Mild Uncertainty Promotes Checking Behavior in Subclinical Obsessive-Compulsive Disorder

Marieke B. J. Toffolo, Marcel A. van den Hout, Ignace T. C. Hooge, Iris M. Engelhard and Danielle C. Cath

Clinical Psychological Science 2013 1: 103 originally published online 20 February 2013
DOI: 10.1177/2167702612472487

Empirical Article

Clinical Psychological Science
1(2) 103–109
© The Author(s) 2013
Reprints and permission:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/2167702612472487
http://cpx.sagepub.com

Mild Uncertainty Promotes Checking Behavior in Subclinical Obsessive-Compulsive Disorder

Marieke B. J. Toffolo[1], Marcel A. van den Hout[1,2], Ignace T. C. Hooge[3], Iris M. Engelhard[1,2], and Danielle C. Cath[1,2]

[1]Department of Clinical and Health Psychology, Utrecht University, Utrecht, The Netherlands; [2]Altrecht Academic Anxiety Center, Utrecht, The Netherlands; and [3]Department of Experimental Psychology, Helmholtz Institute, Utrecht University, Utrecht, The Netherlands

Abstract

Patients with obsessive-compulsive disorder respond to clinical uncertainty with perseverative checking, which, ironically, enhances uncertainty. However, patients also display general subclinical uncertainty, which may tempt vulnerable individuals to seek reassurance by perseveration in response to mild uncertainty that is superimposed on general uncertainty. An experimental eye-tracking paradigm was developed to investigate whether mild uncertainty indeed induces checking behavior in people with high obsessive-compulsive tendencies (OC+, n = 34), compared to people with low obsessive-compulsive tendencies (OC–, n = 31). Participants were presented 50 visual search displays, and they indicated whether a target was "present" or "absent." Decisions about target presence induced little uncertainty, but decisions about its absence were more ambiguous, because participants relied on not having overlooked the target. Results revealed no differences on target-present trials. However, in target-absent trials, OC+ participants searched longer and used more fixations. Thus, even in mildly uncertain situations, individuals with subclinical obsessive-compulsive disorder respond with more checking behavior, which has implications for treatment.

Keywords

obsessive-compulsive disorder, uncertainty, checking, eye tracking

Received 10/26/12; Revision accepted 11/30/12

Obsessive-compulsive disorder (OCD) is a debilitating anxiety disorder characterized by intrusive thoughts, images, or impulses (obsessions) that relate to uncertainty about frightening prospects (e.g., hurting loved ones or spreading diseases), which causes anxiety and distress (American Psychiatric Association, 2000). In response to these intrusions, patients with OCD perform behavior or mental acts (compulsions) to suppress the obsessions and prevent future misfortunes or harm (American Psychiatric Association, 2000). These actions are typically repeated and prolonged beyond the point where the goal of the act is reasonably reached and so lack a "natural terminus" (Rachman, 2002).

The most common compulsions involve checking. They occur in approximately 80% of patients with OCD (Rasmussen & Tsuang, 1986; Summerfeldt, Antony, Downie, Richter, & Swinson, 1997) and (subclinically) in about 15% of the general population (Stein, Forde, Anderson, & Walker, 1997). Checking compulsions are associated with indecisiveness and doubt. Patients typically feel that they cannot be sure that a perceived threat has been sufficiently reduced after one check, and they continue to check (Rachman, 2002). Perseverative checking may be motivated by the wish to reduce uncertainty, but robust experimental findings have shown that checking compulsions have the opposite effect and, paradoxically, increase uncertainty (Boschen & Vuksanovic, 2007; Dek, van den Hout, Giele, & Engelhard, 2010; Hermans et al., 2008; Radomsky, Gilchrist, & Dussault, 2006; van den Hout, Engelhard, de Boer, du Bois, & Dek, 2008; van den Hout, Engelhard, Smeets, Dek, Turksma, & Saric, 2009; van den Hout & Kindt, 2003a, 2003b, 2004). This paradoxical effect of checking behavior occurs relatively quickly, after two to five checks (Coles, Radomsky, & Horng, 2006).

