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Did I turn off the stove? Good inhibitory control can protect from influences of repeated checking

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ABSTRACT

Background and objectives: Obsessive-compulsive disorder (OCD) is an anxiety disorder characterized by compulsions aimed at reducing anxiety associated with intrusive cognitions. However, compulsive behaviors such as repeated checking were found to increase rather than decrease uncertainty related to obsessive thoughts (e.g., whether the gas stove was turned off). Some recent studies illustrate that OCD patients and their family members have inhibitory deficits, often demonstrated by the stop-signal task. The current study aims to investigate relations between inhibitory control and effects of repeated checking.
Methods: Fifty-five healthy participants carried out a stop-signal task followed by a repeated-checking task. Additionally, participants were asked to complete self-report questionnaires measuring OCD, anxiety and depression symptoms.
Results: Confirming our hypothesis, participants with poor inhibitory capabilities demonstrated greater uncertainty and memory distrust as a consequence of repeated checking than participants with good inhibitory control.
Limitations: Our findings concern an initial investigation on a sample of healthy participants and should be replicated and extended to clinical populations.
Conclusions: These results suggest that deficits in inhibitory control may underlie cognitive vulnerability in OCD. An updated model integrating neuropsychological findings with current OCD models is suggested.

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1. Introduction

Obsessive-compulsive disorder (OCD) is a highly debilitating anxiety disorder with a lifetime prevalence of 2%–3% (Huppert, Simpson, Nissenson, Liebowitz, & Foa, 2009; Weismann et al., 1994). There are efficacious psychological and pharmacological interventions for OCD (Rosa-Alcázar, Sánchez-Meca, Gómez-Conesa, & Marín-Martínez, 2008) yet the majority of patients still suffer from symptoms even after undergoing treatment (e.g., Fisher & Wells, 2005), indicating that there is still much room for improvement. Moreover, many potential patients do not receive suitable therapy due to the overload of public mental health clinics or geographical distance of patients from such clinics (Kazdin, 2010). Therefore, understanding factors affecting individual proneness to developing OCD is paramount to improving OCD treatment, particularly since knowledge of etiological factors underlying OCD is lacking (for reviews see Gava et al., 2007; Grabill et al., 2008).

OCD is characterized by the occurrence of unwanted and disturbing intrusive thoughts, images or impulses (obsessions), followed by repetitive behaviors or mental acts (compulsions) aimed at reducing distress or preventing feared events related to obsessions from occurring (Diagnostic and Statistical Manual of Mental Disorders-IV [DSM-IV]; American Psychiatric Association [APA], 2000). However, behaviors that OCD patients typically perform tend to inflict paradoxical effects of increasing rather than decreasing the anxiety caused by obsessions, effectively perpetuating compulsions (Salkovskis, 1999). Compulsive checking is the most prominent outcome of such paradoxical effects characterizing OCD patients (Foa et al., 2005). Rachman (2002) suggested that

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heightened personal responsibility, perceived probability of harm, and the perceived seriousness of harm interact to cause patients to engage in preventive checking that in turn heightens these three factors and reduces confidence in memory, thus perpetuating compulsive checking. This latter segment of the process (i.e., repeated checking causing a reduction in memory certainty in OCD patients) is illustrated by van den Hout's seminal work on healthy participants, demonstrating that compulsive-like behaviors such as checking or staring are enough to induce memory distrust in healthy participants (van den Hout, Engelhard, de Boer, du Bois, & Dek, 2008; van den Hout & Kindt, 2003). Radomsky, Gilchrist, and Dussault (2006) replicated these effects using a real checking procedure rather than a virtual computerized task. These findings suggest a descriptive maintenance model of the vicious circle of doubt, uncertainty and compulsive behaviors that underlie OCD. However, these studies do not explain why some people are more prone to engage in these behaviors and become entangled in this circle.

