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Patients With Obsessive-Compulsive Disorder Check Excessively in Response to Mild Uncertainty

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Patients with obsessive-compulsive disorder (OCD) not only respond to obsessions with perseverative checking, but also engage in more general checking, irrespective of their obsessive concerns. This study investigated whether general checking is specific to OCD and exacerbated when only mild uncertainty is induced. Thirty-one patients with OCD, 26 anxiety- and 31 healthy controls performed a visual search task with eye-tracking and indicated in 50 search displays whether a target was "present" or "absent". Target-present trials were unambiguous, whereas target-absent trials induced mild uncertainty, because participants had to rely on not overlooking the target. Checking behavior was measured by assessing search time and the number of fixations, measured with an eye-tracker. Results showed that in both target-present and target-absent trials patients with OCD searched longer and made more fixations than healthy and anxiety controls. However, the difference in checking behavior between patients with OCD and the control groups was larger in target-absent trials (where mild uncertainty was induced). Anxiety and healthy controls did not differ in checking behavior. Thus, mild uncertainty appears to *specifically* promote checking in patients with OCD, which has implications for treatment.

Keywords: obsessive-compulsive disorder; checking; anxiety; uncertainty; eye-tracking

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CHECKING BEHAVIOR IS ONE OF THE MOST COMMON compulsions in obsessive–compulsive disorder (OCD), with 80% of individuals with lifetime OCD reporting this as one of their primary symptoms (Ruscio, Stein, Chiu, & Kessler, 2010). Compulsions in OCD are defined as repetitive behavior or mental acts *in response* to intrusive thoughts or images (obsessions) to suppress anxiety

and prevent future misfortunes (DSM-5; American Psychiatric Association [APA] 2013). It is thus assumed that compulsive behavior is driven by obsessive uncertainty about frightening prospects. The same assumption underlies cognitive theories of OCD (e.g., Rachman, 1997), which view obsessions as the core feature and checking compulsions as the result of preceding frightening obsessions that typically relate to potential personal guilt. For instance, obsessions about harming a loved one (e.g., stabbing someone while doing the dishes) may be misinterpreted as morally offensive (e.g., equivalent to harming someone) or as likely leading to an unwanted sequel (e.g., assault), which needs to be prevented by compulsively checking all knives and scissors in the house. Thus, both the influential DSM and cognitive theories assume that compulsions such as checking are "output" resulting from preceding frightening thoughts.

However, there are indications that patients with OCD also show subtle checking behavior in the absence of obsessive concerns. Recently, Gillan et al. (2011, 2014) demonstrated that patients with OCD have a deficit in goal-directed learning, which causes them to overly rely on their habit system. In these studies, patients with OCD were asked to perform an appetitive instrumental learning task, which induced habits by rewarding certain behaviors (Gillan et al., 2011), or a shock avoidance task wherein they could avoid receiving electric shocks by responding correctly to warning stimuli (Gillan et al., 2014). When the habitual responses were installed, one response was devalued by removing the reward or disconnecting the electrodes of the shock, while another remained valuable. Patients with OCD did not differ from healthy controls in responding for valuable outcomes, but they did show elevated responses towards devalued outcomes, which indicated overactive habits. This suggests that compulsions may be viewed as excessive habit learning, which inhibits OCD individuals to abstain from this behavior even in the absence of prior obsessions.

In a comparable vein, a recent study showed that patients with OCD use more checking behavior than healthy controls in a basic image-comparison task (comparing two images that were presented simultaneously and indicating whether they were identical; Jaafari et al., 2013). Moreover, OCD checkers used increased checking behavior in a delayed matching to samples task (comparing two images that were projected with a delay in between and indicating whether they were identical), which was unrelated to the stimulus-evoked anxiety (Clair et al., 2013). This emphasizes the automated and habitual part of checking that is displayed irrespective of experienced obsession-related anxiety. Additionally, Harkin, Miellet, and Kessler (2012) examined mental checking behavior in healthy participants with either high or low checking tendencies with an experimental eye tracking paradigm. In their experiment, participants had to perform a memory task that consisted of 3 phases. In Phase 1 participants were presented with 4 letters located randomly in 4 of 6 possible locations on a grid, and had to encode the identity and location of each letter. Then, during the delay period of the memory task the "probe-1 question" requested the location of a specific letter, which had been either part (resolvable trial) or not (misleading trial) of the encoded set. Participants could either answer what the location of the letter was or "skip" the trial if they believed the letter was not present in the encoded set. Finally, in Phase 3 the "probe-2 question" was the actual memory test for each trial and required participants to indicate if a letter was correctly located with respect to the originally encoded set. Results showed that in misleading trials high-checkers checked longer than low-checkers, and specifically that high-checkers spend more time checking and fixated more often in stimulus locations as well as locations that had actually been empty during encoding. This indicated that high checkers are less able to ignore misleading information and that this impaired response inhibition may lead to excessive (mental) checking.

