J. Behav. Ther. & Exp. Psychiat. xxx (2015) 1–8

Contents lists available at ScienceDirect

Journal of Behavior Therapy and Experimental Psychiatry

journal homepage: www.elsevier.com/locate/jbtep

Stop checking: Repeated checking and its effects on response inhibition and doubt

Omer Linkovski [a, b, *], Eyal Kalanthroff [a, b, c, d], Avishai Henik [a, b], Gideon Emanuel Anholt [b]

[a] Zlotowski Center for Neuroscience, Ben-Gurion University of the Negev, Israel
[b] Department of Psychology, Ben-Gurion University of the Negev, Israel
[c] New York State Psychiatric Institute, New York, NY, USA
[d] Columbia University, Department of Psychiatry, College of Physicians and Surgeons, New York, NY, USA

ARTICLE INFO

Article history:
Received 1 July 2014
Received in revised form
25 December 2014
Accepted 28 December 2014
Available online xxx

Keywords:
OCD
Repeated checking
Inhibition
Stop signal
Doubt
Familiarity

ABSTRACT

Background: Repeated checking is a common ritual in obsessive-compulsive disorder (OCD). van den Hout and Kindt (2003b) devised a task demonstrating paradoxical reductions in memory confidence following repeated checking. This effect was later found to be contingent upon response inhibition. The current study aims to (1) test an alternative interpretation, whereby repeated-checking effects are caused by viewing multiple exemplars, and (2) test whether repeated checking affects response inhibition.
Method: 132 students participated in two experiments (66 in Experiment 1 and 66 in Experiment 2). Participants were randomly allocated to a repeated-checking task or a simple-action task that featured similar multiple exemplars without the need for checking. Both tasks were followed by a stop-signal task, measuring response inhibition. Experiment 1 featured a stop-signal task with neutral go-signals while Experiment 2 incorporated familiar and unfamiliar stimuli from the previous task as go-signals.
Results: In both experiments, the repeated-checking group exhibited reduced memory confidence compared to the simple-action group. Groups did not differ in their response inhibition for neutral stimuli (Experiment 1), while familiar go-signals had a detrimental effect on response inhibition (Experiment 2).
Limitations: Our results examine the association between checking and response inhibition in healthy participants without attention deficit hyperactivity disorder and dyslexia. Replication with clinical samples awaits future studies.
Conclusions: Repeated checking impairs memory confidence. Increased familiarity of stimuli shortens the time it takes to respond to them while it impairs inhibition response to them. These effects possibly provide initial evidence for the hypothesized role of response inhibition in the maintenance of OCD.

1. Introduction

1.1. Obsessive-compulsive disorder (OCD)

Obsessive-compulsive disorder affects 2–3% of the population (Ruscio, Stein, Chiu, & Kessler, 2010) and constitutes a heavy burden on public mental health (Hollander et al., 1997). Checking is the most common symptom in OCD (for a review see Markarian et al., 2010). Rachman's (2002) theory of compulsive checking suggests that the duration of checking is affected by cognitive features (i.e., inflated sense of responsibility, perceived seriousness of the negative event and its consequences) that induce distress. Patients attempt to reduce their distress by eliminating the possibility of future negative events from occurring. As a consequence, they engage in checking aimed at achieving impossible certainty. Rachman postulated that checking perpetuates itself in a vicious cycle of thought and action. One tenet in this perpetuation cycle is the fact that checking reduces confidence about the memory of the last check (Tolin et al., 2001). MacDonald and Davey (2005) demonstrated that compulsions occur when negative mood is combined with the motivation ("stop-rule") to perform a task as good as possible (for a review see Meeten & Davey, 2011; but see van den Hout, Kindt, Luigjes, & Marck, 2007). An alternative view maintains that compulsions such as checking arise from neuropsychological deficits (Chamberlain, Blackwell, Fineberg, Robbins, & Sahakian, 2005).

* Corresponding author. Department of Psychology, Ben-Gurion University of the Negev, P.O.B. 653, Beer Sheva, 84105, Israel. Tel.: +972 8 6477209; fax: +972 8 6472072.
E-mail address: omerlink@post.bgu.ac.il (O. Linkovski).

http://dx.doi.org/10.1016/j.jbtep.2014.12.007
0005-7916/

In the past two decades there have been numerous attempts to characterize the neuropsychological and metacognitive profile of OCD patients (for a recent meta-analysis of neuropsychological factors see Abramovitch, Abramowitz, & Mittelman, 2013; for a review of neuropsychological factors see Chamberlain et al., 2005; for a review on metacognition see Rees & Anderson, 2013). Two domains that have been extensively examined are response inhibition and memory confidence.

1.2. Memory confidence in OCD

Research findings suggest that OCD patients suffer from reduced memory confidence (Boschen & Vuksanovic, 2007; Cougle, Salkovskis, & Wahl, 2007; Macdonald, Antony, Macleod, & Richter, 1997; Radomsky, Dugas, Alcolado, & Lavoie, 2014; Tolin et al., 2001; for a review on memory functions in OCD see Harkin & Kessler, 2011). van den Hout and Kindt (2003b) investigated relations between reduced confidence in memory and checking. They devised a task that required participants to repeatedly check three out of six possible gas rings. Their results indicated that checking creates a specific reduction in memory confidence regarding the checked stimuli while actual memory of the checking remains unaffected. These findings were replicated with healthy adults (Boschen & Vuksanovic, 2007; Boschen, Wilson, & Farrell, 2011; Dek, van den Hout, Giele, & Engelhard, 2010; Linkovski, Kalanthroff, Henik, & Anholt, 2013; van den Hout & Kindt, 2004), OCD patients (Boschen & Vuksanovic, 2007; Radomsky et al., 2014), and with checking of real objects (i.e., gas stoves; Coles, Radomsky, & Horng, 2006; Radomsky et al., 2014; Radomsky, Gilchrist, & Dussault, 2006). Investigation of individual differences in this repeated-checking task revealed that the reduction in memory confidence was attenuated in individuals with good response inhibition (Linkovski et al., 2013).

1.3. Response inhibition in OCD

Executive functions are a collection of mechanisms that support goal-directed behaviors (Banich, 2009). Response inhibition is one type of executive function. It has been defined as the ability to stop an inappropriate prepotent action (Logan & Cowan, 1984), and has been found to be deficient in OCD patients. A common way to operationalize response inhibition is the stop-signal task. In the stop-signal task (Logan & Cowan, 1984; Logan, Cowan, & Davis, 1984) the participant is required to indicate whether a certain stimulus is a circle or a square. In a quarter of the trials an auditory stop signal (i.e., a brief “beep” tone) is heard following the presentation of the shape, signaling participants to withhold response and wait for the next trial. Time between appearance of the shape (i.e., go signal) and the auditory tone (i.e., stop signal) is modified according to the participant's performance in the last stopping trial. This tracking procedure enables the estimation of the time it takes a person to stop—SSRT (i.e., stop-signal reaction time). Longer SSRT indicates that a person has a reduced ability to inhibit actions.