Though some studies did not find differences in executive functions between OCD patients and healthy controls (e.g., Moritz et al., 2008; Moritz, Kloss, & Jelinek, 2010), most neuropsychological studies of OCD indicated that these patients show various difficulties in executive functions tasks (e.g., Abramovitch, Dar, Schweiger, & Hermesh, 2011a; Lucey et al., 1997; Meiran, Diamond, Toder, & Nemets, 2011; Penades, Catalan, Andres, Salamero, & Gasto, 2005). The most robust and stable differences between OCD patients and healthy controls were found on tasks that required response inhibition (Bannon, Gonsalvez, Croft, & Boyce, 2002; Penades et al., 2007). Abramovitch, Dar, Schweiger, and Hermesh (2011b) suggested that continuous attempts to control obsessive thoughts cause an overload and impairment in executive control and inhibition. These researchers suggested that the inhibitory control deficit is an epiphenomenon of OCD symptoms. On the other hand, other studies found cognitive control impairments to be a core symptom of OCD (for a review see Muller & Roberts, 2005). Furthermore, Huyser, Veltman, Wolters, de Haan, and Boer (2011) found increased activation of the anterior cingulate cortex (ACC; which is known to play a significant role in cognitive control) in OCD patients, which was only partially affected by cognitive-behavioral therapy, even though therapy successfully reduced patients' obsessive tendencies. These findings support the notion that deficits in inhibitory control may explain why intrusive thoughts, which are not pathological per se (Rachman & de-Silva, 1978), are so hard to ignore and harmful for individuals with OCD. There is still a debate in the literature regarding the direction of the influences of obsessive thoughts and inhibitory control.

The stop-signal task (Logan, 1994; Logan & Cowan, 1984) is perhaps the most common task demonstrating response inhibition differences between control participants and OCD patients or their families (Chamberlain, Fineberg, Blackwell, Robbins, & Sahakian, 2006; Menzies et al., 2007; Morein-Zamir, Fineberg, Robbins, & Sahakian, 2010). It examines the ability to suppress an already initiated action or thought (a pre-potent response) that is no longer appropriate. In this task a go signal is presented and in one-third of the trials, is followed by a stop-signal. The duration between the go signal and the stop signal is referred to as the stop-signal delay (SSD) and is submitted to a tracking procedure. This allows one to estimate the stop-signal reaction time (SSRT), which is the time needed for successful inhibition. SSRT has proven to be an important measure of cognitive control (Verbruggen & Logan, 2008).

To date, no studies have examined individual differences in a repeated-checking task. The aim of the current study was to examine whether individual differences in inhibitory control could offer an etiological explanation for the proneness of certain individuals to develop pathological doubt as a result of checking. Integrating basic cognitive science and applied clinical research would enable us to shed light on inhibition of a pre-potent response as an etiological factor of OCD. In order to do this we used the stop-signal task (Logan & Cowan, 1984), followed by van den Hout's repeated-checking task (van den Hout & Kindt, 2003). We predicted that participants with poor inhibition would exhibit more uncertainty on tasks inducing repeated checking than participants with good inhibition capabilities. Additionally, participants were administered a set of questionnaires measuring OCD, depression and anxiety. This enabled us to control for various clinical symptoms and overview their influence on behavioral results.

2. Method

2.1. Participants

Fifty-five undergraduate students (32 females and 23 males) of Ben-Gurion University of the Negev (Israel) participated in the current study for a small monitory payment. The proportion of males was .42 in the experimental group and .54 in the control group. No age ($F(1,49) < 1$) or gender differences were found between the groups. All participants had normal or corrected-to-normal vision, reported no history of attention deficit or dyslexia, were native Hebrew speakers and were naive as to the purpose of the experiment. Participants were randomly allocated to the two groups: the relevant-checking group (i.e., experimental group) vs. the irrelevant-checking group (i.e., control group), with the restriction that three quarters of participants should be allocated to the experimental condition. This was done because the control group was only used in order to replicate van den Hout and Kindt's (2003) results. Moreover, all main assumptions of the current study addressed the experimental group. Eventually, 42 participants were allocated to the experimental group, and 13 participants were allocated to the control group. Two participants failed to complete the set of tasks and were excluded from further analysis. Additionally, two participants didn't meet the criteria for valid SSRT (both had more than 60% of erroneous responses to the stop-signal task; for more details see Verbruggen, Logan, & Stevens, 2008) and were also excluded from further analysis (all excluded participants were from the experiment group). The mean age of valid participants was 25.05 years ($SD = 2.51$).