However, impaired response inhibition may not be the only explanation for excessive general checking behavior. Importantly, patients with OCD not only report excessive uncertainty and doubt in the area of their obsessional concerns (Salkovskis, 1985), but also show (mild) uncertainty in unrelated areas. For instance, it was demonstrated that patients with OCD are less confident about their general knowledge (Dar, Rish, Hemesh, Taub, & Fux, 2000), and have less confidence in their perception, attention, and memory (Hermans et al., 2008). Does this mild uncertainty, which is thematically unrelated to extreme obsessive concerns, stimulate general checking in OCD? To examine this issue, a novel, experimental eye-tracking paradigm was developed in which checking behavior could be measured in both certain and mildly uncertain situations (Toffolo, van den Hout, Hooge, Engelhard, & Cath, 2013). In this paradigm participants performed a visual search task, in which they had to indicate whether a target was "present" or "absent" (see Figure 1). The target-present trials were unambiguous; the response "present" was based on straightforward inspection of the target, which therefore reflected

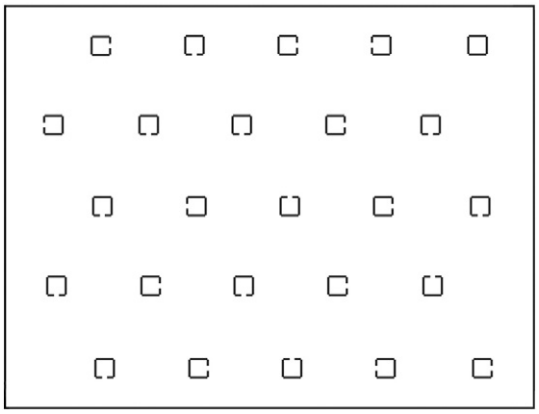

FIGURE 1 Example of a search display; the target is the closed symbol (upper right corner; could be placed in all locations on the display). In the experiment, the elements were white on a dark gray background.

certain situations. Target-absent trials, however, were more ambiguous, because participants had to rely on not having overlooked the target. These trials were therefore held to induce mild uncertainty, and counted as uncertain situations. Toffolo et al. (2013) showed that individuals with high OC tendencies (OC+) searched longer and used more fixations (i.e., used more checking) than individuals with low OC tendencies (OC-) in target-absent, but not in target-present trials. After replicating the findings with respect to prolonged search time (Toffolo, van den Hout, Engelhard, Hooge, & Cath, 2014), it was concluded that mildly uncertain situations, unrelated to obsessive uncertainty, promote checking behavior in individuals with subclinical OCD.

However, since the previous studies were conducted with healthy subjects only, a next logical step is to investigate whether these findings would hold in patients with OCD, and to what extent they are specific to the OCD phenotype. Therefore, the present study, while using the same eye-tracking paradigm as Toffolo et al. (2013, 2014), aimed to extend the previous findings by investigating whether patients with OCD respond to mildly uncertain situations with more checking behavior than both non-OCD anxiety controls and healthy controls that were matched on age, sex and education level. We hypothesized that patients with OCD would respond to target-absent trials with more checking behavior (as operationalized by higher search time and number of fixations) than both anxiety and healthy controls. Furthermore, because previous research showed that patients with OCD generally engage in more checking behavior than healthy individuals, independent of their obsessions, (e.g., Clair et al., 2013; Jaafari et al., 2013), we expected that they would also use more checking behavior in target-present trials than both control groups, but we hypothesized that the difference in target-absent trials would be larger.

