Better super safe than slightly sorry?

Reciprocal relationships between checking behavior and cognitive symptoms in obsessive-compulsive disorder

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Beter het super zekere voor het onzekere nemen?

Wederkerige relaties tussen checkgedrag en cognitieve symptomen in obsessieve-compulsieve stoornis

(met een samenvatting in het Nederlands)

Proefschrift

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Chapter 1

Introduction

Claire, a 38-year old general practitioner[1], has always been concerned about other people's wellbeing. She never had the illusion that she could individually improve the whole world, but, at least, the world around her should not get worse due to her actions. However, during the last 6 years her concerns have amplified, and she feels tormented by her feelings of responsibility for others and the constant urge to prevent harm. Her compulsive behavior started with cleaning up branches, glass, and other garbage that she saw lying on the side of the road when driving to work, because these could cause accidents to cyclists. Moreover, she believed that if she had seen the branches and not removed them, she would be responsible if a bike-rider would trip. When she read a newspaper report about a hit-and-run driver the question popped into her mind whether it would be possible for a driver to not notice a collision, which highly distressed her. Since then she has the recurrent, frightening thought that she can never be certain that she has not caused an accident while driving, and therefore, has to drive her route back and forth several times to trace the road for any signs of a crash. Additionally, she listens frantically to the local radio to check for news reports about possible accidents, and avoids driving during rush hours when roads are particularly busy. Subsequently, she has started to doubt her memory. She has recurrent intrusive thoughts such as "what if I have not turned off the gas stove?" or "what if I did not unplug the coffee machine?", because this would put her elderly neighbor at risk of an explosion or fire. Therefore, she checks potential hazards around the house thoroughly: the stove, light switches, electrical outlets, plugs of appliances and so on have to be checked 12 times before leaving the house or going to bed. Due to her time-consuming compulsions that have increased over the years, she is now unable to work, hardly leaves the house and does not see her friends and family often.

This case illustrates important aspects of the symptomatology that is associated with obsessive-compulsive disorder (OCD), and shows how debilitating, time-consuming, and often irrational this condition can be. Anybody may sometimes think "did I lock the door this morning?" and subsequently feel a bit uncomfortable and have the urge to walk back to check whether the front door is locked before continuing their day. For patients with OCD, however, it is not that easy to dismiss

[1]Biographical details have been changed to prevent the possibility of identifying the patient

feelings of discomfort, and such thoughts and urges have extreme consequences. The intrusive thoughts elicit intense anxiety and uncertainty, and one check is often not sufficient to reduce these feelings and to reassure themselves. As described in the case example, patients often spend hours checking things repeatedly and still may not feel sufficiently certain that potential threats have been removed or even diminished.

How can this disorder be explained? The question may relate to its *development* (what are the origins of OCD and how does it worsen?) or its *maintenance* (given that OCD has developed, what processes are responsible for its persistence?). Research suggests that repeated checking is counterproductive: while perseverative checking may be motivated by the wish to reduce uncertainty, strong data suggest that repeated checking has the effect of paradoxically enhancing uncertainty. In turn, this may reinforce continued or renewed checking, leading to a vicious cycle of increased uncertainty and checking behavior, which helps to explain why OCD persists. These insights in maintaining processes of OCD may also be relevant for understanding its development. Therefore, this dissertation will focus on the role of checking behavior in the *development* of OCD symptoms, and how checking behavior and cognitive symptoms in OCD may mutually reinforce one another. In this introductory chapter the characteristics of OCD will be presented together with some diagnostic changes that occurred over the years, and the difference between normal and abnormal obsessions and compulsions. Then, important cognitive and behavioral theories about the development and maintenance of OCD and compulsive checking will be discussed, which will lead to the objectives and outline of this dissertation.

OCD characteristics

OCD is a heterogeneous disorder characterized by obsessions and/or compulsions, with most patients experiencing both types of symptoms (American Psychiatric Association; APA, 2013). Obsessions are unwanted, intrusive and recurrent thoughts, images, or impulses that cause anxiety and distress. The individual attempts to suppress, ignore, or neutralize the obsessions with some other thought or action, although they are often perceived as uncontrollable (Rachman, 1981). The content of obsessions involves disturbing, offensive or sometimes irrational themes about contamination, doubts, harm to self or others, religion,

unacceptable sexual acts, violence, or orderliness and symmetry (Clark, 2004). Compulsions, on the other hand, are repetitive behaviors (e.g., washing, checking, ordering) or mental acts (e.g. counting, repeating words or numbers in your head) that are aimed at controlling the obsession, preventing or reducing subjective distress, and preventing future misfortune from happening (APA, 2013). The compulsions are often regarded by the individual as excessive or exaggerated (especially in calmer moments), which may provoke subjective resistance. However, the urge to carry out the acts is so strong that the individual most often eventually gives in and executes the compulsion (Rachman & Shafran, 1998).