Uncertainty in OCD patients is extreme (e.g., "Can I trust my memory that I did not hit someone with my car?" or "Can I trust what I see?") and domain specific (some patients may

Corresponding Author:
Marieke B. J. Toffolo, Clinical and Health Psychology, Utrecht University, PO Box 80140, 3508 TC, Utrecht, Netherlands
E-mail: m.b.j.toffolo@uu.nl

be extremely uncertain about memories for locking the door but not about cleaning their hands, or the other way around). Interestingly, patients with OCD also seem to experience a milder, subclinical uncertainty. This type of uncertainty seems more general and occurs in a wide range of domains and ambiguous situations, including confidence in one's memory abilities, decision-making abilities, concentration, and attention (Nedeljkovic & Kyrios, 2007). Furthermore, compared to healthy individuals, patients display a lack of confidence in their ability to discriminate performed events from imagined events (McNally & Kohlbeck, 1993), and they express less confidence in their general knowledge (Dar, Rish, Hemesh, Taub, & Fux, 2000), memory abilities (Boschen & Vuksanovic, 2007; Tuna, Tekcan, & Topcuoglu, 2005), perception, and executive functions (Hermans et al., 2008).

This elevated level of general uncertainty seems to be stable over time and across a number of situations. One may speculate that subclinical (general) uncertainty precedes clinical OCD and may constitute a vulnerability factor for the disorder. Subclinical uncertainty may tempt individuals to seek reassurance by repetitive checking in response to normal doubts that are superimposed on general uncertainty (Nedeljkovic & Kyrios, 2007). Thus, it may be hypothesized that in response to mildly uncertain situations, patients with OCD will use perseveration because even mild uncertainty may bring the yet-elevated level of general uncertainty to a point where perseveration is used to obtain certainty. In turn, perseveration may, ironically, increase uncertainty about checked items, which reinforces the motivation to persevere. Eventually, this may cascade into clinical uncertainty.

People with subclinical OCD suffer from the same type of symptoms as OCD patients but to a lesser degree of severity (Gibbs, 1996). Therefore, one could argue that people with subclinical OCD would show mildly enhanced general uncertainty and would therefore be mildly inclined to respond to uncertain situations with checking. Recent research has indeed shown that healthy participants who were in a "low memory confidence condition" (resembling patients with OCD), as opposed to participants in a "high memory confidence condition," showed greater urges to check (Alcolado & Radomsky, 2011). However, this study did not investigate actual checking behavior. Most studies that investigated actual checking behavior did not link this to uncertainty. For instance, it was shown that patients with OCD perform more checking behavior than healthy controls, both in a basic image-comparison task (Jaafari et al., 2011) and in a more complex virtual-reality task (Kim et al., 2012). However, these studies do not indicate why these patients performed more checking behavior.

Rotge et al. (2008) developed a behavioral task to assess checking behavior, which consisted of a delayed matching-to-sample task. In each of 50 trials, participants were required to compare two images that were displayed, delayed by an interval, and choose whether they were identical or different. After making a choice, participants had the opportunity to check their choice by repeating the trial and correcting their answer, if desired. It was found that checking behaviors occurred more frequently in patients with OCD with checking compulsions than in patients with OCD without checking compulsions and healthy controls, and there was a progressive rise in checking over the course of 50 trials. Moreover, OCD checkers took longer than healthy controls to make their choice before actual checking, which was presumably indicative of the degree of uncertainty at the moment of choice. Thus, OCD checkers seemed to experience more uncertainty and responded to this with more checking behavior. However, this study failed to indicate under what conditions uncertainty would lead to more checking behavior, given that it was unclear which features of the paradigm induced checking. Therefore, we developed a new experimental eye-tracking paradigm to test whether mild uncertainty induces actual checking behavior in people with subclinical OCD and under what conditions this would occur. Participants were presented with 50 visual search displays and asked to indicate whether a target (closed square) was present or absent within multiple open squares. In 50% of the trials, a target was present. The target-present trials were self-evident; the response *present* could be based on the perception of the target. Therefore, these counted as *certain situations*, and for these trials, we did not expect any differences between the groups. However, target-absent trials were more ambiguous, because for the response *absent*, participants had to rely on not having overlooked the target. Hence, we hypothesized that target-absent trials would induce more uncertainty than target-present trials. We expected that people scoring high (OC+), compared with people scoring low (OC–), on obsessive-compulsive tendencies would show enhanced checking behavior, as indexed by a higher search time and a higher number of fixations in target-absent trials (*uncertain situation*) but not in target-present trials (*certain situation*).