OCD patients as well as their healthy first-degree family members exhibit prolonged SSRTs, indicative of deficient response inhibition (Abramovitch et al., 2013; Chamberlain, Fineberg, Blackwell, Robbins, & Sahakian, 2006; Menzies et al., 2007).[1] An association between the effects of repeated checking on memory confidence and response inhibition was obtained in a correlative design (Linkovski et al., 2013). An experimental design could reveal the causal effects of repeated checking on response inhibition.

2. Experiment 1

Our first objective was to test whether familiarity—a possible confound in van den Hout and Kindt's (2003b) repeated checking task—affects memory confidence. In this task participants are assigned to one of two checking groups (i.e., relevant and irrelevant checking). The relevant-checking group conducts repeated checking with the same stimuli that are used to assess their memory and their memory confidence, whereas the irrelevant-checking group conducts checks of other stimuli, unrelated to the stimuli used to assess their objective memory and memory confidence. Therefore, checking and familiarity are confounded. In order to achieve our goal we needed to administer a task that features multiple exemplars of gas stoves but does not require checking or other compulsive-like actions (e.g., van den Hout, Engelhard, de Boer, du Bois, & Dek, 2008). We designed a simple-action task that required participants to attend to multiple exemplars and perform a simple action, which was not checking. We hypothesized that repeated checking would induce a greater deterioration in memory confidence compared to the simple-action task.

Our second objective was to test effects of repeated checking on response inhibition in an experimental design. We hypothesized that repeated checking would impair participants' response inhibition performance. In order to test this hypothesis, participants performed a stop-signal task following completion of either a repeated-checking task or a simple-action task. To test for the possibility that both tasks exert a similar effect on response inhibition, even if they show no difference between them, we formed a baseline SSRT by averaging SSRTs from a large, separate group of students.[2]

2.1. Method

2.1.1. Participants

Sixty-six undergraduate students at Ben-Gurion University of the Negev (Israel) participated for small monitory reimbursement. 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. Ages of the participants ranged from 22 to 29 years old. Thirty-two participants were randomly allocated to the repeated-checking group (i.e., experimental group; Mean Obsessive Beliefs Questionnaire (OBQ) score = 135.94, SD = 32.91; mean Obsessive Compulsive Inventory Revised (OCI-R) = 18.06, SD = 10.82), and 34 participants were randomly allocated to the simple-action group (i.e., control group; mean OBQ score = 132.32, SD = 30.38; mean OCI-R = 15.05, SD = 8.72). The allocation process consisted of a research assistant opening experimental time-slots that were pre-assigned for every group, and students voluntarily signed up for any of the slots without being aware to which of the groups they were assigned. Three participants didn't complete the questionnaires following the task and were excluded from further analysis (one participant was excluded from the repeated-checking task and two were excluded from the simple-action task).

2.1.2. Procedure

Participants were presented with one of two computerized tasks—either a repeated-checking task or a simple-action

[1] There have been several studies that measured inhibitory capabilities with different tasks; these lines of research yielded mixed results (for a recent review see Van Velzen, Vriend, de Wit, & van den Heuvel, 2014; for a recent meta-analysis see Abramovitch et al., 2013).

[2] This dataset was originally collected for an already published study (Kalanthroff & Henik, 2013).

Please cite this article in press as: Linkovski, O., et al., Stop checking: Repeated checking and its effects on response inhibition and doubt, *Journal of Behavior Therapy and Experimental Psychiatry* (2015), http://dx.doi.org/10.1016/j.jbtep.2014.12.007

task—immediately followed by a stop-signal task. Within two weeks[3] after this session, participants completed a set of two questionnaires designed to assess their obsessive-compulsive symptoms and beliefs. Separating the questionnaires from the experimental tasks was conducted in order to prevent possible influence of the repeated checking or response inhibition on obsessive beliefs and behavior. Additionally, avoiding the administration of the repeated-checking task following the presentation of an OCD questionnaire allowed us to prevent possible influences of participants' expectations about the intention of the repeated-checking task.

2.1.2.1. Repeated checking. We used van den Hout and Kindt's (2003b) original task. The task included a life-like gas stove with six gas rings. Participants utilized the computer mouse to manipulate the knobs of the virtual gas stove. An experimenter, located outside the experiment room, monitored the participant's computer screen using a closed circuit camera. A detailed description of the task is available in Linkovski et al. (2013) as well as in van den Hout and Kindt (2003b). Upon completing one practice trial, one checking trial, a pre-test questionnaire, and 20 trials of virtual checking, participants were asked to complete a post-test questionnaire. Each checking trial required participants to use a computer mouse to turn on, turn off and to turn again virtual gas knobs to verify successful shut-down (i.e., check) of three out of six possible gas rings. Pre- and post-test questionnaires were identical and included four questions—one question about objective memory accuracy (the location of the gas rings) and three questions regarding subjective memory (i.e., memory certainty, memory vividness and memory detail) on separate Visual Analogue Scales (VAS).

2.1.2.2. Simple-action task. The task required participants to attend and act on various gas stove alignments, but the required action was not checking. Specifically, in each experimental trial participants saw six gas rings with flames of different intensities. They were instructed to look at the stove at all times. After a varied time interval (ranging between 2 s and 16 s), one of the gas rings disappeared and the participants were required to indicate via the keyboard which gas ring disappeared as quickly and as accurately as possible. The duration of the simple-action task was equated to that of the repeated-checking task. Our aim was to test whether familiarity without checking affects objective memory and memory confidence. Since memory assessment has to occur following a checking trial, participants of this group performed a practice trial, two repeated-checking trials and a post-test questionnaire immediately after completing the simple-action task. Administration of the pre-test questionnaire to this group was avoided in order to refrain from creating anticipation for the memory questionnaire following checking trials (anticipation which did not occur in the repeated-checking group since for that group, unlike for the simple-action task group, there were multiple checking trials without questionnaires). This design was chosen to enable us to assess memory confidence while preventing effects of anticipation for the questionnaire.

2.1.2.3. Stop-signal task. The stop-signal task (Logan & Cowan, 1984) is perhaps the most common task demonstrating response inhibition differences between control participants and OCD patients or their families (Chamberlain et al., 2006). The classic version of this task features visual go signals consisting of a white square and a white circle on a black background. The stop signal is an auditory tone. The task includes one practice block of 32 trials and three experimental blocks of 64 trials each. Each trial starts with a fixation, followed by a visual go stimulus. In 25% of trials an auditory stop signal is sounded after a stop-signal delay (SSD), which is adjusted by the staircase tracking procedure—after each successful stopping the SSD is extended by 50 ms and after each unsuccessful stopping the SSD is shortened by 50 ms. SSRT is calculated as the mean RT for no-stop-signal (NSRT) trials minus the mean SSD.

2.1.2.4. Questionnaires. There were two self-report questionnaires: the Obsessive Compulsive Inventory Revised (OCI-R; Foa et al., 2002), which measures severity of OCD symptoms; and the Obsessive Beliefs Questionnaire (OBQ; Obsessive Compulsive Cognitions Working Group, 2005), which measures typical OCD cognitions.