2.2. Procedure

Participants were presented with two computerized tasks and a set of four questionnaires. Task order was constant: stop-signal task, questionnaires and repeated-checking task. This was done in order to prevent possible influence of the repeated checking on inhibitory capabilities and obsessive beliefs and behavior. Participants were obligated to take a 2-min break after each task.

2.2.1. Stop-signal task

We used the "Stop-it" program (Verbruggen et al., 2008). The go signals were a white square and circle on a black background. The stop signal was an auditory tone (750 Hz, 75 ms). The task included one practice block of 32 trials and three experimental blocks of 64 trials each. Each trial started with a 250 ms fixation (a white plus sign in the center of a black screen), followed by a visual go stimulus. Response keys were "z" for square and "/" for circle. Stickers with corresponding shapes were pasted on the keys. Participants were asked to respond with the index finger of both hands. Instructions stated to press the correct key as fast and accurately as possible and emphasized not to wait for a potential stop signal. The visual stimulus stayed in view for 1250 ms regardless of the latency of the response. Reaction time (RT) was calculated from the

appearance of the visual stimulus to the reaction. Each trial ended with a 2000 ms inter-trial interval. On a random selection of trials an auditory stop signal was sounded. The stop signal was presented after a variable stop-signal delay (SSD) that was initially set at 250 ms and adjusted by the staircase tracking procedure: after each successful stopping the SSD was extended by 50 ms and after each unsuccessful stopping the SSD was shortened by 50 ms. After the SSD was found (with .50 error probability), the SSRT was calculated as the mean RT for no-stop-signal trials minus the SSD. Between blocks, participants had to wait for 10 s before they could start the next block. During this interval, participants received information about their performance in the last block. For further details on the stimuli and procedure see Verbruggen et al. (2008).

2.2.2. Repeated-checking task

We used van den Hout and Kindt's task (2003). The task had 5 steps. The first four were identical to those used by van den Hout and Kindt, while the fifth was an original addition of the current study. An experimenter, located outside the experiment room, monitored the participant's computer screen using a closed circuit camera.

Step 1 included one practice trial of a gas stove task and one of light bulbs, in which participants were asked to turn on and then off, all six gas rings or light bulbs. The animated gas stove was composed of 6 gas rings. Each ring could be turned on, be made to have a higher flame, a lower flame, or be turned off by a corresponding knob that was controlled by the mouse cursor. After turning the gas ring on, a rather realistic gaslight appeared. Similarly, the animated light bulbs were composed of 6 light bulbs that could be operated by 6 corresponding sliding panels.

After each of these two trials, participants were asked to assess which of the six gas rings or light bulbs they successfully turned off. False feedback was given, indicating failure in turning off three rings or bulbs. This was done in order to ensure that turning off and rechecking phases would be taken seriously. At the end of step 1, participants were notified that feedback would not be given from this point on.

Step 2 comprised one "gas stove experimental trial": participants were shown a schematic diagram of the 6 gas rings for 4 s. Three of the circles were painted in yellow indicating which of the gas rings should be turned on. After the schematic diagram disappeared, the animated gas stove was presented. After turning on the gas rings and proceeding, a text page appeared asking participants to turn off the three gas rings they had just turned on. The animated gas stove then appeared in its previous state (i.e., with the gas rings still on). After turning off the rings, a text page appeared asking participants to re-check that the rings were turned off. Participants could only continue after engaging at least three knobs. At this point, upon finishing the gas stove experimental trial, participants were asked to complete the "pre-test questionnaire" that was placed face down next to them. The questionnaire included marking locations of gas rings checked in the last trial on a schematic diagram (Memory Accuracy - Question 1), and indicating the following on a Visual Analogue Scale (VAS): Memory Vividness (Question 2), Memory Detail (Question 3) and Confidence in Memory (Question 4) (see van den Hout & Kindt, 2003). The memory accuracy score ranged from 0 to 3, corresponding to the number of erroneous rings. Visual analogue scale scores of memory vividness, memory detail and confidence in memory ranged between 0 (i.e., lowest level) and 100 (i.e., highest level).