Methods

Participants

Four hundred and eighty students from Utrecht University were screened with the Obsessive-Compulsive Inventory–Revised (Foa et al., 2002). Students who scored at the top 25% (≥ 17, OC+) and bottom 25% (≤ 5, OC–) of the distribution were invited to participate in this study. The final sample included 68 participants: 36 in the OC+ group (age, $M = 22.19$, $SD = 4.90$, 28 women) and 32 in the OC– group (age, $M = 21.12$, $SD = 3.15$, 21 women). Scores in the OC+ group ranged between 17 and 46 ($M = 23.64$, $SD = 7.81$), and OC– scores ranged from 1 to 5 ($M = 3.19$, $SD = 1.45$), $t(66) = 14.58$, $p < .001$). To compare, the mean score of patients with OCD is somewhat higher—namely, 28.01 ($SD = 13.53$)—with a cutoff score of 21 for differentiating with nonanxious controls (Foa et al, 2002). Of the current OC+ sample, 55.6% reached this cutoff score of 21. Data on ethnic and racial background were not collected.

Participants signed an informed consent form and received remuneration or course credit for their participation.

Material

Obsessive-Compulsive Inventory–Revised. Obsessive-compulsive tendencies were measured with the Dutch translation (Cordova-Middelbrink, Dek, & Engelbarts, 2007) of the Obsessive-Compulsive Inventory–Revised (Foa et al., 2002). The inventory contains 18 items concerning OCD characteristics, each measured on a 4-point Likert scale (e.g., "I check repeatedly doors, windows, drawers etc."; 0 = *not at all*, 4 = *extremely*). It also has good validity, test-retest reliability, and internal consistency in clinical (Foa et al, 2002) and nonclinical populations (Hajack, Huppert, Simons, & Foa, 2004).

Visual search task. The visual stimulus of the task used in this experiment was similar to the one used by Vlaskamp, Over, and Hooge (2005). The task consisted of one block of 50 individual search displays, each containing 25 elements (see Fig. 1). Half of the search displays contained 25 squares with a gap in one of the four edges (the distracters; i.e., *target-absent trials*), and the other half of the search displays contained 24 distracters and one closed square (the target; i.e., *target-present trials*). The size of all elements (target and distracters) was 0.41° × 0.41°, and the gap size of the distracters was 0.21°. The elements were white on a dark gray background and were placed on a hexagonal grid in a display measuring 30.01° × 27.8°. In target-present trials, the target position was randomly chosen among these locations, and the other locations were occupied by the distracters. The target-absent and target-present trials were presented in a random order to each participant.

Measures. Checking behavior was operationalized by search time and the number of fixations. Search time was the time that it took participants to search through the field until a response was made. The number of fixations was measured with an eye tracker (see Apparatus section), which indexed how many fixations were made while searching through the field.

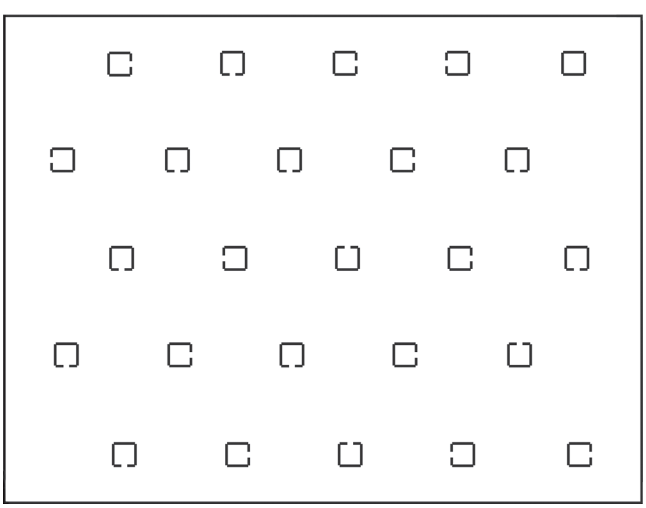

Fig. 1. Example of a search display; the target is the closed symbol (upper-right corner; in the experiment, the elements were white on a dark gray background).