The OCI-R (Foa et al., 2002) was designed to measure different symptoms of OCD. Eighteen items are used to construct six subscales of different OCD symptoms (e.g., washing, obsessing, hoarding, ordering, checking, and neutralizing) as defined in the fourth version of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2000).

The OBQ assesses beliefs 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.

2.1.2.5. Data analysis. The following analyses were conducted to test our a priori assumptions. Replicating van den Hout and Kindt's (2003b) original results was conducted by completing four one-way repeated measures analysis of variances (ANOVAs) to VAS scores with time (pre-test questionnaire vs. post-test questionnaire) as a within-subjects factor for all four memory measurements (i.e., accuracy, confidence, vividness and detail). To test our first hypothesis regarding the effect of viewing multiple exemplars on memory confidence, a comparison of memory measurements between groups (i.e., repeated-checking vs. simple-action) was conducted by four one-way ANOVAs to VAS scores of the post-test questionnaire, with group as a between-subject factor.

Inhibitory performance of the two groups was assessed using two independent *t*-tests for SSRT and accuracy rates with group as an independent variable. A one-way ANOVA was used to compare SSRT of participants from both groups to SSRT of a large control group (N = 120) that completed only the stop-signal task and served as the baseline in the current study.

2.2. Results

In the repeated-checking group we found that objective memory was not affected by the repeated checking, $F(1, 30) < .001$, $p > .99$. As for the subjective memory measurements, all three measurements (i.e., memory confidence, memory vividness and memory detail) significantly deteriorated, $F(1, 30) = 41.17$, partial eta squared (PES) = .58, $p < .001$; $F(1, 30) = 20.63$, $PES = .41$, $p < .001$; $F(1, 30) = 29.57$, $PES = .5$, $p < .001$; for memory confidence, memory vividness and memory detail, respectively (Table 1).

Groups (repeated-checking vs. simple-action) did not differ in their objective memory, $F(1, 61) = .59$, $p = .56$. As hypothesized, the repeated-checking group demonstrated significantly lower scores in all three subjective memory measurements, $F(1, 61) = 7.94$, $PES = .12$, $p < .01$; $F(1, 61) = 4.97$, $PES = .08$, $p < .05$; $F(1, 61) = 4.37$, $PES = .07$, $p < .05$; for memory confidence, memory vividness and memory detail, respectively (Table 1).

[3] An initial e-mail was sent to participants five days post–experiment but the time it took for the participants to reply varied within the limit of two weeks.

Please cite this article in press as: Linkovski, O., et al., Stop checking: Repeated checking and its effects on response inhibition and doubt, *Journal of Behavior Therapy and Experimental Psychiatry* (2015), http://dx.doi.org/10.1016/j.jbtep.2014.12.007

Table 1
Summary of mean scores in pre- and post-test questionnaires for the repeated-checking and simple-action groups.

	Repeated-checking		Simple-action
	Pre-test	Post-test	Post-test
Memory accuracy	.29 (.78)	.29 (.64)	.19 (.73)
Memory vividness	78.32 (22)**	53.39 (29.04)	69.22 (27.33)*
Memory detail	78.48 (21.29)**	52.94 (26.14)	66.19 (24.19)*
Memory confidence	91.26 (17.54)**	53.77 (29.61)	74.53 (30.87)*

Note. For "memory accuracy", the means of the number of errors are presented. Asterisks in the "pre-test" column indicate a significant difference in questionnaire scores within participants of the repeated-checking group. Asterisks in the simple-action "post-test" column indicate a significant difference in post-test questionnaire scores between participants in the simple-action group and the repeated-checking group. Standard deviations are in parentheses. $^{**}p < .001$, $^{*}p < .05$.

Contrary to our initial hypothesis, independent *t*-tests for SSRT and accuracy rate in stopping trials yielded no difference between groups in their SSRT, $t(60) = 1.54$, $p = .13$ (repeated checking: mean = 238 ms, $SD = 44$; simple action: mean = 256 ms, $SD = 46$); nor in their accuracy, $t(60) = .49$, $p = .63$ (repeated checking: mean = .52, $SD = .03$; simple action: mean = .52, $SD = .04$). In order to test whether response inhibition was equally affected in both groups or whether response inhibition was not affected in either of the groups, SSRT of participants in the current experiment was compared to SSRT of a large control group (N = 120) that only performed the stop-signal task. A one-way ANOVA for SSRT data was performed, with group as a between-subjects variable (repeated-checking, simple-action, control). A main effect for group was not significant, $F(2, 180) = 1.25$, $PES = .01$. In order to check for possible effects of the repeated checking on the "go process", we conducted another independent *t*-test for NSRTs, with group as a between-subjects factor. The groups did not differ in their reaction times, $t(60) = .5$, $p = .62$ (repeated checking: mean = 539 ms, $SD = 149$; simple action: mean = 553 ms, $SD = 140$). All analyses were conducted again using OCI-R and OBQ scores as covariates. Results did not change.

2.3. Discussion

The current study compared two groups that performed either a repeated-checking task or a simple-action task, followed by a stop-signal task with neutral stimuli as go signals. Our main finding was that repeated checking reduces memory confidence more than a simple-action task. This rules out the possibility of familiarity confounding the results of the repeated-checking task. However, contrary to our predictions, we found that response inhibition was not affected by these tasks.

The fact that repeated checking led to significantly lowered memory confidence as well as two different subjective memory indices (i.e., vividness and detail), compared to a simple-action task, strengthens the validity of van den Hout and Kindt's (2003b) repeated-checking task. Our results eliminate the possibility that multiple exemplars are the cause for participants' reduced memory confidence. The common explanation for this reduction in subjective memory is that increased familiarity augments conceptual processing (e.g., "knowing") while reducing perceptual processing (e.g., "remembering"; van den Hout & Kindt, 2003a, 2003b). However, our results can extend van den Hout and Kindt's (2003b) model as we demonstrate that increased familiarity alone cannot account for the subjective memory deterioration. In the current experiment, increasing familiarity to identical stimuli for both groups yielded a reduction in memory confidence only in the context of repeated checking. Therefore, we suggest that checking specifically plays a crucial role in the self-preservation mechanism that was suggested by Rachman (2002) and elaborated on by van den Hout and Kindt (2003a, 2003b).

The lack of difference between groups in response inhibition contradicted our hypothesis and may suggest that checking has no effect on inhibitory capabilities. However, in line with research exploring the effects of repeated checking on memory (Giele et al., 2013), an alternative hypothesis might be that the effect is stimulus specific. The current stop-signal task featured neutral, unfamiliar stimuli. Possibly, repeated checking affects response inhibition only to previously checked stimuli. This hypothesis is strengthened when considering OCD patients' difficulties to inhibit compulsive behavior (e.g., washing hands) when encountering one stimulus (e.g., family member) but having no problems inhibiting this very same compulsive behavior when encountering a different stimulus (e.g., a dog). A derivative hypothesis is that performing a stop-signal task in which familiar stimuli serve as go signals would be more likely to be affected by repeated checking. Experiment 2 tested this prediction.