Method

PARTICIPANTS

The study was approved by the Institutional Review Board of University Medical Center Utrecht (METC-UMCU). Patients with OCD and anxiety control patients were recruited from the Altrecht Academic Anxiety center (AAA; outpatient care, OCD $n = 23$; anxiety controls $n = 26$), and the Vincent van Gogh Center for Anxiety and Obsessive–Compulsive Disorders (VVG-CAD; inpatient care, $n = 8$). Patients were included who had either a primary DSM-IV diagnosis of OCD or a primary anxiety disorder diagnosis (without comorbid OCD), as assessed with the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I; First, Spitzer, Gibbon & Williams, 1996; van Groenestijn, Akkerhuis, Kupka, Schneider & Nolen, 1999). The complete SCID-I was administered by the treatment center before the start of treatment. Additionally, the OCD module of the SCID-I was administered by the first author after participants finished the Visual Search Task (see Procedure) to confirm diagnosis without influencing the task. The first author has previously been trained under supervision of Dr. Danielle Cath, who has been licensed to carry out SCIDs in the Netherlands. The anxiety control group encompassed patients with a main DSM-IV diagnosis of social phobia ($n = 13$), panic disorder with/without agoraphobia ($n = 4$), generalized anxiety disorder ($n = 4$), posttraumatic stress disorder ($n = 4$), or severe specific phobia ($n = 1$). Healthy controls were recruited from the community via advertisements and snowball sampling. Exclusion criteria for all groups were as follows: diagnosis of psychotic disorder, current drug and/or alcohol abuse, using benzodiazepines on a regular basis, vision problems or nonfluency in Dutch. Healthy controls were excluded when they were diagnosed with any current psychiatric disorder.

All groups were matched on age, gender, and education level. A 3-point scale was used to determine participants' highest educational level (1 = low; primary education or high school; 2 = moderate; professional vocational training [community college]; 3 = high; college or university). Four healthy control subjects were removed prior to data analysis. One reported after participation to be diagnosed with a current eating disorder, one reported current OCD-symptoms (checking the stove, electrical outlets, etc., around the house repeatedly on a daily basis), one

reported drug abuse the day before participation, and one had misunderstood task instructions. Additionally, two anxiety control subjects were removed; one was re-diagnosed with autistic disorder, and one scored over 3 *SD*s above the anxiety group mean on the OCI-R (score = 49; see Measures). The final sample consisted of 31 patients with OCD, 31 matched healthy controls, and 26 matched anxiety controls.

MEASURES

Yale-Brown Obsessive Compulsive Scale (Y-BOCS; Goodman et al., 1989)
The Dutch version (Arrindell, Albersnagel, & Van Oppen, 1990) of the self-rated version of the Y-BOCS was administered to patients with OCD to assess the severity of OCD symptoms, irrespective of the type of obsessions or compulsions present. It is a 10-item scale, rated on 5-point Likert scales (e.g., "how much distress do you experience of your obsessions"; 0 = *none*, 4 = *extreme*). The Y-BOCS has excellent internal consistency, $\alpha = .89$ (Goodman et al., 1989), and test–retest reliability, $r = .89$ (Kim, Dysken, & Kuskowski, 1990).

Obsessive–Compulsive Inventory-Revised (OCI-R; Foa et al., 2002)
The Dutch translation (Cordova-Middelbrink, Dek, & Engelbarts, 2007) of the OCI-R was administered to the anxiety and healthy control groups to assess obsessive–compulsive tendencies. It contains 18 items concerning OCD characteristics, each measured on 4-point Likert scales (e.g., "I check things more often than needed"; 0 = *not at all*, 4 = *extremely*). The OCI-R has good internal consistency in both patients with OCD ($\alpha = .81$) and nonanxious controls ($\alpha = .89$) and excellent test–retest reliability, *r*s = .82 and .84. The clinical cutoff score is 21 (Foa et al., 2002).

Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988)
The Dutch translation of the BAI was administered to assess anxiety symptoms in all groups. It is a 21-item self-report measure that assesses the experience of common anxiety symptoms during the past week, rated on 4-point Likert scales (e.g., "heart pounding" or "unsteady"; 0 = *not at all*, 3 = *very much*).

Beck Depression Inventory, Second Edition (BDI-II; Beck, Steer, & Brown, 1996)
The Dutch translation (Beck, Steer, Brown, & van der Does, 2002) of this 21-item inventory (ranging from 0 to 3) was administered to all groups to assess the severity of depressive symptoms. The BDI-II has demonstrated excellent internal consistency ($\alpha = .93$ among college students, $\alpha = .92$ among outpatients; Beck et al., 1996).

Intolerance of Uncertainty Scale (IUS; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994)
The Dutch translation (De Bruin, Rassin, van der Heiden, & Muris, 2006) of the IUS was administered across all groups to assess emotional, cognitive, and behavioral reactions to ambiguous situations, implications of being uncertain, and attempts to control the future. It contains 27 items, rated on a 5-point Likert scale (e.g., "Uncertainty stops me from having a firm opinion"; 1 = *not at all characteristic of me*, 5 = *entirely characteristic of me*). The internal consistency of the scale is excellent ($\alpha = .91$) and its test–retest reliability is good ($r = .78$; Dugas, Freeston & Ladouceur, 1997).