Step 3 differed for the experimental and control groups. The experimental group (i.e., relevant checking) completed 20 additional experimental gas stove trials (identical to the procedure depicted in step 2), while the control group (i.e., irrelevant checking) completed 20 experimental light bulbs trials (identical to the procedure depicted in step 2, only with light bulbs instead of a gas stove animation and matching schematic diagram; see van den Hout & Kindt, 2003).

Step 4 was again identical for both groups. All participants were given a gas stove experimental trial after which the experimenter entered unexpectedly and asked participants to complete the post-test questionnaire, which was identical to the pre-test questionnaire.

Step 5 began with a text page notifying participants they could now choose either to leave the room and terminate the experiment at that moment or they could endure a 20-s delay and observe the gas stove in its current state. A camera focused on the screen was monitored by the experimenter in another room, who was able to verify if the participant carried out a final re-check.

2.2.3. Questionnaires

Participants completed 4 printed self-report questionnaires: the Obsessive Compulsive Inventory (OCI; Foa, Kozak, Salkovskis, Coles, & Amir, 1998); the Obsessive Beliefs Questionnaire (OBQ-44; Obsessive Compulsive Cognitions Working Group, 2005); the State-Trait Anxiety Index (STAI; Spielberger, Gorsuch, & Lushene, 1970); and the Beck Depression Inventory (BDI-2; Beck, Rial, & Rickets, 1974). The order of the questionnaires was randomized.

The OCI is designed to measure different symptoms of OCD. Forty-two items are used to construct two general subscales of Distress and Frequency of OCD symptoms as defined in the Diagnostic and Statistical Manual of Mental Disorders (APA, 2000).

The OBQ assesses the frequency of beliefs and appraisals that are considered crucial to pathogenesis of obsessions. Forty-four items are used to construct three subscales of different domains: (1) responsibility and threat estimation, (2) perfectionism and intolerance for uncertainty, and (3) importance and control of thoughts.

The STAI is used to assess nonspecific anxiety symptoms. The STAI consists of 40 items that are used to construct two subscales that provide information on: (1) temporary or state anxiety, and (2) long-standing personality trait anxiety in adults.

The BDI measures severity of clinical-depression symptoms as defined by the American Psychiatric Association (2000). It consists of 21 items that result in a single scale.

3. Results

First we analyzed the data in the same manner as done by van den Hout and Kindt (2003) in order to present a replication of their findings. After that we analyzed data regarding the 5th step that was added to the repeated-checking task in the current study. Finally, we addressed the correlations of the repeated-checking task to the stop-signal task and to the questionnaires.

3.1. Repeated checking

Cronbach's Alpha of the 6 subjective memory items of the repeated-checking questionnaire (pre- and post-test for Memory Vividness, Memory Detail, and Confidence in Memory; Questions 2–4, respectively) was .81, indicating high internal consistency within participants.

A repeated-measures MANOVA (multivariate analysis of variance) was applied to answers of all subjective memory questions of the repeated-checking questionnaire with group (relevant checking, irrelevant checking) as a between participants variable and timing (pre-test questionnaire, post-test questionnaire) as a within participants variable. As expected, the interaction between group and timing was significant, $F(1, 49) = 12.91$, $MSE = 891.06$, $p < .001$, indicating that the reduction in scores in the post-test questionnaires compared to the pre-test questionnaires was significantly greater for the relevant-checking group compared with the

Table 1
Summary of mean scores (standard deviations) in the pre- and post-test questionnaires for the relevant- and irrelevant-checking groups.