3. Experiment 2

OCD patients perform compulsions aimed at specific stimuli (e.g., repeatedly checking a specific door). The same patient may be unaffected by different stimuli of the same category. Tolin et al. (2001) found that patients demonstrated larger uncertainty when required to identify personally relevant words compared to neutral ones. Others have found specific patterns of brain activation in response to symptoms-related images (Mataix-Cols et al., 2004). The influence of specific stimuli on response inhibition has been sparsely addressed. Morein-Zamir and colleagues (Morein-Zamir, Fineberg, Robbins, & Sahakian, 2010) combined OCD-relevant stimuli within an inhibitory task. Although their results suggest that response inhibition is not affected by stimulus relevance to OCD symptoms, this might be due to their choice of stimulus modality (i.e., written words). OCD-relevant pictures serve as stronger triggers to uncover attentional differences that are not evident when using words (Moritz, Von Mühlenen, Randjbar, Fricke, & Jelinek, 2009).

One possible way to mimic the specificity effect in healthy participants is to modify the familiarity of stimuli in the context of compulsive-like actions. Note that this does not suggest that familiarity equals symptom provocation. Familiarity has generally been shown to affect reaction times in different tasks (visual localization: Johnston & Schwarting, 1997; implicit recollection: Szymanski & MacLeod, 1996) but differences in familiarity were never investigated in the context of response inhibition.

In Experiment 2 we used a design that was identical to that of Experiment 1 but with a modified version of the stop-signal task that featured three differences: (1) the stop-signal task featured both familiar and unfamiliar stimuli with respect to the previous task (i.e., familiar – gas ring, unfamiliar – light bulb); (2) independent measurements of response inhibition were calculated for the two classes of stimuli (familiar and unfamiliar); and (3) we adjusted the tracking procedure so that the stop-signal delay was adjusted by 10 ms in every stopping trial and not by 50 ms as in Experiment 1.

Our main hypothesis was that repeated checking would affect response inhibition for familiar, but not for unfamiliar, stimuli. Specifically, we hypothesized that following a repeated-checking task, participants would exhibit deficient response inhibition for the previously checked stimuli. Within the checking group there are two effects that would indicate a deficient response inhibition to familiar stimuli: (1) more erroneous responses to stop signals in gas-ring trials (i.e., familiar stimuli) compared to light-bulb trials (i.e., unfamiliar stimuli), and (b) longer SSRT for familiar stimuli.

Please cite this article in press as: Linkovski, O., et al., Stop checking: Repeated checking and its effects on response inhibition and doubt, *Journal of Behavior Therapy and Experimental Psychiatry* (2015), http://dx.doi.org/10.1016/j.jbtep.2014.12.007

3.1. Method

3.1.1. Participants

Sixty-six undergraduate students at Ben-Gurion University of the Negev (Israel) participated for small monitory reimbursement or class credit. The participants' ages ranged from 21 to 26 years old. The same inclusion criteria as in Experiment 1 were applied. Twenty-eight participants were randomly allocated to the repeated-checking group (i.e., experimental group; mean OBQ score = 132.32, *SD* = 30.38; mean OCI-R = 15.05, *SD* = 8.72), and 38 participants were randomly allocated to the simple-action group (i.e., control group; mean OBQ score = 218.19, *SD* = 36.79; mean OCI-R = 20.16, *SD* = 12.98). Two participants failed to complete the experimental procedures and another participant reported not adhering to task instructions (i.e., decided not to turn on the gas stove at all); all three were excluded from further analysis.

3.1.2. Procedure

The procedure of Experiment 2 was identical to the procedure of Experiment 1 except for the stop-signal task differing in several parameters. The stop-signal task in Experiment 2 featured pictures of familiar gas rings and unfamiliar light bulbs (both were taken from van den Hout & Kindt, 2003b) as "go signals" (instead of the neutral square and circle used in Experiment 1). In this modified stop-signal task, participants saw one of two stimuli (i.e., a gas ring or a light bulb) in one of two states (turned on or turned off) and were required to determine, by a key-press, whether the object was turned on or off. Note that the familiarity of the object was irrelevant to the task. This task included 360 go trials, 90 for each illustration, and 120 stop trials, 30 for each illustration. SSD was subjected to a tracking procedure with 10 ms changes. In order to compare inhibitory capabilities for familiar and unfamiliar stimuli, two independent tracking procedures were used for gas rings and light bulbs (e.g., successful stopping in a gas ring trial affected SSD only for the next gas-stove trial). SSRT, accuracy rates, and average NSRT were calculated separately for trials featuring gas rings and light bulbs.

3.1.3. Data analysis

All analyses were identical to those in Experiment 1. Additional analyses are elaborated. Accuracy of responses in stop trials was analyzed by checking between-as well as within-group differences in responses to stimuli that differed in their familiarity. The between-groups comparison was accomplished by conducting two separate one-way ANOVAs for each group (repeated-checking and simple-action tasks) with familiarity as a within-subject factor (i.e., familiar − gas ring, unfamiliar − light bulb). The within-group comparison was accomplished by conducting separate repeated measures ANOVAs for each group (repeated-checking and simple-action tasks) with familiarity as a within-subject factor. In order to test whether repeated checking affected simple RTs, we conducted an identical analysis for NSRT.

3.2. Results

3.2.1. Repeated checking

In order to replicate the results of van den Hout and Kindt (2003b), we compared performance of the repeated-checking task group in the pre-test questionnaire, with their performance in the post-test questionnaire. Objective memory was not affected by the repeated checking, $F(1, 24) = 1.04$, $p = .32$. As for meta-memory measurements, all three measurements significantly deteriorated, $F(1, 24) = 14.96$, $PES = .38$, $p < .001$; $F(1, 24) = 16.1$, $PES = .40$, $p < .001$; $F(1, 24) = 8.05$, $PES = .25$, $p < .01$; for memory vividness, memory detail and memory confidence, respectively.

In order to test our a priori hypothesis regarding the importance of checking in deterioration of memory confidence, we compared performance of both groups in the post-test questionnaires. Groups did not differ in their objective memory, $F(1, 63) = 1.6$, $p = .20$. Replicating results of Experiment 1, significant differences were observed for memory vividness, memory detail and memory confidence, $F(1, 63) = 5.39$, $PES = .05$, $p < .001$; $F(1, 63) = 12.05$, $PES = .16$, $p < .001$, $F(1, 63) = 11.79$, $PES = .16$, $p < .01$, respectively (Table 2).

3.2.2. Familiarity and response inhibition

We used two measures to assess response inhibition—SSRT and accuracy rates in stop trials. Calculating SSRT according to traditional models requires the participant to perform the task with 50% accuracy on stop-signal trials (Verbruggen & Logan, 2009). Application of appropriate inclusion criteria in our participant sample resulted in exclusion of 28 participants—nine from the repeated-checking group and 19 from the simple-action task group. In the following sections we conduct an accuracy analysis on our entire sample and then conduct an analysis of accuracy and SSRT only on the participants that met the inclusion criteria for analysis of the SSRT.