Although various patterns of obsessions and compulsions exist among patients with OCD, research indicates that certain obsessions and compulsions tend to co-occur. In fact, five main symptom dimensions can be distinguished (Katerberg, et al., 2010):

- Doubts: obsessions about feeling extremely responsible for causing or failing to prevent harm, and checking compulsions and reassurance-seeking;
- Taboo: repugnant obsessions concerning sex, violence, and religion;
- Contamination/cleaning: contamination obsessions, and washing and cleaning rituals;
- Rituals/superstition: superstitious obsessions and compulsions such as lucky numbers or colors, rituals such as ritualized eating behaviors, and mental rituals;
- Hoarding/Symmetry: hoarding obsessions and compulsions, symmetry, ordering and arranging compulsions, and symptoms related to fear of losing things or making an error (note that hoarding is viewed in the DSM-5 (APA, 2013) as an independent disorder).

Within individual patients many combinations of symptoms may be present, for instance, counting rituals while checking or checking for germs when having primary washing compulsions.

OCD has an estimated lifetime prevalence of 2.3% and a 12-month prevalence of 1.2% (Ruscio, Stein, Chiu, & Kessler, 2010). The disorder seems to take a chronic course if it is left untreated. Although most people with OCD show changes over time in the severity of clinical symptoms, most of them continue to have clinical or subclinical symptoms during their lives (Skoog & Skoog, 1999). In addition,

there is a high comorbidity with other psychological disorders, particularly anxiety disorders (e.g. generalized anxiety disorder) or mood disorders (Ruscio et al, 2010; Torres et al., 2006). OCD is a seriously impairing disorder, and has a negative impact on both social and work related activities. Compared with people with other psychological disorders, those with OCD tend to be less likely to be married, more likely to be living alone, and to be unemployed or have an inactive work status (Torres et al., 2006).

Changes over time in the diagnosis of OCD

One of the first modern descriptions of OCD comes from French doctors in the 19th century, who named the disorder "folie de doute", or doubting madness (see for an overview: Berrios, 1989). Esquirol (1838) viewed the disorder as a variety of insanity or psychosis, and defined it as "involuntary, irresistible, and instinctive activity", and that "the patient is chained to actions that did not originate from his reason, that his conscience rejects and his will cannot suppress" (see Berrios, 1989). Pierre Janet (1889, 1903; in Stone, 1997) pictured OCD as proceeding in stages. In the first stage, *psychastenie*, the patient suffers from feelings of imperfection, doubts and extreme indecisiveness. The second stage of the disorder, labeled *forced agitation*, included repetitive, excessive behaviors, alongside ruminations, compulsive acts, and an inflated need for precision and perfection. Only the final stage was named *obsessions and compulsions* by Janet, in which the patient is tortured by forbidden thoughts in the domain of violence, sacrilege or lust. Additionally, one may have certain obsessive ideas that are close to delusion. Around the same time, Freud (1895) formulated the characteristics of a psychiatric condition that he called "obsessional neurosis". According to his observations, obsessions consist of ideas or thoughts that force themselves upon the patient and are associated with an emotional state, such as anxiety, doubt, remorse, or anger. In some cases these ideas were responded to or replaced by acts or impulses which served as relief or as protective procedures.

Half a century later the first classification system of mental disorders, the Diagnostic and Statistical Manual of Mental Disorders (DSM; APA, 1952), was published. The description of "obsessive compulsive reaction", which was in the DSM-II (APA, 1968) referred to as "obsessive compulsive neurosis", still reflected the views of psychodynamic theory, and closely resembled Freud's earlier formulation.

The publication of the DSM-III (APA, 1980) brought a revolutionary transformation to psychiatry. It clustered overt symptoms and transformed mental illnesses from broad, etiologically defined entities with unclear boundaries between normal and abnormal behavior, to symptom-based, categorical diseases (Mayes & Horwitz, 2005). The disorder was now named OCD, which was categorized as an anxiety disorder and had clearly defined symptoms and differential diagnoses.