MATERIAL

Visual Search Task
The task used by Toffolo et al. (2013, 2014) was applied. It consisted of 50 individual search displays (trials) presented in random order; each containing 25 white elements on a dark gray background (see Figure 1), presented with Matlab (MathWorks Benelux, 2012). Half of the search displays contained 25 squares with a gap in one of the four edges (the distracters; *target-absent trials*), and the other half of the search displays contained 24 distracters and one closed square (the target; *target-present trials*). The size of all elements (target and distracters) was .41° × .41°, and the gap size of the distracters was 0.21°. The elements were placed on a hexagonal grid in a 30.01° × 27.8° display. In target-present trials, the target position was randomly chosen among these locations, and the other locations were occupied by the distracters.

Two questions at the end of the task assessed feelings of uncertainty in both trial types (translation of Dutch questions): "How certain did you feel when you responded that there was a target present in the field?" and "How certain did you feel when you responded that there was no target present in the field?" rated on 10-point scales (0 = *not certain*, 9 = *very certain*).

Checking behavior was operationalized by search time (i.e., the time it took participants to search through the field until making a response) and the number of fixations (measured with an eye-tracker, see Apparatus).

APPARATUS

Eye movements were recorded at 52 Hz using a portable, EyeTeck TM3 eye-tracker (Design

Interactive, Inc., Oviedo, FL). The eye movement data were analyzed off-line. Fixation detection was done by a self-written Matlab program that marked fixations by an adaptive velocity threshold method, which is quite common (Engbert & Kliegl, 2003; Nyström & Holmqvist, 2010; Smeets & Hooge, 2003). The adaptive velocity threshold method used for the current study was developed for data from low frequency eye-trackers (Hooge & Camps, 2013). Fixation durations shorter than 58 ms (3 samples) were removed from the analysis.

PROCEDURE

Participants were tested individually in a dimly lit testing room at the treatment center or at Utrecht University. After complete description of the study to the participants, written informed consent was obtained. Participants were seated in front of a 17-inch monitor with the eye-tracker placed beneath, and head movements were restricted by a chin-and-forehead rest. After a 9-point calibration of the eye-tracker, the task started with six practice trials, followed by the 50 search displays. Before each trial, a fixation point was presented in the center of the screen. Immediately after pressing the space bar, the search display appeared. During each trial, participants were asked to indicate whether a target was present or absent in the search display, by pressing the left (target-present) or right (target-absent) arrow key. Participants were unaware of the number of search displays that contained a target. After finishing the computer task, the OCD module of the SCID-I was administered and participants filled out the questionnaires (Y-BOCS/OCI-R, BAI, BDI-II, and IUS), and were debriefed and paid 10 euros for their participation.

Results

CLINICAL CHARACTERISTICS

Table 1 reports descriptive statistics and clinical characteristics. The matched groups did not differ in age, F (2, 87) = 1.31, p = .27, gender, χ^2 (2) = .15, p = .93, and education level, χ^2 (4) = .98, p = .91. Patients with OCD scored within the moderate range on OCD symptom severity (Y-BOCS). Both anxiety and healthy controls scored within the nonclinical range on OC tendencies (OCI-R). Both patients with OCD and anxiety disorders respectively scored higher than healthy controls on the BAI, t (53.17) = 5.05, p < .001, d = 1.28, 95% CI [.72, 1.81], t (36.79) = 6.27, p < .001, d = 1.75, 95% CI [1.12, 2.34], BDI-II, t (47.16) = 4.84, p < .001, d = 1.23, 95% CI [.67, 1.76], t (55) =5.98, p < .001, d = 1.59, 95% CI [.97, 2.16], and IUS, t (57) = 3.51, p = .001, d = .91, 95% CI [.37, 1.42], t (55) = 4.92, p < .001, d = 1.31, 95% CI [.72, 1.86]. Finally, patients with anxiety disorders scored higher than patients with OCD on anxiety symptoms, t (55) = 2.15, p = .036, d = .57, 95% CI [0.03, 1.10], but these groups did not differ on the BDI-II or IUS, ps > .37.