Participants who performed repeated checking demonstrated reduced accuracy in stopping trials to familiar stimuli compared to unfamiliar stimuli, $F(1, 24) = 5.18$, $PES = .18$, $p < .05$. Similarly, participants in the simple-action group also exhibited reduced accuracy for familiar stimuli, $F(1, 38) = 17.49$, $PES = .31$, $p < .001$ (Table 3). These results indicate that it is harder to stop responses in the presence of familiar stimuli, regardless of the previous task.

Analysis of SSRT in the stop-signal task required two criteria to assure that participants met the theoretical assumptions of the model used to extrapolate a valid SSRT (Verbruggen & Logan, 2009): 1) an accuracy rate in stop trials higher than 40 percent and lower than 60 percent, and 2) data analysis was conducted only upon SSRT stabilization. Stabilization was defined as having had two SSD direction changes within ten trials (for a detailed description of the analysis see Kalanthroff, Goldfarb, & Henik, 2013). SSRT was calculated by subtracting the median SSD from the average NSRT (Verbruggen & Logan, 2009). Familiarity did not modulate SSRT in any of the groups, $F(1, 15) = 2.55$, $p = .13$, for the repeated-checking group, and $F(1, 19) = .70$, $p = .41$, for the simple-action group.

In order to test differences in accuracy in stopping trials for individuals who met the inclusion criteria for the SSRT, we compared accuracy rates in stopping trials for each group. Rates in stopping trials featuring familiar stimuli were significantly worse for the checking group, $F(1, 15) = 7.06$, $PES = .32$, $p < .05$, and significantly worse for the simple-action group, $F(1, 19) = 7.95$, $PES = .29$, $p < .05$.

Table 2
Summary of mean scores in the pre- and post-test questionnaires for the repeated-checking and simple-action groups.

	Repeated-checking		Simple-action
	Pre-test	Post-test	Post-test
Memory accuracy	.08 (.28)	.12 (.33)	.08 (.27)
Memory vividness	75.8 (16.52)**	57.24 (29.04)	72.03 (24.49)**
Memory detail	81 (15.06)**	58.4 (25.55)	77.41 (18.25)**
Memory confidence	83.92 (24.49)*	63.77 (27.13)	83.62 (19.91)*

Note. For "memory accuracy", the means of the number of errors are presented. Asterisks in the "pre-test" column indicate a significant difference in questionnaire scores within participants of the repeated-checking group. Asterisks in the simple-action 'post-test' column indicate a significant difference in post-test questionnaire scores between participants in the simple-action group and the repeated-checking group. Standard deviations are in parentheses. $^{**}p < .001$, $^{*}p < .05$.

Please cite this article in press as: Linkovski, O., et al., Stop checking: Repeated checking and its effects on response inhibition and doubt, *Journal of Behavior Therapy and Experimental Psychiatry* (2015), http://dx.doi.org/10.1016/j.jbtep.2014.12.007

Table 3
Results of all participants for familiar and unfamiliar stimuli in the stop-signal task following repeated-checking and simple-action tasks.

Previous task	Stop trials	Go trials
	Accuracy	RT
Repeated checking		
Familiar stimuli	.57 (.07)*	484 (60)**
Unfamiliar stimuli	.59 (.07)	502 (62)
Simple action		
Familiar stimuli	.6 (.09)**	513 (65)**
Unfamiliar stimuli	.63 (.09)	537 (81)

Note. Asterisks in the "accuracy" column under "stop trials" indicate a significant difference between familiar and unfamiliar stimuli within participants of each group. Asterisks in the "RT" column under "go-trials" indicate a significant difference between familiar and unfamiliar stimuli within participants of each group. Standard deviations are in parentheses. $^{**}p < .001$, $^{*}p < .05$.

3.2.3. *Familiarity and the "go" process*

Analysis of NSRT of the entire sample revealed shorter reaction times when the go stimulus was familiar (i.e., gas rings), $F(1, 24) = 22.04$, $PES = .48$, $p < .001$, and $F(1, 38) = 13.78$, $PES = .27$, $p < .001$, for the repeated-checking and simple-action groups, respectively (Table 3). This pattern of results remained identical for the participants who met the inclusion criteria for SSRT, $F(1, 15) = 16.64$, $PES = .52$, $p < .001$, and $F(1, 19) = 6.86$, $PES = .27$, $p < .05$, for the repeated-checking and simple-action groups, respectively.

3.3. *Discussion*

In Experiment 2 we manipulated familiarity of stimuli and used a modified stop-signal task to test whether compulsive-like actions on a stimulus would hinder the ability to inhibit other reactions to it. Our results replicated the findings of Experiment 1, demonstrating that it was checking, and not mere exposure to multiple exemplars, that affected memory confidence. As for our main hypothesis, repeated checking and simple actions did impair response inhibition to previously checked stimuli and increased the likelihood of erroneous responses in stopping trials, with effect sizes varying from small to medium depending on the previous task, which can be anticipated in such tasks. However, similar to the results of Experiment 1, unfamiliar stimuli did not affect the ability to stop. Moreover, familiarity improved the ability to respond to checked stimuli as evidenced by shorter RTs in go trials for both groups (i.e., repeated checking and simple action). A limitation of the current study is the fact that familiarity affected only one measure of response inhibition while not affecting SSRT. Possible explanations for that are addressed in the General Discussion.

4. General discussion

Two experiments in the current study were designed to test the importance of checking in the deterioration of memory confidence and to explore effects of checking and familiarity on response-inhibition performance. First, we demonstrated that checking is indeed crucial for the deterioration of memory confidence as well as other subjective memory appraisals (i.e., memory vividness and memory detail) and that multiple exemplars are insufficient to produce such effects. Second, we demonstrated that familiarity impairs response inhibition to familiar stimuli and does not affect response inhibition to novel stimuli.

We provided two replications demonstrating that participants who conducted an action that is not compulsive rated themselves higher in memory confidence and additional subjective memory indices (i.e., memory vividness and memory detail), compared to participants who conducted repeated checking. Additionally, we found that repeated checking does not influence the general ability to inhibit responses. It is the familiarity of a stimulus that reduces the ability to stop reactions to it; this was evident by increased error rates for familiar stimuli compared to unfamiliar ones and by shorter reaction times in:go trials (NSRT; i.e., trials that did not feature a stop signal). These two effects can be considered as converging evidence since the go process and the stop process are considered to be at least partially independent (Verbruggen & Logan, 2008b, 2009).

Our results concerning the relation between response inhibition, familiarity and checking have important implications. Considering the field of inhibition in cognitive psychology, response inhibition in early adulthood is considered a stable ability. So far, researchers have been able to affect it by using quite robust manipulations—influencing participant's arousal level (Kalanthroff, Cohen, & Henik, 2013; Verbruggen & De Houwer, 2007), influencing emotional valence and intensity (Pessoa, Padmala, Kenzer, & Bauer, 2012), or influencing the stimulus-response mappings in the stop-signal task (e.g., Verbruggen & Logan, 2008a). Our results indicate that response inhibition was affected by a more subtle procedure of increasing familiarity. In the realm of experimental psychopathology, our results validate the use of van den Hout and Kindt's (2003b) repeated-checking task as a valuable method to investigate relations between checking and memory confidence. It seems appropriate to broaden the use of this task and include new dependent measures to directly assess the quality of checking (e.g., exact time of each checking episode, the number of direction changes of each knob).