Apparatus

Search displays were presented with Matlab (MathWorks Benelux, n.d.). Eye movements were recorded at 52 Hz with a portable EasyGaze eye tracker (Design Interactive, Inc., Oviedo, FL). The eye movement data were analyzed offline. Fixation detection was done by a self-written Matlab program that marked fixations by an adaptive velocity threshold method. Velocities were obtained by fitting a parabola through three subsequent data points. The derivative of this fitted parabola was used to estimate the value of the velocity of the second (center) data point. This procedure was repeated for all data points (except the first and last). In this analysis, everything that is not a saccade is called a *fixation*. To remove the saccades from the signal, we calculated average and standard deviation for the absolute velocity signal. Data points were removed if absolute velocities were higher than the average velocity plus 3 times the standard deviation. This procedure was repeated until the velocity threshold converged to a constant value or the number of repetitions reached 50. Then, we removed fixations with durations shorter than three samples (58 ms).

Procedure

Participants were tested individually in a dimly lit laboratory. They received verbal and written instructions about the task before they provided written informed consent. Then, they were seated approximately 58 cm in front of a 17-in. monitor (1,280 × 1,024 pixels). Head movements were restricted by the use of a chin-and-forehead rest. The eye tracker was placed beneath the monitor. The chair could be adjusted so that the participant sat comfortably and looked at the middle of the screen. The task started with the calibration of the eye-tracking system. Then, participants received written instructions, followed by six practice trials to familiarize themselves with the task. When participants had no further questions, the 50 search displays (trials) were presented. Before each trial, a fixation point was presented in the center of the screen. Immediately after the space bar was pressed, the search display appeared. During each trial, participants were asked to indicate whether a target was present or not in the search display, by pressing the left arrow key (target-present) or the right (target-absent). Participants did not know how many trials contained a target. After completing the task, participants were debriefed and paid for their participation.

Results

Three participants were excluded in the analyses. One of them made 37 errors on 50 trials but had normal reaction times, which seems to indicate reversal of correct responses. The other two made 19 and 28 errors on 50 trials, which was more than 2.5 standard deviations of the mean (errors, M = 5.87, SD = 5.96). Combined with their very fast reaction times (absent trials, M = 1.3 and M = 0.4), which were respectively 3.3 and 4 standard deviations from the mean (M = 5.5, SD = 1.28), it seemed that they had not followed instructions correctly. The final analyses consisted of 65 participants (age, M = 21.69, SD = 4.18), with 34 OC+ participants and 31 OC– participants.

Each trial was presented for 10 s. If a participant did not respond within 10 s, no search time could be recorded. Four OC+ participants had one no-response trial, and one OC+ participant had five no-response trials. The no-response trials were excluded from the analyses. There were no nonresponses in the OC– group.

Results are presented in Figure 2, where average search time scores for each of the 25 absent and present trials are given by group. Preliminary analyses were performed to ensure no violation of the assumptions of normality and homogeneity of (co)variance. Two two-way mixed analyses of variance were used to compare the groups on search time and number of fixations in both target-present and target-absent trials. One-tailed tests were used to examine our main hypotheses, which were directed toward one side of the data distribution (i.e., more use of checking behavior). As suggested by Figure 2, there was a main effect of condition on search time; participants checked significantly longer in absent trials (M = 5.5, SD = 1.28) than present trials (M = 3.26, SD = 0.78), $F(1, 63) = 368.53$, $p < .001$, $\eta^2 = .85$. There was no main effect of group; overall, the OC+ and OC– groups did not differ in search time, $F(1, 63) = 3.18$, $p = .08$. The crucial Group (OC+/OC–) × Condition (absent/present) interaction was significant, $F(1, 63) = 2.83$, $p < .05$ (one-tailed), $\eta^2 = .04$. Pairwise comparisons showed that in target-present trials, OC+ participants (M = 3.37, SD = 0.8) did not differ from OC– participants (M = 3.15, SD = 0.75) on search time, $t(63) = 1.13$, $p = .26$, yet in target-absent trials, OC+ participants checked significantly longer (M = 5.78, SD = 1.36) than OC– participants (M = 5.18, SD = 1.13), $t(63) = 1.95$, $p < .05$ (one-tailed).[1]