DATA EXCLUSION

For 15 participants of the final sample (5 OCD, 2 anxiety controls, 8 healthy controls) the eye-tracker

Table 1
Participant Characteristics Divided per Group

	Patients with OCD	Anxiety controls	Healthy controls
Age	36.97 (11.73)	32.27 (8.06)	34.10 (12.49)
Gender			
Male	35.5% (*n* = 11)	30.8% (*n* = 8)	32.3% (*n* = 10)
Female	64.5% (*n* = 20)	69.2% (*n* = 18)	67.7% (*n* = 21)
Education level			
1. Low	22.6% (*n* = 7)	26.9% (*n* = 7)	22.6% (*n* = 7)
2. moderate	25.8% (*n* = 8)	30.8% (*n* = 8)	22.6% (*n* = 7)
3. high	51.6% (*n* = 16)	42.3% (*n* = 11)	54.8% (*n* = 17)
Y-BOCS	18.19 (7.12)	-	-
OCI-R	-	12.27 (8.77)	8.63 (5.87)
BAI	16.87 (9.03)	22.73 (11.53)	6.94 (6.20)
BDI-II	19.68 (12.36)	20.81 (10.00)	7.35 (6.93)
IUS	78.36 (20.64)	83.04 (17.47)	62.10 (14.67)

Note. For age, and all clinical ratings mean scores are reported with *SD*s between parentheses.
Y-BOCS = Yale-Brown Obsessive Compulsive Scale; OCI-R = Obsessive-.
Compulsive Inventory-Revised; BAI = Beck Anxiety Inventory; BDI-II = Beck Depression Inventory, Second Edition; IUS = Intolerance of Uncertainty Scale.

Table 2
Evaluative Certainty Data (Manipulation Check) in Both Target-Present and Target-Absent Trials by Group.

	OCD patients	Anxiety patients	Healthy controls	*F*-test significance	Effect size
Certainty in target-present trials	8.23 (1.12)	7.85 (1.49)	7.94 (1.57)	$p = .56$	$\eta_p^2 = .01$
Certainty in target-absent trials	7.42 (1.09)	6.85 (1.52)	7.06 (1.75)	$p = .34$	$\eta_p^2 = .03$

Note. (Mean; SDs between parentheses). Score ranged from 0 (*not certain*) to 9 (*very certain*).

could not be calibrated adequately or showed a malfunction during the task. Therefore, eye-tracking data of these participants were not recorded, and thus, not included in the analyses of the number of fixations [1] (although these participants were included in the analyses of search time). Additionally, one anxiety control patient had outliers on search time in the target-absent trials and on number of fixations in both target-present and target-absent trials (there were no outliers within the OCD and healthy control groups). These values were changed to $M + 3$ *SD*s, according to the recommendations given in Field (2009; Chapter 5, pp. 153).

MANIPULATION CHECK

To examine whether participants experienced more uncertainty in target-absent than in target-present trials, a mixed analysis of variance (ANOVA) was performed, with the evaluative certainty questions as within-subject factor and group as between-subject factor. A main effect of condition indicated that overall participants were significantly less certain about their response in target-absent ($M = 7.13$, $SD = 1.48$) than in target-present trials ($M = 8.01$, $SD = 1.39$), F (1, 85) = 32.45, $p < .001$, $\eta_p^2 = .28$. There were no overall differences between groups, F (2, 85) = 1.12, $p = .33$, nor an interaction between uncertainty level in target-absent and target-present trials and group, $F < 1$, $p = .88$. Additionally, we examined the evaluative certainty data in both target-present and target-absent trials independently by group. Table 2 shows that there were also no differences between the groups in level of (un)certainty when analyzing the target-absent and target-present trials separately.

MAIN ANALYSES

Results are graphically presented in Figure 2. Preliminary data analyses showed that scores were normally distributed, but the assumption of homogeneity of variances was violated for search time. However, we did not apply statistical corrections, because analysis of variance is reasonably robust against violation of this assumption when group sizes are comparable, which was the case. There were no mean outcome differences between the sites, therefore "site" was not included in the analyses.