As for the clinical importance of the current results, OCD patients exhibit deficient response inhibition (Abramovitch et al., 2013; Snyder, Kaiser, Warren, & Heller, 2014); however, the meaning and significance of this deficit is the topic of an ongoing debate (Abramovitch & Abramowitz, 2014; Harsányi et al., 2014). A recent meta-analysis suggested that this inhibitory deficit lacks clinical significance (Abramovitch et al., 2013). Results of the current Experiment 1 support this suggestion as we demonstrated that repeated checking did not influence response inhibition. However, results of Experiment 2 provide support for the importance of response inhibition in OCD, by demonstrating that repeated checking and increased familiarity impaired one's ability to stop responses to attended stimuli. Therefore we suggest that our results offer a possible bridge between conflicting accounts of response inhibition deficits in maintenance of OCD. Specifically, compulsions may arise from several factors (Rachman, 2002; Salkovskis, 1985; but see also Anholt, Linkovski, Kalanthroff, & Henik, 2012; Chamberlain et al., 2005). Once an OCD patient conducts compulsive actions, his/her response-inhibition ability to the OCD-relevant content deteriorates, increasing the possibility of future compulsive acts on that specific stimulus. This suggestion broadens Rachman's (2002) theory of compulsions to neuropsychology. We suggest that the deterioration of response inhibition to checked stimuli can be considered a fifth tenet in the self-perpetuating cycle of compulsions that was suggested by Rachman and possibly in Salkovskis's theory (1985). We further suggest that one reason for the inconsistencies in the efforts to characterize a neuropsychological profile of OCD patients stems from the fact that most research employed neutral stimuli. Our proposed addition to Rachman's model, however, predicts that using OCD-relevant stimuli in response inhibition tasks would provide larger and more consistent differences between patients and control groups[4] (see Discussion of

[4] Several studies have found a similar pattern of results measuring different forms of inhibition (e.g., not measuring response inhibition: Moritz et al., 2009; Rao, Arasappa, Reddy, Venkatasubramanian, & Reddy, 2010; but see Moritz et al., 2008).

Please cite this article in press as: Linkovski, O., et al., Stop checking: Repeated checking and its effects on response inhibition and doubt, *Journal of Behavior Therapy and Experimental Psychiatry* (2015), http://dx.doi.org/10.1016/j.jbtep.2014.12.007

Experiment 1 for related findings). Another line of future research should strive to incorporate inhibitory measurements into Davey and colleagues' work on "stop-rules" (MacDonald & Davey, 2005); it is especially interesting since they (Meeten & Davey, 2011) conceptualize compulsions as goal-directed behaviors and deficient inhibition interferes with this class of behaviors (Banich, 2009). No one has yet to test the influence of response inhibition on the deployment of stop rules.

One possible limitation of the current study includes the use of an analog sample while not controlling for various psychopathologies. However, the seminal work of van den Hout and Kindt (2003a, 2003b) demonstrated the universal effect of checking on memory in a similar sample, and drew conclusions about the detrimental effects of checking in OCD patients. Such studies enabled us to study the basic elements in common mechanisms that relate stimulus familiarity with one's ability to withhold one's response. Replication of these results with OCD patients and incorporation of emotional content into the task are warranted prior to expanding Rachman's (2002) model. This suggestion is related to a second limitation in the current study, namely the use of previously checked stimuli to mimic the interaction of OCD patients with compulsion-inducing stimuli. Future studies may use disorder-specific stimuli, eliciting stronger emotional reactions that would possibly influence response inhibition as well as attentional processes in general (Pessoa, 2009). A third limitation regards the stop-signal task used in Experiment 2. The fact that inhibitory differences between familiar and unfamiliar stimuli were not evident in SSRT is intriguing. One post-hoc explanation concerns the procedure of the simple-action group. Participants in this group were also required to act (though not compulsively) on numerous exemplars, therefore it is possible that it is the action on the exemplar that caused the similar pattern of results in both groups. This could be tested by devising a control task that features multiple exemplars that necessitate neither acting nor engaging in compulsive-like rituals (e.g., van den Hout et al., 2008). However, it is possible that reducing the size of the adjustment to 10 ms in the modified stop-signal task (that was used in Experiment 2) may have resulted in participants completing the task with too many accurate stopping trials, effectively disqualifying them from further analysis of SSRT. One possible way to address this difficulty in future research would be to increase the number of stopping trials. This solution should be exercised with caution since the number of go trials would increase proportionally. This general prolonging of the task may mask the effect either due to participant fatigue or due to the fact that the repeated exposure to the unfamiliar stimuli would improve their familiarity and decrease possible specific effects.

The current study's design allows us to reason about the importance of response inhibition and familiarity in the vicious cycle of OCD. This is supported by the clinical observations that patients usually focus their compulsions on personally familiar topics and stimuli. The relevance of our results to the etiology of OCD and the question of whether individuals with poor response inhibition would be more susceptible to the effects of stimulus familiarity is an intriguing query for future research.

Acknowledgments

We would like to thank Ms. Desiree Meloul for her all suggestions and helpful comments.

References

Abramovitch, A., & Abramowitz, J. S. (2014). Improbability of response inhibition as a causal etiological factor of obsessive-compulsive disorder. *Psychiatry Research, 217*(3), 253–254. http://dx.doi.org/10.1016/j.psychres.2014.01.050.

Abramovitch, A., Abramowitz, J. S., & Mittelman, A. (2013). The neuropsychology of adult obsessive-compulsive disorder: a meta-analysis. *Clinical Psychology Review, 33*(8), 1163–1171. http://dx.doi.org/10.1016/j.cpr.2013.09.004.

American Psychiatric Association. (2000) (4th ed.). *Diagnostic and statistical manual of mental disorders* (4th ed.), (Vol. 1, p. 943). http://dx.doi.org/10.1176/appi.books.9780890423349 text revision (DSM-IV-TR). Text.

Anholt, G. E., Linkovski, O., Kalanthroff, E., & Henik, A. (2012). If I do it, it must be important: Integrating basic cognitive research findings with cognitive behavior theory. *Psicoterapia Cognitiva E Comportamentale, 18*(1), 69–77.

Banich, M. T. (2009). Executive function: the search for an integrated account. *Current Directions in Psychological Science, 18*(2), 89–94. http://dx.doi.org/10.1111/j.1467-8721.2009.01615.x.

Boschen, M. J., & Vuksanovic, D. (2007). Deteriorating memory confidence, responsibility perceptions and repeated checking: comparisons in OCD and control samples. *Behaviour Research and Therapy, 45*(9), 2098–2109. http://dx.doi.org/10.1016/j.brat.2007.03.009.

Boschen, M. J., Wilson, K. L., & Farrell, L. J. (2011). Attenuating memory distrust in a repeated checking task. *Behaviour Research and Therapy, 49*(8), 466–471. http://dx.doi.org/10.1016/j.brat.2011.05.001.