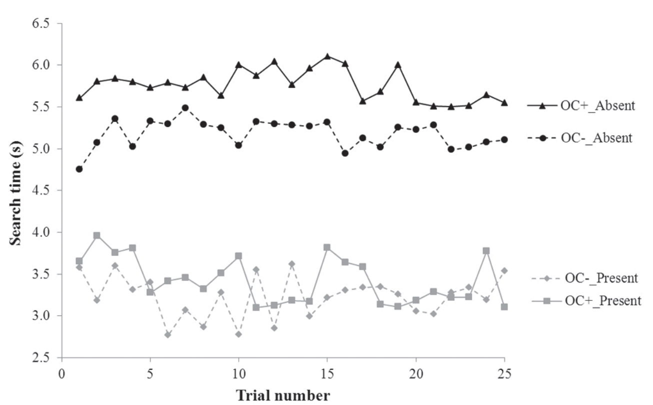

Fig. 2. Mean search time (s) per trial in target-absent and target-present trials for OC+ and OC– participants (i.e., high and low obsessive-compulsive tendencies, respectively).

Because there was a strong positive correlation between search time and number of fixations on target-absent trials, $r(65) = .94$, $p < .001$, and target-present trials, $r(65) = .93$, $p < .001$, a highly similar analysis-of-variance pattern occurred for the number of fixations. A main effect of condition was evident; participants used significantly more fixations in absent trials (M = 21.92, SD = 4.7) than present trials (M = 12.74, SD = 2.72), $F(1, 63) = 406.01$, $p < .001$, $\eta^2 = .87$. There was a nonsignificant trend for group; OC+ participants seemed to make more fixations than OC– participants, $F(1, 63) = 3.34$, $p = .07$. The crucial Group (OC+/OC–) × Condition (absent/present) interaction was significant, $F(1, 63) = 2.93$, $p < .05$ (one-tailed), $\eta^2 = .04$. Pairwise comparisons revealed that OC+ participants (M = 13.08, SD = 2.72) did not make more fixations than OC– participants (M = 12.36, SD = 2.7) in the target-present trials, $t(63) = 1.07$, $p = .29$. However, in target-absent trials, OC+ participants (M = 23.0, SD = 4.91) indeed made significantly more fixations than OC– participants (M = 20.73, SD = 4.21), $t(63) = 1.99$, $p < .05$ (one-tailed).

Finally, there was no difference in the number of errors made during the task between OC+ participants (M = 4.68, SD = 3.17) and OC– participants (M = 5.03, SD = 3.42), $t(63) = 0.44$, $p = .67$.

Discussion

While performing a visual search task, OC+ individuals used no more checking behavior in the target-present condition, in which the accuracy of the response was relatively straightforward. In the target-absent condition, however, the groups did differ: OC+ participants showed longer search times and, perhaps more important, a higher number of fixations than OC– participants. Furthermore, only OC+ participants had nonresponses, which indicated an even longer search time beyond the response limit. Because the number of nonresponses was small, no statistical test could be performed, but the direction of this finding fits well with the increased search time of OC+ people in comparison with OC– people. Finally, there was no difference between the groups in the number of errors made during the task, which indicates that increased checking behavior did not increase accuracy.

The target-absent trials represented a more ambiguous, uncertain situation, given that participants could not base their response on visual feedback of the target. Participants had to rely on not having overlooked the target, which is arguably a more ambiguous criterion. Therefore, the findings are in line with the proposed theory—namely, that increased general uncertainty may provoke people with OCD to engage in repetitive checking in response to an uncertain situation, because this uncertainty is superimposed on an elevated level of general uncertainty (Nedeljkovic & Kyrios, 2007). The findings also nicely fit with a more specified version of this "general uncertainty" theory proposed by Lazarov, Dar, Liberman, and Oded (2012). The core of their argument is that patients with OCD lack a subjective conviction regarding internal states and therefore have to rely on external proxies, such as rules or procedures. It is possible that in the present experiment, the target-absent trials did not provoke checking in the OC+ group because the trials triggered some general uncertainty but, more specifically, because the target-absent trials forced the OC+ participants to rely on internal states (e.g., "Did I properly attend to the squares?" "Does my memory serve me well?").