	Relevant-checking		Irrelevant-checking	
	Pre-test	Post-test	Pre-test	Post-test
Memory accuracy	0.18 (.51)	0.29 (0.61)	0.31 (0.85)	0.23 (0.44)
Memory vividness	75.63 (22.22)	52.97 (27.99)	72.84 (28.86)	82 (18.06)
Memory details	76.71 (17.86)	51.29 (29.03)	80.31 (17.39)	83 (19.04)
Confidence in memory	77.37 (25.16)	52.95 (30.89)	86.54 (27.03)	86.62 (21.09)

Note. For 'memory accuracy', means of the number of errors are presented.

irrelevant-checking group (see Table 1). The interaction between timing and questions was not significant, $F < 1$, indicating that the reduction in scores in the post-test questionnaire was similar for all subjective memory questions.

In order to further investigate whether objective memory was affected by the repeated checking, a two-way ANOVA (analysis of variance) was applied to the answers of Memory Accuracy (i.e., Question 1) in the repeated-checking questionnaire, with group (relevant checking, irrelevant checking) as a between participants variable and timing (pre-test questionnaire, post-test questionnaire) as a within participants variable. As expected, the interaction between group and timing was not significant, $F(1, 49) < 1$.

Post-hoc analysis revealed no significant main effect for timing on Memory Accuracy, $F(1, 50) < 1$. As expected, significantly lower scores were found in the post-test questionnaires compared to pre-test questionnaires for Memory Vividness, Memory Detail and Confidence in Memory only for the relevant-checking group, $F(1, 37) = 25.31$, $MSE = 385.47$, $p < .001$, PES (partial eta squared) $= .41$; $F(1, 37) = 26.99$, $MSE = 454.94$, $p < .001$, $PES = .42$; $F(1, 37) = 23.05$, $MSE = 491.64$, $p < .001$, $PES = .38$, respectively. For the irrelevant-checking group none of the differences between the pre- and the post-questionnaire were significant, $F(1, 12) = 2.09$, $p = .17$ for Memory Vividness; $F(1, 12) < 1$ for Memory Detail; and $F(1, 12) < 1$ for Confidence in Memory (see Table 1 and Fig. 1).

In order to investigate whether participants from the relevant-checking group were more likely to choose to re-check the gas stove before finishing the experiment (i.e., step 5 of the repeated-checking task), the Mann–Whitney test was applied to "re-checking choice" (choose to re-check, choose not to re-check) and group (relevant checking, irrelevant checking). Eighty-two percent of the participants in the relevant-checking group and 38% of the participants in the irrelevant-checking group chose to re-check. This difference was significant, $z = -2.92$, $p < .01$.

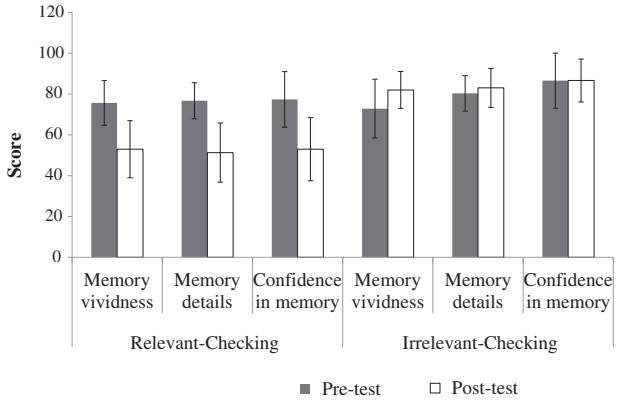

Fig. 1. Mean scores for the pre-test and the post-test questionnaires for the relevant-checking and the irrelevant-checking groups. Error bars are one standard error of the mean.