Chamberlain, S. R., Blackwell, A. D., Fineberg, N. A., Robbins, T. W., & Sahakian, B. J. (2005). The neuropsychology of obsessive compulsive disorder: the importance of failures in cognitive and behavioural inhibition as candidate endophenotypic markers. *Neuroscience and Biobehavioral Reviews, 29*(3), 399–419. http://dx.doi.org/10.1016/j.neubiorev.2004.11.006.

Chamberlain, S. R., Fineberg, N. A., Blackwell, A. D., Robbins, T. W., & Sahakian, B. J. (2006). Motor inhibition and cognitive flexibility in obsessive-compulsive disorder and trichotillomania. *The American Journal of Psychiatry, 163*(7), 1282–1284.

Coles, M. E., Radomsky, A. S., & Horng, B. (2006). Exploring the boundaries of memory distrust from repeated checking: increasing external validity and examining thresholds. *Behaviour Research and Therapy, 44*, 995–1006. http://dx.doi.org/10.1016/j.brat.2005.08.001.

Cougle, J. R., Salkovskis, P. M., & Wahl, K. (2007). Perception of memory ability and confidence in recollections in obsessive-compulsive checking. *Journal of Anxiety Disorders, 21*(1), 118–130. http://dx.doi.org/10.1016/j.janxdis.2006.03.015.

Dek, E. C. P., van den Hout, M. A., Giele, C. L., & Engelhard, I. M. (2010). Repeated checking causes distrust in memory but not in attention and perception. *Behaviour Research and Therapy, 48*(7), 580–587. http://dx.doi.org/10.1016/j.brat.2010.03.009.

Foa, E. B., Huppert, J. D., Leiberg, S., Langner, R., Kichic, R., Hajcak, G., et al. (2002). The Obsessive-Complusive Inventory: development and validation of a short version. *Psychological Assessment, 14*(4), 485–495. http://dx.doi.org/10.1037//1040-3590.14.4.485.

Giele, C. L., van den Hout, M. A., Engelhard, I. M., Dek, E. C. P., Hoogers, E. E. P., & de Wit, K. (2013). Ironic effects of compulsive perseveration. *Memory, 21*(4), 417–422.

Group, O. C. C. W. (2005). Psychometric validation of the obsessive belief questionnaire and interpretation of intrusions inventory—part 2: factor analyses and testing of a brief version. *Behaviour Research and Therapy, 43*(11), 1527–1542. http://dx.doi.org/10.1016/j.brat.2004.07.010.

Harkin, B., & Kessler, K. (2011). The role of working memory in compulsive checking and OCD: a systematic classification of 58 experimental findings. *Clinical Psychology Review, 31*(6), 1004–1021. http://dx.doi.org/10.1016/j.cpr.2011.06.004.

Harsányi, A., Csigó, K., Rajkai, C., Demeter, G., Németh, A., & Racsmány, M. (2014). Two types of impairments in OCD: obsessions, as problems of thought suppression; compulsions, as behavioral-executive impairment. *Psychiatry Research, 215*(3), 651–658. http://dx.doi.org/10.1016/j.psychres.2013.11.014.

Hollander, E., Stein, D. J., Kwon, J. H., Rowland, C., Wong, C. M., Broatch, J., et al. (1997). Psychosocial function and economic costs of obsessive-compulsive disorder. *CNS Spectrums, 2*, 16–25.

Johnston, W. A., & Schwarting, I. S. (1997). Novel popout: an enigma for conventional theories of attention. *Journal of Experimental Psychology: Human Perception and Performance, 23*(3), 622–631.

Kalanthroff, E., Cohen, N., & Henik, A. (March 2013). Stop feeling: inhibition of emotional interference following stop-signal trials. *Frontiers in Human Neuroscience, 7*, 78. http://dx.doi.org/10.3389/fnhum.2013.00078.

Kalanthroff, E., Goldfarb, L., & Henik, A. (2013). Evidence for interaction between the stop signal and the Stroop task conflict. *Journal of Experimental Psychology: Human Perception and Performance, 39*(2), 579–592. http://dx.doi.org/10.1037/a0027429.

Kalanthroff, E., & Henik, A. (2013). Individual but not fragile: individual differences in task control predict Stroop facilitation. *Consciousness and Cognition, 22*(2), 413–419. http://dx.doi.org/10.1016/j.concog.2013.01.010.

Linkovski, O., Kalanthroff, E., Henik, A., & Anholt, G. (2013). Did I turn off the stove? Good inhibitory control can protect from influences of repeated checking. *Journal of Behavior Therapy and Experimental Psychiatry, 44*(1), 30–36. http://dx.doi.org/10.1016/j.jbtep.2012.07.002.

Logan, G. D., & Cowan, W. B. (1984). On the ability to inhibit thought and action: a theory of an act of control. *Psychological Review, 91*(3), 295–327. http://dx.doi.org/10.1037//0033-295X.91.3.295.

Logan, G. D., Cowan, W. B., & Davis, K. A. (1984). On the ability to inhibit simple and choice reaction time responses: a model and a method. *Journal of Experimental Psychology: Human Perception and Performance, 10*(2), 276–291. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/6232345.

Please cite this article in press as: Linkovski, O., et al., Stop checking: Repeated checking and its effects on response inhibition and doubt, *Journal of Behavior Therapy and Experimental Psychiatry* (2015), http://dx.doi.org/10.1016/j.jbtep.2014.12.007

Macdonald, P. A., Antony, M. M., Macleod, C. T., & Richter, M. A. (1997). Memory and confidence in memory judgments among individuals with obsessive-compulsive disorder and non-clinical controls. *Behavior Research and Therapy, 35*(6), 497–505.

MacDonald, C., & Davey, G. C. L. (2005). A mood-as-input account of perseverative checking: the relationship between stop rules, mood and confidence in having checked successfully. *Behaviour Research and Therapy, 43*(1), 69–91. http://dx.doi.org/10.1016/j.brat.2003.11.003.

Markarian, Y., Larson, M. J., Aldea, M. A., Baldwin, S. A., Good, D., Berkeljon, A., et al. (2010). Multiple pathways to functional impairment in obsessive-compulsive disorder. *Clinical Psychology Review, 30*(1), 78–88. http://dx.doi.org/10.1016/j.cpr.2009.09.005.

Mataix-Cols, D., Wooderson, S., Lawrence, N., Brammer, M. J., Speckens, A., & Phillips, M. L. (2004). Distinct neural correlates of washing, checking, and hoarding symptom dimensions in obsessive-compulsive disorder. *Archives of General Psychiatry, 61*(6), 564–576. http://dx.doi.org/10.1001/archpsyc.61.6.564.

Meeten, F., & Davey, G. C. L. (2011). Mood-as-input hypothesis and perseverative psychopathologies. *Clinical Psychology Review, 31*(8), 1259–1275. http://dx.doi.org/10.1016/j.cpr.2011.08.002.