A mixed ANOVA compared the groups on search time (seconds) in target-present and target-absent trials. [2] There were main effects of condition, F (1, 85) = 304.63, $p < .001$, $\eta_p^2 = .78$, and group, F (2, 85) = 4.15, $p = .019$, $\eta_p^2 = .09$. The crucial Group × Condition interaction was also significant, F (2, 85) = 4.00, $p = .022$, $\eta_p^2 = .09$. Planned Helmert contrasts showed that in target-absent trials, patients with OCD ($M = 8.55$, $SD = 3.00$) searched significantly longer than healthy ($M = 6.86$, $SD = 1.69$) and anxiety controls ($M = 7.21$, $SD = 2.00$) combined, $p = .004$, $d = .65$, 95% CI [.20, 1.10], which was a medium to large effect size. In target-present trials, the difference in search time between patients with OCD ($M = 4.72$, $SD = 1.38$) and healthy ($M = 4.16$, $SD = .95$) and anxiety controls ($M = 4.33$, $SD = .90$) combined demonstrated a statistically nonsignificant yet medium effect size, $p = .056$, $d = .43$, 95% CI [−.01, .87], and there was no difference between the control groups in both target-absent, $p = .57$, and target-present trials, $p = .57$. The final hypothesis was that the difference in checking behavior between OCD patients and control groups would be *larger* in target-absent than target-present trials. A final contrast showed that the difference in search time between target-absent and present trials was larger for the OCD group than the control groups combined, $t = 2.77$, $p = .007$, $d = .59$ (medium effect size), whereas the two control groups did not differ, $t < 1$, $p = .69$. Figure 2 shows that this difference between conditions is indeed caused by a larger difference between the groups in the target-absent than target-present trials.

[1] The matching process was not affected by this. When excluding these participants the groups (still) did not differ in age, F (2, 72) = 1.62, $p = .21$, gender, χ^2 (2) = .47, $p = .79$, and education level, χ^2 (4) = 2.98, $p = .56$.

[2] The maximum stimulus presentation was 30 s. Therefore, if a participant did not respond within 30 s, no search time could be recorded. Two patients with OCD had one no-response trial, and one patient with OCD had 2 no-response trials. The no-response trials were excluded from the analyses. The OCD patients with no-response trials did not range among the more severe; Y-BOCS scores 16–20. There were no non-responses in the anxiety or healthy control groups.

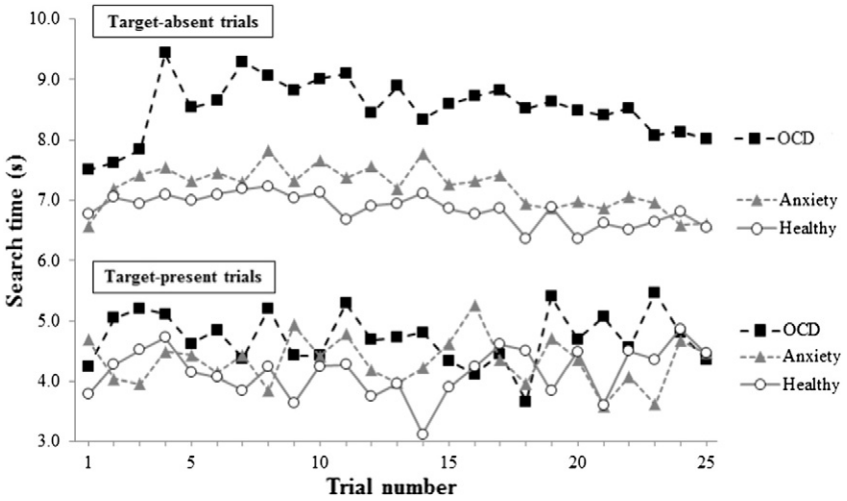

FIGURE 2 Mean search time (s) per trial in both target-present and target-absent trials for the patients with OCD (n = 31), anxiety controls (n = 26), and healthy controls (n = 31).

Because of strong positive correlations between search time and number of fixations in target-present, r (73) = .90, p < .001, and target-absent trials, r (73) = .94, p < .001, a highly similar data-pattern was found for the number of fixations. Again, there were main effects of condition, F (1, 70) = 296.69, p < .001, η_p^2 = .81, and group, F (2, 70) = 4.49, p = .015, η_p^2 = .11, but the interaction was not significant, F (2, 70) = 2.12, p = .128, η_p^2 = .06.[3] However, planned contrasts showed that patients with OCD (M = 30.79, SD = 8.66) used significantly more fixations in target-absent trials than healthy (M = 25.51, SD = 6.51) and anxiety controls (M = 26.75, SD = 5.54) combined, p = .009, d = .66, 95% CI [.16, 1.14], which was a medium to large effect size. Patients with OCD (M = 16.17, SD = 3.21) also used more fixations in target-present trials than healthy (M = 14.13, SD = 2.58) and anxiety controls (M = 15.14, SD = 2.65) combined, p = .03, d = .54, 95% CI [.05, 1.02] (medium effect size), and the control groups did not differ in target-absent, p = .55, and target-present trials, p = .22. Again, the difference in number of fixations between target-absent and target-present trials was larger for the OCD group than the control groups combined, t = 2.06, p = .043, d = .51 (medium effect size), but the two control groups did not differ, t < 1, p = .90.