3.2. Inhibition and memory

For each participant, SSRT was calculated using the "Stop-it" program (Mean = 243 ms, $SD = 49$ ms; Verbruggen et al., 2008). For all memory measurements (i.e., questions 1–4), a 'change effect' was calculated as the pre- minus post-score for any given question. Four separate regressions were conducted with 'change effects' as a dependent variable and SSRT as a predictor. This was done in order to investigate the effect of inhibitory control on the repeated-checking manipulation. As expected, in the relevant-checking group SSRT explained a significant proportion of variance of the 'change effect', $R^2 = .18$, $F(1, 36) = 7.67$, $p < .01$ for Memory Vividness; $R^2 = .30$, $F(1, 36) = 15.17$, $p < .001$ for Memory Details; and $R^2 = .12$, $F(1, 36) = 4.75$, $p < .05$ for Confidence in Memory. These results indicated that shorter SSRT (i.e., high inhibitory control) corresponded to a smaller difference between pre- and post-test questionnaires. SSRT did not explain a significant proportion of variance of the 'change effect' in the irrelevant-checking group, $F < 1$, for all subjective memory measurements (i.e., questions 2–4). As expected, SSRT did not explain a significant proportion of variance of the 'change effect' for Memory Accuracy (e.g., question 1): $R^2 = .32$, $F(1, 36 = 1.17$, $p = .287$ for the relevant checking group, and $F < 1$ for the irrelevant-checking group. This indicates that objective memory was not affected by the repeated-checking manipulation regardless of inhibitory control efficiency.

Regarding our a priori hypothesis of inhibitory control constituting a predominant vulnerability factor for influences of repeated checking, we divided participants from the relevant-checking group into three sub-groups according to their SSRT percentile. Twelve participants with the lowest SSRT were assigned to the good inhibitory control group (SSRT < 217 ms), 13 participants with the highest SSRT were assigned to the poor inhibitory control group (SSRT > 252 ms), and 13 participants in the middle were assigned to the mediocre inhibitory control group and were excluded from this analysis. Four separate two-way ANOVAs were applied to the answers of each question of the repeated-checking questionnaire with SSRT-group (poor inhibitory control, good inhibitory control) as a between participants variable and timing (pre-test, post-test) as a within participant variable. A significant interaction between SSRT-group and timing was found for Memory Vividness, $F(1, 23) = 14.82$, $MSE = 234.10$, $p < .001$, $PES = .39$; for Memory Details, $F(1, 23) = 18.02$, $MSE = 269.48$, $p < .001$, $PES = .44$; and for Confidence in Memory, $F(1, 23) = 4.68$, $MSE = 368.75$, $p < .05$, $PES = .17$. For Memory Accuracy there was no significant interaction between SSRT-group and timing, $F(1, 23) < 1$.

Further analysis revealed significantly lower scores in the post- compared to pre-test questionnaires for the poor inhibitory control group for Memory Vividness, $F(1, 12) = 28.68$, $p < .001$; $PES = .70$; for Memory Details $F(1, 12) = 31.57$, $p < .001$, $PES = .73$; and for Confidence in Memory, $F(1, 12) = 13.12$, $p < .01$, $PES = .52$ (for questions 2–4, respectively). Comparing the scores in the post-test questionnaires to the pre-test questionnaires for all subjective memory questions for the good inhibitory control group revealed much smaller differences for Memory Vividness, $F(1, 11) = 7.68$, $p < .05$, and no significant difference for Memory Details and Confidence in Memory, $F(1, 11) = 1.32$, $p = .28$, and $F(1, 11) = 2.75$, $p = .13$, respectively (Fig. 2). These results indicate a much larger influence of repeated checking on the poor inhibitory control group than on the good inhibitory control group.

3.3. Clinical measurements

Correlations between SSRT and all the questionnaire scales and subscales were examined and none of them reached significance (with the highest correlation being between SSRT and trait anxiety,