Menzies, L., Achard, S., Chamberlain, S. R., Fineberg, N., Chen, C. H., Del Campo, N., et al. (2007). Neurocognitive endophenotypes of obsessive-compulsive disorder. *Brain, 130*(12), 3223–3236. http://dx.doi.org/10.1093/brain/awm205.

Morein-Zamir, S., Fineberg, N. A., Robbins, T. W., & Sahakian, B. J. (2010). Inhibition of thoughts and actions in obsessive-compulsive disorder: extending the endophenotype? *Psychological Medicine, 40*(2), 263–272. http://dx.doi.org/10.1017/S003329170999033X.

Moritz, S., Fischer, B.-K., Hottenrott, B., Kellner, M., Fricke, S., Randjbar, S., et al. (2008). Words may not be enough! No increased emotional Stroop effect in obsessive-compulsive disorder. *Behaviour Research and Therapy, 46*(9), 1101–1104. http://dx.doi.org/10.1016/j.brat.2008.05.005.

Moritz, S., Von Mühlenen, A., Randjbar, S., Fricke, S., & Jelinek, L. (2009). Evidence for an attentional bias for washing- and checking-relevant stimuli in obsessive-compulsive disorder. *Journal of the International Neuropsychological Society, 15*(3), 365–371. http://dx.doi.org/10.1017/S1355617709090511.

Pessoa, L. (2009). How do emotion and motivation direct executive control? *Trends in Cognitive Sciences, 13*(4), 160–166. http://dx.doi.org/10.1016/j.tics.2009.01.006.

Pessoa, L., Padmala, S., Kenzer, A., & Bauer, A. (2012). Interactions between cognition and emotion during response inhibition. *Emotion, 12*(1), 192–197. http://dx.doi.org/10.1037/a0024109.

Rachman, S. (2002). A cognitive theory of compulsive checking. *Behaviour Research and Therapy, 40*(6), 625–639.

Radomsky, A. S., Dugas, M. J., Alcolado, G. M., & Lavoie, S. L. (2014). When more is less: doubt, repetition, memory, metamemory, and compulsive checking in OCD. *Behaviour Research and Therapy, 59*, 30–39. http://dx.doi.org/10.1016/j.brat.2014.05.008.

Radomsky, A. S., Gilchrist, P. T., & Dussault, D. (2006). Repeated checking really does cause memory distrust. *Behaviour Research and Therapy, 44*(2), 305–316. http://dx.doi.org/10.1016/j.brat.2005.02.005.

Rao, N. P., Arasappa, R., Reddy, N. N., Venkatasubramanian, G., & Reddy, Y. C. J. (2010). Emotional interference in obsessive-compulsive disorder: a neuropsychological study using optimized emotional Stroop test. *Psychiatry Research, 180*(2–3), 99–104. http://dx.doi.org/10.1016/j.psychres.2009.10.017.

Rees, C. S., & Anderson, R. A. (2013). A review of metacognition in psychological models of obsessive-compulsive disorder. *Clinical Psychologist, 17*(1), 1–8. http://dx.doi.org/10.1111/cp.12001.

Ruscio, A. M., Stein, D. J., Chiu, W. T., & Kessler, R. C. (2010). The epidemiology of obsessive-compulsive disorder in the National Comorbidity Survey Replication. *Molecular Psychiatry, 15*(1), 53–63. http://dx.doi.org/10.1038/mp.2008.94.

Salkovskis, P. M. (1985). Obsessional-compulsive problems: a cognitive-behavioural analysis. *Behaviour Research and Therapy, 23*(5), 571–583.

Snyder, H. R., Kaiser, R. H., Warren, S. L., & Heller, W. (2014). Obsessive-compulsive disorder is associated with broad impairments in executive function: a meta-analysis. *Clinical Psychological Science*. http://dx.doi.org/10.1177/2167702614534210. E-pub before print.

Szymanski, K., & MacLeod, C. (1996). Manipulation of attention at study affects an explicit but not an implicit test of memory. *Consciousness and Cognition, 175*(5), 165–175. Retrieved from http://www.sciencedirect.com/science/article/pii/S1053810096900100.

Tolin, D. F., Abramowitz, J. S., Brigidi, B. D., Amir, N., Street, G. P., & Foa, E. B. (2001). Memory and memory confidence in obsessive-compulsive disorder. *Behaviour Research and Therapy, 39*(8), 913–927. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19285350.

van den Hout, M. A., Engelhard, I. M., de Boer, C., du Bois, A., & Dek, E. (2008). Perseverative and compulsive-like staring causes uncertainty about perception. *Behaviour Research and Therapy, 46*(12), 1300–1304. http://dx.doi.org/10.1016/j.brat.2008.09.002.

van den Hout, M., & Kindt, M. (2003a). Phenomenological validity of an OCD-memory model and the remember/know distinction. *Behaviour Research and Therapy, 41*(3), 369–378. http://dx.doi.org/10.1016/S0005-7967(02)00097-9.

van den Hout, M., & Kindt, M. (2003b). Repeated checking causes memory distrust. *Behaviour Research and Therapy, 41*(3), 301–316. http://dx.doi.org/10.1016/S0005-7967(02)00012-8.

van den Hout, M., & Kindt, M. (2004). Obsessive–compulsive disorder and the paradoxical effects of perseverative behaviour on experienced uncertainty. *Journal of Behavior Therapy and Experimental Psychiatry, 35*(2), 165–181. http://dx.doi.org/10.1016/j.jbtep.2004.04.007.

van den Hout, M., Kindt, M., Luigjes, J., & Marck, C. (2007). Compulsive perseveration: empirical criticism on the mood-as-input model. *Behaviour Research and Therapy, 45*(6), 1221–1230. http://dx.doi.org/10.1016/j.brat.2006.09.001.

Van Velzen, L. S., Vriend, C., de Wit, S. J., & van den Heuvel, O. A. (June 2014). Response inhibition and interference control in obsessive-compulsive spectrum disorders. *Frontiers in Human Neuroscience, 8*, 419. http://dx.doi.org/10.3389/fnhum.2014.00419.

Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition & Emotion, 21*(2), 391–403. http://dx.doi.org/10.1080/02699930600625081.

Verbruggen, F., & Logan, G. (2008a). Automatic and controlled response inhibition: associative learning in the go/no-go and stop-signal paradigms. *Journal of Experimental Psychology: General, 137*(4), 649–672. http://dx.doi.org/10.1037/a0013170.Automatic.

Verbruggen, F., & Logan, G. D. (2008b). Response inhibition in the stop-signal paradigm. *Trends in Cognitive Sciences, 12*(11), 418–424. http://dx.doi.org/10.1016/j.tics.2008.07.005.

Verbruggen, F., & Logan, G. D. (2009). Models of response inhibition in the stop-signal and stop-change paradigms. *Neuroscience and Biobehavioral Reviews, 33*(5), 647–661. http://dx.doi.org/10.1016/j.neubiorev.2008.08.014.

Please cite this article in press as: Linkovski, O., et al., Stop checking: Repeated checking and its effects on response inhibition and doubt, *Journal of Behavior Therapy and Experimental Psychiatry* (2015), http://dx.doi.org/10.1016/j.jbtep.2014.12.007