The diagnostic criteria of OCD did not change much in the successive DSM-III-R (APA, 1987), DSM-IV (APA, 1994), and DSM-IV-TR (APA, 2000). However, for the publication of DSM-5 (APA, 2013), the classification and diagnostic criteria of OCD were revised. The most important change was the separation of OCD from the "Anxiety disorders" and placing it within a new category entitled "Obsessive-Compulsive and Related Disorders" (OCRDs), which also includes body dysmorphic disorder, trichotillomania (hair-pulling disorder), excoriation disorder (skin-picking), hoarding disorder (which was previously regarded as an OCD subtype), substance/medication-induced OCRD, OCRD due to another medical condition, and other specified OCRDs. This approach reflects the growing evidence that suggests that OCD and OC-spectrum disorder are both behaviorally and phenomenologically distinct from other anxiety disorders (van Ameringen, Patterson, & Simpson, 2014). Importantly, anxiety symptoms are frequently present in OCD and OC-spectrum disorders, but have a more variable and heterogeneous nature compared to other anxiety disorders, making anxiety less stable and reliably present in these conditions (Stein, et al., 2010). However, to emphasize the important relationship between anxiety disorders and OCRDs, the two categories were placed adjacent to each other in the DSM-5 (APA, 2013).

Normal and abnormal obsessions and compulsions

It was long assumed that obsessive and compulsive phenomena are specific to patients with OCD, but these symptoms can actually be observed to different degrees almost universally. Anybody may sometimes experience thoughts that just pop into mind for no apparent reason, such as "Did I lock the door this morning?" or "What if I would veer my car of the road or into oncoming traffic?". In addition, some people may have specific routines when checking the house before going on vacation or perform certain rituals when playing an important sports game (such as tennis player Raphael Nadal who bounces the ball and pics his shirt and shorts a

certain number of times before each service). A groundbreaking study of Rachman and de Silva (1978) showed that 84% of the nonclinical population reported unwanted, intrusive thoughts or impulses that had a similar form and content as clinical obsessions. However, clinical obsessions differ from normal obsessions in being more frequent, intense and less easily dismissed. Moreover, recent research suggests that the content of at least some clinical obsessions differs from normal obsessions by being more violent or surreal (Rassin & Muris, 2006). When investigating compulsive behavior in the general population, Muris, Merckelbach and Clavan (1997) found that nearly 55% of healthy individuals reported having a ritual or compulsion that had close similarity in content with clinical compulsions. However, clinical compulsions were more frequent and intense, elicited more discomfort and were more strongly related to distressing thoughts and negative mood. Importantly, clinical compulsions also have a self-harming element that distinguishes them from normal rituals: individuals give into the irresistible urge to engage in the behavior, even though the compulsions are very time-consuming (at least 1 hour per day; APA, 2013) and lead to substantial interference and impairment in daily life (Clark, 2004). The question ensues when normal obsessions or compulsions become pathological and what role perseverative behavior may play in this transition.

Behavioral perspectives on OCD

In the late 1960s and early 1970s behavior theories for OCD were developed, which were based on the two-stage learning theory of fear and avoidance (Mowrer, 1960). According to this theory, obsessional fears develop through classical conditioning in which a neutral object (e.g., car) starts to elicit anxiety, because it is associated with an aversive experience (e.g., an intrusive thought of veering the car of a bridge). To decrease obsessive fear and discomfort patients engage in avoidance or reassurance seeking behavior, which is reinforced because of its anxiety-reducing and –preventing effects. Therefore, obsessions may be viewed as “conditioned noxious stimuli” that cause fear and distress and that patients have difficulties habituating to. In turn, these stimuli cause patients to engage in avoidance behaviors (i.e., compulsions) to alleviate distress, although this relief is often only temporarily (Rachman, 1971; Rachman & Hodgson, 1980). In line with this theory, behavior interventions for OCD were developed (e.g., Meyer, 1966; Rachman, Hodgson, & Marks, 1971; Rachman, Marks, & Hodgson, 1973), which are now

known as “Exposure and Response Prevention (ERP)”. ERP consists of two steps: a) the patient is exposed to the obsessional image, thought or impulse that elicits high anxiety/discomfort and compulsive urges, and b) the patient is instructed to refrain from all attempts (overt or covert) at avoiding, neutralizing or alleviating the discomfort of the image, thought or impulse (Rachman, 1976; Rachman et al., 1979). Important experimental research of Rachman, de Silva, and Röper (1976) showed that exposure to a fear-relevant situation indeed produced a marked increase in anxiety/discomfort and in urges to perform compulsive rituals in patients with OCD, and furthermore, when patients refrained from carrying out their compulsions, a spontaneous decay of discomfort and compulsive urges emerged within the first hour. Patients experience through ERP that the feared consequences of not performing the compulsive act do not occur and that their anxiety and discomfort will fade simultaneously. This will result in adjustment of obsessive-related goal expectation, which in turn should lead to termination of compulsive behavior (Clark, 2004).