Finally, the groups (OCD, M = 3.42, SD = 3.22; anxiety controls, M = 3.08, SD = 2.91; healthy controls, M = 4.48, SD = 3.89) did not differ in the number of errors made in the task, F (2, 85) = 1.37, p = .26.

Discussion

This study investigated whether patients with OCD use more checking behavior than healthy controls in general, and whether this is more distinct when only mild uncertainty is induced. Furthermore, to investigate the specificity of the hypothesized effect, an anxiety control group was included. In both target-present and target-absent trials, there were no differences in search time and number of fixations between anxiety and healthy controls, whereas patients with OCD checked somewhat longer and used more fixations than both control groups in target-present trials (medium effect size). Crucially, in target-absent trials, in which all groups experienced less certainty than in target-present trials, the differences between the groups were larger (with medium to large effect sizes). In these mildly uncertain situations, patients with OCD checked longer and used more fixations than both anxiety and healthy controls. In target-present trials, the difference in search time between patients with OCD and the combined control groups was 11%, but in target-absent trials this difference was 22%. Thus, the specific tendency of patients with OCD to use more general checking behavior is more distinct under conditions of (mild) uncertainty. Additionally, there were no differences in the number of errors made during the task. Thus,

[3] According to Tabachnick & Fidell (2007), planned comparisons/contrasts of a priori hypotheses may be conducted in the absence of a significant omnibus interaction effect (see also Foa et al., 2003, footnote 9, pp. 437). When specific hypotheses are articulated, planned comparisons/contrasts can provide more information about the direction of a difference than an omnibus interaction test, so that it is more informative to calculate the significance of these planned comparisons/contrasts. Moreover, a planned comparison/contrast is considerably more powerful than an interaction test. That is, a truly significant difference may not be detected in an interaction test due to insufficient power, whereas a planned comparison/contrast, testing theoretically driven hypotheses, may detect that difference.

although patients with OCD engaged in more checking behavior than healthy and anxiety controls, this did not increase accuracy. Therefore, the nature of the performed checking mimicked the irrationality of compulsive checking; it was continued beyond the point where the goal of the act was reasonably reached and had no natural terminus (Rachman, 2002).

These results strengthen previous findings, which showed that individuals with high OC tendencies, who may be vulnerable to the development of OCD, respond to mildly uncertain situations with more checking behavior than individuals with low OC tendencies (Toffolo et al., 2013, 2014). Furthermore, because patients with OCD engaged in more checking behavior in target-absent trials than *both* anxiety and healthy controls, and there were no differences between the control groups, mild uncertainty appears to specifically promote checking behavior in patients with OCD. These findings therefore add to previous research by demonstrating that patients with OCD not only use more checking behavior in general, irrespective of their obsession-related anxiety (Clair et al., 2013; Jaafari et al., 2013), but importantly, that this is exacerbated in mildly uncertain situations.

One may argue that patients with OCD often experience the possibility of making a mistake as anxiety-provoking, and thus, that the mild uncertainty induced by the target-absent trials is similar to actual obsessions. We agree that the fear of making a mistake may be related to some OCD concerns, but the uncertainty that was induced in this task seems much milder than the uncertainty induced by actual intrusive and recurrent obsessions as defined by the DSM-5 (APA, 2013). Additionally, patients may not have liked the possibility of making a mistake in this task, but they knew there were no negative consequences when making a mistake (something they do fear in their obsessions). Furthermore, on the evaluative certainty questions ("How certain did you feel when you responded that there was a/no target present in the field?") all participants reported to be less certain in target-absent trials than in target-present trials, but this (un)certainty rating was still above average (M = 7.13 on 0–9 scale). This thus indicates that the target-absent trials indeed only induced mild uncertainty, which differs from full-blown obsessions. However, it is possible that the evaluative certainty questions may not accurately reflect how certain participants felt while searching for the target. Specifically, these questions stated, "How certain did you feel *when responding* the target was (not) present?" The questions were thus examining one's certainty while *responding*, not while *searching* for the target. The increased checking duration among patients with OCD may have helped to alleviate uncertainty. Therefore, although patients with OCD may have felt more uncertain than the control groups at the beginning of a trial, by the time they completed a trial they were experiencing a similar level of uncertainty as the control conditions. Accordingly, future studies should include a measure of uncertainty at the beginning of each trial or ask how certain participants feel "*while searching for the target*," because this could more accurately reflect (un)certainty levels during the task. Furthermore, although it seems unlikely that the task induced a high increase in obsessions, we cannot be certain of this. Therefore, future studies should measure whether patients with OCD experience an increase in obsessions during the task to be able to control for this and ensure that the increased checking behavior is caused by mild uncertainty and not by experienced obsessions.