Clinical checking in OCD is typically motivated by extreme and domain-specific uncertainty. This observation led Radomsky to stress "the importance of importance" in OCD research (Radomsky & Rachman, 2004). However, the present data suggest that even in subclinical OCD, the induction of mild uncertainty that is not relevant to OCD results in mild but quantifiable checking. Furthermore, the performed checking behavior resembles the irrationality of compulsive checking (Rachman, 2002); more checking did not enhance the possibility of finding a target that was not there and did not increase accuracy. The eye-tracking paradigm therefore seems promising for investigating checking behavior in both certain and uncertain situations.

The findings add to the existing literature by demonstrating that uncertainty not merely induces greater urges to check (Alcolado & Radomsky, 2011) but that this provokes more actual checking behavior in OC+, but not OC–, individuals. The findings suggest some alleys for new research. First, the research may be linked to the ongoing discussion about endophenotypes of OCD. OCD is a moderately heritable condition, although the details of this genetic basis and the gene-environment interaction are not yet well understood (Nicolini, Arnold, Nestadt, Lanzagorta, & Kennedy, 2009; van Grootheest, Cath, Beekman, & Boomsma, 2007). Therefore, the identification of endophenotypes, which are "measurable components unseen by the unaided eye on the pathway between disease and distal genotype" (Gottesman & Gould, 2003), may be helpful in refining diagnosis and characterizing the disorder (Chamberlain & Menzies, 2009). Because these endophenotypes are understood to be heritable traits that serve as risk factors for the disorder, they should be present in both patients and their unaffected relatives (Gottesman & Gould, 2003). For instance, Chamberlain and Menzies (2009) reported that patients with OCD and their unaffected relatives showed impaired inhibitory control, and these deficits were related to brain gray matter structural abnormalities. Possibly, general uncertainty, which runs across the various subtypes of OCD, together with the inclination to respond to uncertainties with perseverative checking also represents an OCD-related endophenotype. Therefore, it needs to be investigated whether patients with OCD show a similar behavior pattern in response to uncertain situations as found in the present study.

Moreover, to examine whether this increased general uncertainty may constitute a true vulnerability factor for the development of OCD, unaffected family members of patients with OCD should be studied with the same paradigm. If a comparable pattern would indeed be found in both patients with OCD and unaffected relatives, then it would be timely to examine whether in the natural course of OCD, the emergence of extreme uncertainties is in fact preceded by perseverative checking behavior in response to milder forms of uncertainty. Monitoring individuals at risk (e.g., first-degree relatives of patients with OCD), to obtain a large sample of individuals turning from nonclinical into clinical, would run into serious power problems. Note, however, that over time, many patients with OCD experience changes in the nature of their obsessions. Worry about contamination may be replaced by worry about spreading, say, HIV. Furthermore, although cognitive behavior therapy is effective in the treatment of the disorder, about 35% relapse within the first year (Braga, Cordioli, Niederauer, & Manfro, 2005). Thus, following patients with OCD after completion of treatment may offer the opportunity to study the natural course of the development of new OCD problems. A second study could therefore be aimed at following patients who have finished cognitive behavior therapy and investigating their responses to new obsessive uncertainties. Both theoretically and clinically, it would be important to experimentally test whether motivating treated patients not to respond to emerging new uncertainties by checking would prevent mild, general uncertainty from turning into clinical problems and whether such intervention reduces relapse rate.

Acknowledgments

We thank Evianne Smit, Rosa Groen, Kevin Zwambag, and Tosca Schilperoort for their help with data collection.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Funding

The work reported was supported by the Netherlands Organization for Scientific Research (NWO; No. 400-09-428). Iris M. Engelhard was supported with a Vidi innovational research grant by NWO.