The efficacy and effectiveness of ERP treatment for OCD is well established. It yields more improvement than other therapies, such as anxiety management without ERP (Lindsay, Crino, & Andrews, 1997) and some forms of pharmacotherapy (Foa et al., 2005), and improvement after ERP tends to persist over time (O’Sullivan & Marks, 1990; van Oppen, Balkom, de Haan, van Dyck, 2005). However, ERP also has some limitations. Approximately 20-30% of patients either refuse ERP treatment or drop out prior to completion of treatment (Foa, Steketee, Grayson, & Doppelt, 1983; Stanley & Turner, 1995). Moreover, most patients in the aforementioned studies had cleaning or checking rituals. Therefore, ERP seemed most effective for patients with overt compulsions, and less effective for other OCD subtypes, such as pure obsessions and covert/mental neutralizing responses (Rachman, 1983). New approaches and conceptualizations of OCD were therefore necessary, and given that cognitive phenomena play a central role in OCD (e.g., obsessive concerns about responsibility and uncertainty, as depicted in the case example at the beginning of this chapter), it was inevitable that cognitive theories would be integrated in the behavioral framework (Whittal & McLean, 1999).

Cognitive perspectives on OCD

A first cognitive behavioral model of OCD was proposed by Salkovskis in 1985. In this model Salkovskis integrated Rachman's behavioral perspective on OCD (Rachman & Hodgson, 1980) with Beck's theory of emotion and emotional disorders (Beck, 1976). The cognitive model proposes that normal, unintended intrusive cognitions, images or impulses become clinical obsessions when the occurrence and/or content of the intrusions is misinterpreted as an indication that the individual is responsible for causing or preventing harm to oneself or others (Salkovskis, 1985; 1999). Rachman (1997) refined this theory by arguing that obsessions are caused by catastrophic misinterpretations of the personal significance, importance, and/or revealing and threatening nature of one's intrusive thoughts (images, impulses). The misinterpretations cause discomfort and anxiety, which in turn leads to compulsive behavior to suppress the thought or avoid certain situations or objects to prevent misfortunes from happening. For instance, an intrusive image of pushing someone in front of an approaching train would be evaluated by most individuals as uncomfortable, but insignificant and meaningless for their actual behavior. However, individuals at risk for OCD would interpret this thought as immoral and as a significant threat, because they feel that having such thoughts is equivalent to performing the action. To decrease anxiety, the person suppresses the unwanted intrusion by performing a neutralizing ritual (e.g., tapping five times with their foot on the ground and replacing the intrusion with a good thought, "I am a good person") and may start to avoid stations and railway tracks completely to prevent possible harm in the future. Although these strategies may be somewhat successful in the short term, they ultimately contribute to the persistence and intensification of the obsessions by increasing its salience, frequency, and attentional focus on the intrusion and related stimuli. Furthermore, the compulsions and feelings of responsibility are reinforced, because the actions are followed by the absence of the feared consequences, which will cause the individual to believe that their action was reasonable and effective (Salkovskis, 1985).

Empirical evidence shows that patients with OCD indeed make more faulty appraisals of their intrusions than non-obsessional individuals, and some appraisals, such as worry that a thought will come true, and the importance of controlling thoughts, are specific to patients with OCD (Morillo, Belloch, & García-Soriano, 2007). Cognitive behavior treatment (CBT) therefore involves challenging these

appraisals through various cognitive restructuring techniques, such as behavioral experiments and “pie-charting” (brainstorming all possible people or situations that could have some responsibility in the outcome; Whittal & McLean, 1999).