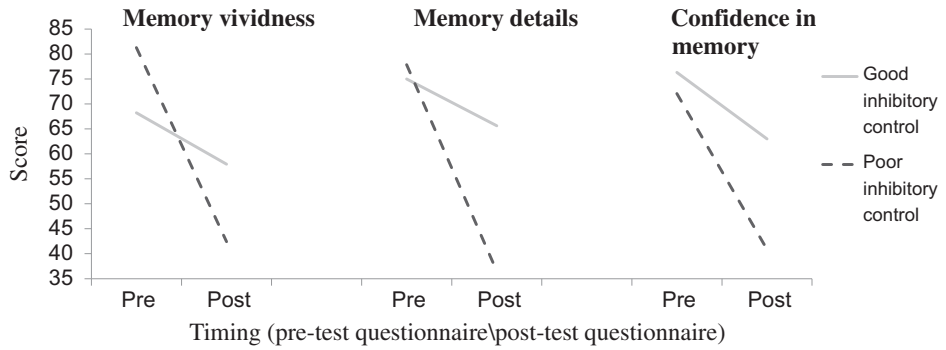

Fig. 2. Mean scores for the pre-test and the post-test repeated-checking questionnaire for the good and poor inhibitory control subjects in the relevant-checking group.

$r = .10$, $p = .49$). Furthermore, none of the correlations between the clinical measures total scores or subscales and the repeated-checking questionnaire 'change effects' were significant (with the highest correlation being between 'change effect' in the Confidence in Memory questionnaire and BDI, $r = .17$, $p = .22$). It is important to stress that all questionnaires had high internal consistency in the current sample as measured by Cronbach's Alpha: OBQ - .92; OCI - .96; BDI - .83; STAI - .95.

Relations between our findings and OCD symptoms were tested by controlling OCI scores while re-conducting three separate two-way ANOVAs on the subjective memory indexes. SSRT-group (poor inhibitory control, good inhibitory control) was a between participants variable and timing (pre-test, post-test) was a within participant variable. Controlling for OCI scores was done by entering sub-scales of the OCI questionnaire as a covariate to all analyses. A significant interaction between SSRT-group and timing was found for Memory Vividness, $F(1, 21) = 13.91$, $MSE = 245.44$, $p < .001$, $PES = .40$; for Memory Details, $F(1, 21) = 17.134$, $MSE = 284.99$, $p < .001$, $PES = .45$; and for Confidence in Memory, $F(1, 21) = 4.317$, $MSE = 395.72$, $p < .05$, $PES = .17$. These analyses suggest that the effects found in the current study are not caused due to individual differences in OCD symptoms but by individual differences in inhibitory control capabilities.

4. Discussion

The present investigation is the first study to examine individual differences in susceptibility to the undermining effects of repeated checking on memory confidence, as well as the first experimental investigation of relations between response inhibition performance and effects of repeated checking. Furthermore, it was designed to demonstrate the role of response inhibition as a possible etiological factor for an OCD model. First, we analyzed the results of the repeated-checking questionnaire. Repeated checking didn't decrease objective memory for either the relevant-checking or the irrelevant-checking groups. For both groups, vividness of memory was found to be lower in post-test questionnaires compared to pre-test questionnaires; this difference was much larger in the relevant-checking group. Most importantly, lower levels of memory detail and confidence in memory were found in the post-test questionnaires only for the relevant-checking group. This indicates that confidence in memory deteriorated after the repeated relevant-checking manipulation. This validates the manipulation and replicates van den Hout and Kindt's (2003) findings.

The main finding of the current study is that for the relevant-checking group, SSRT explained a significant proportion of variance of the reduction in the post-test questionnaire score, which suggests that an efficient inhibitory control mechanism protects from the harmful effects of repeated checking over memory confidence. Moreover, contrasting the good SSRT group (a third of the participants who had the shortest SSRT) with the poor SSRT group (a third of the participants who had the longest SSRT) revealed a reduction in the post-test questionnaire scores for the poor SSRT group and a smaller reduction (for Memory Vividness) or no reduction at all (for Memory Detail and Confidence in Memory) in the post-test questionnaire scores for the good SSRT group. These results indicate that individuals with good inhibitory control were less influenced by the repeated-checking manipulation. It seems that poor inhibitory control increases vulnerability for harmful effects of neutral compulsive-like behaviors, while good inhibitory control provides some protection from those harmful effects. Participants in the relevant-checking group were far more likely to voluntarily extend the experiment in order to re-check the gas stove and confirm their answers to the post-test questionnaire. It seems that repeated-checking not only increases memory uncertainty, as was revealed by van den Hout and Kindt (2003), but it ironically also increases the need for more checking as it encourages one to act on one's uncertainty.

