.73(2.61)	114.27 (135.66)	0.27 (0.65)
Control participants	Intrusive	Mean (SD)	108.69 (128.41)	−0.27 (1.79)	0.00 (0.00)	3.64 (3.29)	45.93 (109.65)	0.36 (0.50)
Patients with OCD	Neutral	Mean (SD)	194.61 (328.27)	−0.45 (2.25)	0.36 (0.92)	6.27 (4.67)	402.30 (350.81)	0.45 (1.63)
Patients with OCD	Intrusive	Mean (SD)	150.29 (167.57)	0.55 (1.75)	0.00 (0.00)	5.55 (3.98)	206.19 (190.70)	0.64 (1.63)

the type of thought induction.

The go/no-go task.

There was a significant intergroup difference in the commission error rate (errors in the no-go condition; $F(1, 39) = 5.15$, $p = 0.03$, $\eta^2 p = 0.12$); patients with OCD had a higher commission error rate than healthy participants. The size effect was moderate. No difference in the commission error rate was observed when comparing intrusive thought and neutral thought inductions ($F(1, 39) = 0.01$, $p = 0.91$, $\eta^2 p < 0.001$), and there was no *group* x *thought induction* interaction ($F(1, 39) = 0.71$, $p = 0.40$, $\eta^2 p < 0.001$). Hence, neither group shown an effect of *thought induction* (see Table 5).

The two groups did not differ significantly in terms of the omission error rate (*i.e.* errors in the "go" condition): $F(1, 39) = 1.45$, $p = 0.24$, $\eta^2 p = 0.03$. The main effect of *thought induction* was not significant: $F(1, 39) = 3.01$, $p = 0.09$, $\eta^2 p = 0.07$. There was no *group* x *thought induction* interaction: $F(1, 39) = 0.71$, $p = 0.40$, $\eta^2 p = 0.02$.

The number-letter task.

We observed an intergroup difference in the RT shift cost ($F(1, 39) = 5.75$, $p = 0.02$, $\eta^2 p = 0.13$), with a greater RT shift cost for patients with OCD than for healthy controls. A trend towards an effect of *thought induction* ($F(1, 39) = 4.03$, $p = 0.052$, $\eta^2 p = 0.09$) was observed, although there was no *group* x *thought induction* interaction ($F(1, 39) = 0.74$, $p = 0.40$, $\eta^2 p = 0.02$).

The main effect of *group* was not significant for the error shift costs ($F(1, 39) = 0.04$, $p = 0.84$, $\eta^2 p = 0.001$) There was neither an effect of *thought induction* ($F(1, 39) = 0.12$, $p = 0.74$, $\eta^2 p = 0.003$) nor a *group* x *thought induction* interaction ($F(1, 39) = 0.05$, $p = 0.83$, $\eta^2 p = 0.001$).

The local-global task.

In the local-global task, the main effect of *group* failed to achieved significance: ($F(1, 39) = 0.006$, $p = 0.94$, $\eta^2 p < 0.001$), and there was no main effect of *thought induction* on the RT shift cost ($F(1, 39) = 0.76$, $p = 0.39$, $\eta^2 p = 0.02$). The patients with OCD were not slower than the healthy controls (see Table 5). Importantly, the two-way *group* x *thought induction* interaction was not significant ($F(1, 39) = 0.09$, $p = 0.77$, $\eta^2 p = 0.002$).

When considering the error shift cost, there was no intergroup difference

($F(1, 39) = 0.05$, $p = 0.82$, $\eta^2 p = 0.001$) and no effect of *thought induction* ($F(1, 39) = 0.03$, $p = 0.87$, $\eta^2 p < 0.001$). The *group* x *thought induction* interaction was not significant ($F(1, 39) = 2.87$, $p = 0.10$, $\eta^2 p = 0.07$).

4. Discussion

The objectives of the present study were (i) to evidence an executive impairment in OCD patients and (ii) to compare the effect of the most distressing intrusive thought on executive function (response inhibition and mental flexibility) in patients with OCD and in healthy control participants. As expected, the patients with OCD had significantly higher scores than the control group participants for all questionnaires (the VOCI and the BDI), with the exception of the VOCI obsession subscale. This finding might be due to the fact that the VOCI was completed after the IITIS (with the latter highlighting the intrusive thought). Two types of intrusive thought (contamination and doubt) were prevalent in OCD participants, whereas doubt was prevalent in control participants. This is in agreement with the literature data [4] [6]. We found an effect of group on the behavioral aspects of executive function in the self-reported BRIEF-A. Patients with OCD generally considered that they had poor executive function (for both behavioral and cognitive dimensions) in everyday life. The effect size was moderate for the BRI and the GEC, and modest for the MI.

We measured the effect of inducing the intrusive or neutral thought on anxiety, worry and guilt. As expected, we observed a greater effect of intrusive thoughts on anxiety, worry and guilt in the OCD group than in the control group. However, the difference between neutral thought induction and intrusive thought induction was the same in the two groups for all three variables (*i.e.* there was no *group* x *intrusive thought* interaction). Generally, obsessions (intrusive thoughts) are more distressing and interfere more with everyday life for patients with OCD than for non-clinical participants [3] [27]. Inducing the participant's most distressing intrusive thought does not have the same effect as obsessions or spontaneous intrusive thoughts do. OCD participants had higher anxiety, worry and guilt scores than control participants.