Cognitive theory of compulsive checking

In the footsteps of the general cognitive behavioral model of OCD (Salkovskis, 1985), new cognitive theories were developed to explain more specific OC symptomatology. Rachman (2002) proposed a cognitive theory of compulsive checking, one of the most common compulsions in OCD, with 80% of individuals with lifetime OCD reporting this as one of their primary symptoms (Ruscio, et al., 2010). This theory attempts to explain why and when checking behavior becomes compulsive. It proposes that the interaction between an increased sense of responsibility, the perceived probability of harm and the anticipated seriousness of harm makes people engage in preventative checking behavior. However, because patients feel they can never be completely sure that a perceived threat has been adequately removed and because checking behavior may paradoxically inflate feelings of responsibility and memory uncertainty, this behavior will persist.

Dysfunctional beliefs

In accordance with the cognitive behavior theory of OCD, the Obsessive Compulsive Cognitions Working Group (OCCWG, 1997) has identified six dysfunctional belief-domains that are considered central to the etiology and maintenance of OCD: inflated responsibility, over-importance of thoughts (i.e., thought-action fusion), importance of controlling one’s thoughts, overestimation of threat, intolerance of uncertainty, and perfectionism. Subsequently, the Obsessive-Compulsive Questionnaire-87 (OBQ-87; OCCWG, 2003) was developed to assess these six domains. After revision, a shorter version of the questionnaire (OBQ-44; OCCWG, 2005) contained three subscales, each combining two subscales from the original questionnaire: inflated responsibility/overestimation of threat, perfectionism/intolerance of uncertainty, and importance/control of thoughts. The maladaptive beliefs are expected to give rise to corresponding faulty appraisals in which obsession-prone individuals, for instance, misinterpret an unwanted intrusion as a highly threatening mental event (threat appraisal; e.g., having the thought is equally bad as performing the action), for which they are responsible to prevent

(responsibility appraisal), and only the elimination of the intrusive thought and its associated distress are evidence that safety has been reestablished (need to control appraisal; Clark & Simos, 2013).

Research shows that the OBQ-44 strongly correlates with OC symptoms and that patients with OCD score higher on obsessive beliefs than healthy controls (OCCWG, 2005). Furthermore, a prospective study that followed first-time expecting parents through the postpartum period showed that the tendency to negatively interpret the presence and meaning of unwanted infant-related intrusive thoughts mediated the relationship between pre-childbirth obsessive beliefs and late postpartum OC symptoms (Abramowitz, Nelson, Rygwall, & Khandker, 2007). This is consistent with the idea that negative *appraisals* of normally occurring intrusions derive from obsessive beliefs and are associated with enhanced OC symptoms. Thus, dysfunctional beliefs and negative appraisals appear to be important for the understanding of OCD, and changing these cognitions seems a central feature of recovery from OCD. However, some researchers also criticize the relevance of obsessive beliefs, and recent findings challenge the basic principles of the cognitive theory of OCD.

Critiques on cognitive perspectives on OCD

The main goal of the OCCWG (1997) was to identify core dysfunctional beliefs that were exclusive to OCD and thus, distinguish OCD from other disorders. However, Anholt and Kallanthroff (2013) point out that it is questionable whether the dysfunctional-belief domains discriminate well between OCD and other disorders and whether dysfunctional beliefs play a role in all OCD subtypes. First, the initial OCCWG validation study (2003) itself did not find significant differences on intolerance of uncertainty, overestimation of threat and perfectionism between patients with OCD and anxious controls. Furthermore, overestimation of threat was found to be the only domain in which patients with OCD exhibited higher scores than pathological gamblers (Anholt et al., 2004), and patients with (a history of) eating disorders scored comparable to or higher than patients with OCD on the complete OBQ-87 (Lavender, Shubert, de Silva, & Treasure, 2006). Moreover, a recent review showed that when general distress is controlled, there is no evidence that patients with OCD endorse dysfunctional beliefs more strongly than patients with other anxiety disorders (Julien, O'Connor, & Aardema, 2007). Finally, and most

importantly, because large proportions of patients with OCD (55-66%) do not show elevations in OBQ scores (Taylor et al., 2006; Anholt et al., 2010), belief domains may not play a role in all OCD subtypes.