Finally, it is also possible that patients with OCD used more checking behavior than the control groups because of deficits in inhibitory control. Linkovski, Kalanthroff, Henik, and Anholt (2013) showed that people with poor inhibitory control experience more uncertainty and memory distrust following repeated checking than people with good inhibitory control. However, since this was unrelated to OCD symptoms we cannot be certain that patients with OCD would show the same effect. Nevertheless, as mentioned in the introduction, Harkin et al., (2012) also emphasized the importance of inhibitory control in OCD. They showed that individuals with high checking tendencies are less able to ignore misleading information and that impaired inhibition may subsequently lead to excessive mental checking. Possibly, this also plays a role in the physical checking in the present study. Perhaps patients with OCD in our study were also less able to ignore the distractors in the search field, because of poor inhibitory control, and therefore used more checking behavior before they could be certain that the target was/was not present. Although this does not rule out the fact the target-absent trials caused patients with OCD to feel more uncertain about whether they could really trust themselves on not overlooking the target, it is a good alternative/additional explanation that deserves further exploration. Therefore, future studies should not only include (other) measures of experienced uncertainty and obsessions during the task, but also measure inhibitory control (for instance, by including a stop-signal task) to investigate what best explains the checking behavior in the certain and (mildly) uncertain situations.

The tendency to respond to mild uncertainty with increased checking behavior may have negative

consequences and serve to maintain OCD. Strong evidence indicates that checking may reinforce obsessive uncertainty, as extensive research showed that repeated checking paradoxically leads to memory distrust, the very thing it is intended to reduce (e.g., Boschen & Vuksanovic, 2007; Coles, Radomsky, & Horng, 2006; Dek, van den Hout, Giele & Engelhard, 2010; Radomsky, Gilchrist, Dussault, 2006; van den Hout & Kindt, 2003a). In turn, this may promote continued or renewed checking, leading to a vicious cycle of increased uncertainty/distrust and checking behavior. Therefore, if patients with OCD respond to mild uncertainty, for instance, normal doubts (e.g., "did I turn of the stove"), with increased checking behavior, this may have the same paradoxical effect of enhancing uncertainty, and subsequently lead to the mutually reinforcing cycle of checking and uncertainty. It is thus tempting to speculate that the transition from mild OC symptoms to clinical pathology is marked by the use of checking to reduce uncertainty, a safety behavior that is counterproductive and may cascade into the extreme uncertainty and endless checking, characterizing full-blown OCD. Therefore, the findings may have some clinical implications. We suggest that treatment of OCD (e.g., cognitive behavior therapy) should not only target checking compulsions that are performed in response to obsessions, but also general checking behavior. When patients are educated about the paradoxical effects of checking, and encouraged not to give in to checking temptations, even when only mild uncertainties emerge, this may help them resist the urge to check, and possibly prevent mild uncertainties from turning into clinical obsessions. However, empirical research is needed to test this suggestion.

A limitation of the present study is that we did not administer the OCI-R to the OCD group, and are therefore unable to differentiate between OCD subtypes. Although we did receive the OCI-R scores of the patients with OCD that were assessed by the treatment center at baseline, the sample size was too small to analyze the effects for the separate dimensions within this sample. Future studies may therefore increase the sample size and examine whether the effect of mild uncertainty on checking behavior would differ for patients with primary checking OCD compared with patients with other primary OCD symptoms (e.g., by using the OCI-R). However, because the present study found medium effect sizes for the heterogeneous OCD group, one may expect the effects to be even more distinct for patients with primary checking compulsions.

In sum, this study showed that patients with OCD not only use more checking behavior in general, but importantly, that this is exacerbated when (mild) uncertainty is induced. Moreover, to the best of our knowledge, this is the first study to demonstrate that increased general checking behavior may be specific to patients with OCD by including an anxiety control group that did not engage in more checking behavior, although they did experience a similar level of intolerance of uncertainty. Given the detrimental effects of this coping strategy (e.g., van den Hout & Kindt, 2003a), it may be involved in the transition between subclinical and clinical OCD, and general checking may therefore be an important target for behavior treatment and relapse prevention in OCD.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest.

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