The study by Basso and colleagues [28] showed that executive function impairments were more related to co-morbid depressive symptoms than to OCD *per se*. Given that our patients with OCD had a higher BDI score and that depression affects executive function, we used the BDI score as a covariate in our analysis. Overall, we expected to observe a group effect in each cognitive task (*i.e.* impaired executive function in patients with OCD, relative to control participants) and a greater effect of intrusive thought induction in the patients with OCD than in the controls (*i.e.* with a significant *group* x *intrusive thought* interaction). In the literature, there is some evidence of impaired response inhibition in OCD, as assessed in go/no-go tasks [13] [29]. It is usually assumed that commission errors (*i.e.* a response when none is required, such as no-go errors and false alarms) reflect impulsivity and impaired inhibitory control. In our experi-

ment, the go/no-go task revealed a significant intergroup difference in the commission error rate; patients with OCD made more commission errors than controls. Furthermore, there was no effect of intrusive thought induction in the OCD group or the control group. Our findings are in line with the results of Abramowitch and colleagues meta-analysis [15], which showed a small effect on commission errors in inhibitory control tasks. Commission errors are thought to reflect impaired motor inhibition, whereas omission errors in the go/no-go test may reflect attentional control problems (inattention). We did not observe a difference between the OCD and control groups, regardless of the type of induction. This result is consistent with the literature data [30]. A shifting impairment in OCD has been reported [9]. In the present study, we administered two tasks that required switching between tasks or mental sets: the number-letter task [17] and the local-global task [16]. In both tasks, shift costs were calculated for RTs and error rates by subtracting the score in the "no switching" condition from the score in the "switching" condition. An intergroup difference in RT shift costs (but not in error shift costs) was observed in the number-letter task (with greater shift cost for patients with OCD and a moderate effect size). There was a small, non-significant difference in RTs between neutral and intrusive thought induction for both groups, and the effect size was moderate. In the literature (as in the present study), intergroup differences in the RT shift cost tend to be greater than intergroup differences in the error shift cost. Likewise, no effect on the RT shift cost or the error shift cost was observed in the local-global task; there were no intergroup differences, no effects of thought induction, and no interactions. In patients with OCD, the local-global task may be less sensitive than the number-letter task for assessing mental set-shifting. The symptoms in OCD may result from over-focused attention at the local level, which affects the stimulus process [31]. This hypothesis was confirmed in a local-global paradigm: OCD participants were impaired in a global task, relative to control participants [32]. However, the latter researchers did not control for depressive symptoms. It is also possible that the composition of the OCD group (*i.e.* checkers vs. washers, etc.) differed from that of the present study. Our present results in the local-global task and for the omission error rate in the go/no-go task did not confirm the previously reported excessive focus on local detail in a "heterogeneous" OCD group. One can hypothesize that over-focused attention is specific to "checkers". When controlling for depression, we observed an intergroup difference in the commission error rate (in the go/no-go task) and a significant effect of *group* on the RT shift cost of the number-letter task. OCD participants performed less well than healthy controls in both executive tasks. In both groups, we also observed a trend towards an effect of thought induction in the number-letter task. More importantly, intrusive thought induction did not have a greater effect on the OCD group than on the control group in either task. With regard to the categories of intrusive thoughts, most patients with OCD are washers and then checkers. There are few studies of OCD subcategories and executive

function. In the study by Van der Linden, Ceschi, Zermatten, Dunker, and Perroud [33], patients with OCD (checkers and washers) had more difficulty in inhibiting a prepotent response (in the Hayling response inhibition task) than control individuals, although there was no difference between checkers and washers. In another study [30], checkers had poorer results than washers in the Stroop test, the trail-making test, category fluency, and commission errors in the go/no-go test. There were also significant differences between checkers and washers in the inhibition and the cognitive flexibility scores. The presence and severity of hoarding symptoms in OCD was found to be associated with impaired decision-making [34]. It is possible that checkers and washers perform differently in the executive function tasks used in our research. Our OCD group consisted of washers and checkers. Ideally, this heterogeneity should have been taken into account in the statistical analysis but sample size in each category was too small. It may be important to consider the OCD symptom dimensions when studying neuropsychological task performances.

This study has several limitations: 1) the sample size could be more important; 2) in order to determine the extent to which executive deficits are specific to OCD or a general impairment relative to a clinical condition, a control group with another disorder could be studied; 3) the effects of medication on executive functioning have not been considered.

5. Conclusion

Patients with OCD reported that they have poor executive function in everyday life, with impaired mental flexibility (in the number-letter task) and response inhibition (in the go/no-go task) than control participants. The local-global task (a test of mental flexibility) did not reveal a difference between patients with OCD and control participants, and so appears to be less effective for assessing mental set-shifting in the context of OCD. The induction of an intrusive thought had no effect on patients with OCD (relative to controls) when considering anxiety, worry, guilt and executive function scores. As a recommendation, we could say that ecological tests (such as BRIEF-A) seem more useful to differentiate OCD patients from control participants than laboratory tests.

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