Additionally, research showed that when inspecting treatment effects, OBQ-44 scores decreased whether or not the treatment had a specific cognitive component (Whittal, Thordarson, & McLean, 2005), which is problematic for the cognitive appraisal model. Moreover, when reviewing the efficacy of cognitive therapies (CT) that were based on the appraisal model, CT was found to be an effective treatment of OCD, but not more effective than ERP in OCD symptom reduction, change in belief domains, treatment refusal, and drop-out rate (Julien et al., 2007). Some studies even indicate that ERP appears to be *more effective* than CT for treating OCD (Fisher & Wells, 2005; Olatunji et al., 2013). Hence, misinterpretations of intrusions and dysfunctional beliefs may not be necessary or sufficient for the development of OCD, and a specific focus on cognitions does not seem to increase treatment effects. Therefore, obsessions may not play such a central role in OCD development and maintenance as assumed by cognitive theories (e.g., Rachman, 1997; Salkovskis, 1985), and therefore, it may be fruitful to take another look at the role of behavioral aspects in the development and maintenance of OCD to increase our understanding of the disorder and consequently enhance treatment efficacy.

The role of compulsive behavior for understanding OCD

Robust experimental findings have shown that compulsive checking, the most prevalent compulsive behavior in OCD (Ruscio et al., 2010), may serve to maintain the disorder, by paradoxically enhancing uncertainty. In a series of studies, van den Hout and Kindt (2003a, 2003b, 2004) asked healthy participants to perform a virtual checking task. Participants were instructed to turn on, turn off, and check a virtual stove multiple times, and asked to rate their memory and meta-memory of their last check directly after the first and final checking trial. Results consistently indicated that after repeatedly checking the same stimulus, memory confidence, vividness and detail of the last check decreased remarkably. Interestingly, however, memory accuracy generally remained intact after repeated checking. In the following decade the findings were replicated in patients with OCD (Boschen & Vuksanovic, 2007; Radomsky, Dugas, Alcolado & Lavoie, 2014), when using more ecologically valid methods (i.e., a real stove; Radomsky, Gilchrist & Dussault, 2006), and with mental

instead of physical checking (Radomsky & Alcolado, 2010). Furthermore, it was demonstrated that after 2-5 checks, individuals already show memory deterioration of the checked stimuli (Coles, Radomsky, & Horng, 2006). Thus, engaging in this counterproductive strategy leads patients with OCD to distrust their memory, the very thing it is intended to reduce. In turn, this may promote continued or renewed checking, leading to a vicious cycle of increased uncertainty/distrust and checking behavior, which helps to explain why OCD persists.

Note that obsessive uncertainty not only relates to memory, but to other cognitive operations as well (Nedeljkovic & Kyrios, 2007). Examples are uncertainty about perception ("Can I really trust that what I see is true?"), or text comprehension ("Do I properly understand what I say?"). In such cases, patients try to reduce uncertainty, for example, by prolonged staring at objects or repeating sentences. Interestingly, just like perseverative checking causes memory distrust, OCD-like staring causes uncertainty about visual perception (van den Hout, Engelhard, de Boer, du Bois & Dek, 2008). Moreover, OCD-like repetition of simple sentences (e.g., my hands are clean, my hands are clean, etc) induces uncertainty about the meaning of the sentence (Giele, van den Hout, Engelhard, & Dek, 2014). Finally, asking healthy participants to carry out compulsive cleaning rituals for one week causes increases in uncertainty about contamination and in overestimating the likelihood and severity of contamination (Deacon & Maack, 2008). Together these findings indicate that compulsive behavior itself directly contributes to the exacerbation, and thus the maintenance of OC symptoms.

However, compulsive behavior may also play a role in the development of the disorder. Recently, Gillan and colleagues (2011, 2014) demonstrated that patients with OCD have a deficit in flexible and goal-directed behavioral control, which forces them to overly rely on their habit system. In these studies, patients with OCD were asked to either 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. Results indicated that 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 over-active

habits. This suggests that compulsions may not always be carried out as goal-directed, purposeful, efforts to reduce the likelihood of threat or to provide relief (Rachman, 1997), but may also be viewed as excessive habit learning, which can be triggered regardless of desirability of the consequences. Furthermore, these studies show that excessive compulsive-like, automatic behaviors develop in patients with OCD in the absence of any prior obsessions, which suggests that there may be a behavioral disturbance in OCD that is independent of obsessive thoughts (Gillan & Robbins, 2014). Therefore, compulsions may not only be viewed as response to preceding frightening intrusions, but patients with OCD may also use compulsive behavior in the absence of obsessive concerns.