Note

1. The main results differed somewhat when all participants were included in the analyses. There was still a main effect of condition on search time; participants checked significantly longer in absent trials (M = 5.35, SD = 1.48) than present trials (M = 3.19, SD = 0.89), $F(1, 66) = 322.28$, $p < .001$, $\eta^2 = .83$. There was no main effect of group; overall, the OC+ and OC– groups did not differ in search time, $F(1, 66) = 2.09$, $p = .15$. However, the crucial Group (OC+/OC–) × Condition (absent/present) interaction on search time was no longer significant when all participants were included, $F(1, 66) = 2.02$, $p = .08$ (one-tailed), $\eta^2 = .03$. With regard to number of fixations, findings did not change. There was a main effect of condition; participants used significantly more fixations in absent trials (M = 21.68, SD = 5.06) than present trials (M = 12.62, SD = 2.87), $F(1, 66) = 386.84$, $p < .001$, $\eta^2 = .86$. There was also a main effect of group;

OC+ participants made more fixations than OC– participants, $F(1, 66) = 4.46$, $p < .05$, $\eta^2 = .07$, and the crucial Group (OC+/OC–) × Condition (absent/present) interaction was significant, $F(1, 66) = 3.73$, $p < .05$ (one-tailed), $\eta^2 = .06$.

References

Alcolado, G. M., & Radomsky, A. S. (2011). Believe in yourself: Manipulating beliefs about memory causes checking. *Behaviour Research and Therapy*, *49*, 42–49. doi:10.1016/j.brat.2010.10.001.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.

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*, 2098–2109. doi:10.1016/j.brat.2007.03.009

Braga, D. T., Cordioli, A. V., Niederauer, G., & Manfro, G. (2005). Cognitive-behavioral group therapy for obsessive-compulsive disorder: A 1-year follow-up. *Acta Psychiatrica Scandinavica*, *112*, 180–186.

Chamberlain, S. R., & Menzies, L. (2009). Endophenotypes of obsessive-compulsive disorder: Rationale, evidence and future potential. *Expert Review of Neurotherapeutics*, *9*, 1133–1146. doi:10.1586/ern.09.36

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

Cordova-Middelbrink, J. A., Dek, E. C. P., & Engelbarts, M. M. B. (2007). *Automatisering bij subklinische obsessief-compulsieve stoornis* [Automatic processes in subclinical obsessive compulsive disorder] (Unpublished master's thesis). Utrecht University, Utrecht, Netherlands.

Dar, R., Rish, S., Hermesh, H., Taub, M., & Fux, M. (2000). Realism of confidence in obsessive-compulsive checkers. *Journal of Abnormal Psychology*, *109*, 637–678. doi:10.1037//0021-843X.109.4.673

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*, 580–587. doi:10.1016/j.brat.2010.03.009

Foa, E. D., Huppert, J. D., Leiberg, S., Langner, R., Kichic, R., Hajcek, R., & Salkovskis, P. M. (2002). The Obsessive-Compulsive Inventory: The development and validation of a short version. *Psychological Assessment*, *14*, 485–496. doi:10.1037/1040-3590.14.4.485

Gibbs, N. A. (1996). Non-clinical populations in research on obsessive-compulsive disorder: A critical review. *Clinical Psychology Review*, *16*, 729, 773.

Gottesman, I. I., & Gould, T. D. (2003). The endophenotype concept in psychiatry: Etymology and strategic intentions. *American Journal of Psychiatry*, *160*, 636–645. doi:10.1176/appi.ajp.160.4.636

Hajack, G., Huppert, J. D., Simons, R. F., & Foa, E. B. (2004). Psychometric properties of the OCI-R in a college sample. *Behaviour Research and Therapy*, *42*, 115–123. doi:10.1016/j.brat.2003.08.002

Hermans, D., Engelen, U., Grouwels, L., Joos, E., Lemmens, J., & Pieters, G. (2008). Cognitive confidence in obsessive compulsive disorder: Distrusting perception, attention and memory. *Behavior Research Therapy*, *46*, 98–113. doi:10.1016/j.brat.2007.11.001

Jaafari, N., Frasca, M., Rigalleau, F., Rachid, F., Gil, R., Olié, J. P., . . . Vibert, N. (2011). Forgetting what you have checked: A link between working memory impairment and checking behaviors in obsessive-compulsive disorder. *European Psychiatry*. Advance online publication. doi:10.1016/j.eurpsy.2011.07.001