One might suspect that obsessive-compulsive or other clinical symptoms are the cause for some, if not all, of our findings. This can be ruled out both by the lack of correlation between SSRT and the OCI and OBQ questionnaire scores in our non-clinical participants, and by the lack of correlation between the scores of all the questionnaire scales and the reduction in pre-test to post-test scores for all questions. Moreover, the differences in the repeated-checking's negative influences on the good and poor inhibitory control groups were significant even when controlling for obsessive-compulsive symptoms. This suggests that SSRT is a unique and predominant factor in determining vulnerability to OCD. In other words, our results indicate that inhibitory deficits contribute to the development and maintenance of OCD. This corresponds with the findings of Huyser et al. (2011) but not with those of Abramovitch et al. (2011a, 2011b). Nevertheless, considering the rather small and non-clinical sample that was used in the current study, we cannot entirely rule out the option that obsessive-compulsive symptoms play a role in the development of OCD (and inhibitory deficits) in a clinical population. Though it seems that inhibitory deficits might cause obsession eventually, we cannot rule out the option that obsessive thoughts can cause inhibitory deficits (Abramovitch et al., 2011a, 2011b). The directionality of the influence of OCD and inhibitory deficits is an area for future studies.

Intrusive thoughts are very common and occur in at least 90% of the general population (Salkovskis, 1999). Nevertheless, in only a fraction of the population these intrusions develop into obsessional cognitions. Clinical research has long tackled the question regarding the reasons for this pathological development. A predominant psychological model that explains this process is the cognitive behavioral model (Rachman, 2002; Salkovskis, Forrester,

& Richards, 1998). According to this model, OCD patients misinterpret intrusive cognitions as indicating imminent danger. As a consequence of this interpretation, they experience anxiety, discomfort and engage in anxiety-neutralizing (compulsive) behavior. Compulsive behavior and attempts of mental control elicit paradoxical effects of increasing these thoughts, perpetuating a vicious circle (Purdon & Clark, 2002). Though such cognitive-behavioral models are very useful, the role of inhibitory control in manifesting OCD is still unclear. We suggest a possible expansion of Rachman's model (2002), in which poor inhibitory control serves as an important factor in perpetuating compulsive behaviors. We agree that inhibitory control might be implicitly linked to Rachman's model and believe that it is important to explicitly explore this possibility.

Some limitations should be noted. 1) In order to prevent influences of the repeated-checking procedure on the clinical evaluation, the questionnaires were always given before the repeated-checking procedure and possibly influenced it. Although, considering that all participants underwent the same procedure, the comparison between the experimental groups and between them and the control group should not have been affected. 2) The current study concerns an initial investigation on a sample of healthy participants using a single task to measure inhibitory control. Future research should replicate and extend these findings using multiple inhibition measures and clinical populations. However, despite these limitations, our results suggest that inhibition deficits should be taken into account when considering the development and maintenance of the compulsive-obsessive vicious circle. Furthermore, our results encourage the notion that efficient inhibitory control can break this circle. van den Hout and Kindt's (2003) findings, which were replicated here, support Salkovskis et al.'s model (1998) by demonstrating that repeated checking tends to paradoxically increase memory uncertainty, a major vehicle of obsessional thoughts. The current study suggests that good inhibitory control lessens this paradoxical effect. It seems that the ability to inhibit an already initiated response applies to intrusive thoughts and helps to inhibit the behavioral tendency produced by repeated checking.

Anholt, Linkovski, Kalanthroff, and Henik (2012) recently suggested that this vicious circle may originate from sporadic behaviors receiving meaning, as if one says: "If I do it, it must be important". The current study results strengthen this notion as we demonstrate that thoughts of individuals with poor inhibitory control are affected by neutral compulsive behaviors. In turn, these thoughts cause individuals to act, and thus the vicious circle is perpetuated.

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