Kim, K., Roh, D., Kim, C., Cha, K. R., Rosenthal, M. Z., & Kim, S. I. (2012). Comparison of checking behavior in adults with or without checking symptom of obsessive-compulsive disorder using a novel computer-based measure. *Computer Methods and Programs in Biomedicine*, *108*, 434–441. doi:10.1016/j.cmpb.2012.03.014

Lazarov, A., Dar, R., Liberman, N., & Oded, Y. (2012). Obsessive-compulsive tendencies and undermined confidence are related to reliance on proxies for internal states in a false feedback paradigm. *Journal of behavior Therapy and Experimental Psychiatry*, *43*, 556–564. doi:10.1016/j.jbtep.2011.07.007

MathWorks Benelux. (n.d.). *MATLAB: The language of technical computing*. Retrieved from http://www.mathworks.nl/products/matlab/index.html

McNally, R. J., & Kohlbeck, P. A. (1993). Reality monitoring in obsessive-compulsive disorder. *Behaviour Research and Therapy*, *31*, 249–253. doi:10.1016/0005-7967(93)90023-N

Nedeljkovic, M., & Kyrios, M. (2007). Confidence in memory and other cognitive processes in obsessive-compulsive disorder. *Behaviour Research and Therapy*, *45*, 2899–2914. doi:10.1016/j.brat.2007.08.001

Nicolini, H., Arnold, P., Nestadt, G., Lanzagorta, N., & Kennedy, J. L. (2009). Overview of genetics and obsessive-compulsive disorder. *Psychiatry Research*, *170*, 7–14. doi:10.1016/j.psychres.2008.10.011

Rachman, S. (2002). A cognitive theory of compulsive checking. *Behaviour Research and Therapy*, *40*, 625–639. doi:10.1016/S0005-7967(01)00028-6

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

Radomsky, A. S., & Rachman, S. (2004). The importance of importance in OCD memory research. *Journal of Behaviour Therapy and Experimental Psychiatry*, *35*, 137–51. doi:10.1016/j.jbtep.2004.04.005

Rasmussen, S. A., & Tsuang, M. T. (1986). Clinical characteristics and family history in *DSM-III* obsessive-compulsive disorder. *American Journal of Psychiatry*, *143*, 317–322.

Rotge, J. Y., Clair, A. H., Jaafari, N., Hantouche, E. G., Pelissolo, A., Goillandeau, M., . . . Aouizerate, B. (2008). A challenging task for assessment of checking behaviors in obsessive-compulsive disorder. *Acta Psychiatrica Scandinavica*, *117*, 465–473. doi:10.1111/j.1600-0447.2008.01173.x

Stein, M., Forde, D., Anderson, G., & Walker, J. (1997). Obsessive-compulsive disorder in the community: An epidemiologic survey with clinical reappraisal. *American Journal of Psychiatry*, *154*, 1120–1126.

Summerfeldt, L., Antony, M. M., Downie, F., Richter, M. A., & Swinson, R. P. (1997). Prevalence of particular obsessions and compulsions in a clinic sample. In R. P. Swinson, M. M. Antony, S. Rachman, & M. A. Richter (Eds.), *Obsessive compulsive disorder: Theory, research, and treatment* (pp. 3–32). New York, NY: Guilford Press.

Tuna, S., Tekcan, A. I., & Topcuoglu, V. (2005). Memory and metamemory in obsessive-compulsive disorder. *Behaviour Research and Therapy*, *43*, 15–27. doi:10.1016/j.brat.2003.11.001

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

van den Hout, M. A., Engelhard, I. M., Smeets, M. A. M., Dek, E. C. P., Turksma, K., & Saric, R. (2009). Uncertainty about perception and dissociation after compulsive-like staring: Time course of effects. *Behaviour Research and Therapy*, *47*, 535–539.

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

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

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

van Grootheest, D. S., Cath, D. C., Beekman, A. T., & Boomsma, D. I. (2007). Genetic and environmental influences on obsessive-compulsive symptoms in adults: A population-based twin-family study. *Psychological Medicine*, *37*, 1635–1644. doi:10.1017/S0033291707000980

Vlaskamp, B. N. S., Over, E. A. B., & Hooge, I. T. C. (2005). Saccadic search performance: The effect of density. *Experimental Brain Research*, *167*, 246–259. doi:10.1007/s00221-005-0032-z