This was indeed demonstrated by a number of recent studies that investigated checking. When investigating participants' eye movements during a basic image comparison task (comparing two images that were projected simultaneously and indicating whether they were identical or not) patients with OCD made more gaze moves, and thus, checked more often, than healthy controls (Jaafari et al., 2013). More specifically, Kim et al. (2012) showed that OCD checkers used more checking behavior than OCD non-checkers and healthy controls in a virtual-reality task in which they could freely move around and check multiple items in a virtual house. Furthermore, OCD checkers were also found to use more checking behavior than OCD non-checkers and healthy controls in a delayed matching to samples task (comparing two images that were projected with a delay in between and indicating whether they were identical or not), and there was a progressive increase in checking behavior for patients with checking compulsions over the course of 50 trials (Rotge et al., 2008). In a similar delayed matching to samples task Clair et al. (2013) showed that the increased checking behavior of OCD checkers was independent of memory abilities and stimulus-evoked anxiety, which emphasizes the automated part of checking that is displayed irrespective of experienced obsession-related anxiety. Interestingly, increased checking behavior did not increase accuracy in any of the checking tasks, which resembles the irrationality and uselessness of compulsive checking (Rachman, 2002).

Thus, there is ample evidence showing that compulsive behavior may not only be "output" resulting from obsessive uncertainties: compulsions also serve to maintain OCD, and patients with OCD tend to use more checking behavior in general than people with no OC tendencies, also when the checking is unrelated to patients'

obsessive concerns. But what triggers this checking behavior? And does this inclination to checking contribute to the development of other OCD symptoms?

Objectives and outline of this dissertation

Apart from obsessive uncertainty, patients with OCD also seem to experience a milder, subclinical type of uncertainty, which appears to be more general and occurs in a wide range of domains. For instance, patients with OCD show less confidence in their general knowledge (Dar, Rish, Hemesh, Taub, & Fux, 2000) and in their ability to discriminate performed events from imagined events (McNally & Kohlbeck, 1993). Furthermore, patients with OCD are more uncertain about their memory, decision-making abilities, level of concentration and attention (Nedeljkovic & Kyrios, 2007; Tuna, Tekcan, & Topcuoglu, 2005), and their perception and executive functions (Hermans et al., 2008). Thus, this elevated level of general uncertainty seems stable over time and across a number of situations. Therefore, one may speculate that subclinical uncertainty precedes clinical OCD and may put the individual at risk of trying to reduce incidental uncertainty by engaging in checking behavior. Thus, the tendency of patients with OCD to use more checking behavior in general may be more pronounced when uncertainty is induced. In turn, it may be hypothesized that when individuals respond with repeated checking to normal doubts (e.g., did I turn of the gas stove") this may have the same paradoxical effect as compulsive checking of reinforcing uncertainty (e.g., van den Hout & Kindt, 2003a), which may cascade into the vicious cycle of increased uncertainty and checking, and contribute to the development of full-blown OCD.

To unravel the role of checking behavior in the development of OCD, and to investigate the reciprocal relationship between checking and cognitive symptoms, the first aim of this dissertation was to investigate if mild uncertainty, thematically unrelated to obsessive concerns, indeed stimulates general checking in OCD. Secondly, this dissertation aimed at investigating whether checking behavior directly contributes to the exacerbation of OCD symptoms. When we have a better understanding of when patients with OCD use checking behavior, and what detrimental effects this behavior may have, we can subsequently investigate whether abstaining from checking behavior, even when only mild uncertainties arise, may help to prevent the development of extreme, obsessive concerns. Thus, to investigate general checking behavior in response to mild uncertainty, and to examine direct

effects of checking on memory distrust and obsessive cognitions the following studies were conducted.

In **chapter 2**, a novel experimental eye-tracking paradigm is introduced to test whether mild uncertainty, thematically unrelated to extreme obsessive concerns, promotes checking behavior in people with subclinical OCD. In this study, undergraduate students with either high or low OC tendencies were asked to perform a visual search task, in which they indicated whether a target was “present” or “absent” in a search display. Decisions about target presence were self-evident, whereas decisions about its absence induced uncertainty, because participants had to rely on not having overlooked the target. Checking behavior was measured by assessing the time it took participants to search through the field and the number of fixations, measured with an eye-tracker.

In **chapter 3** we tried to replicate the findings of the first study (again in non-clinical individuals) and extend the findings by investigating whether intolerance of uncertainty could account for the effect. Furthermore, by including participants with scores on the whole range of OC tendencies we investigated whether there was a positive correlation between OC tendencies and checking behavior in mildly uncertain situations.

Chapter 4 presents the results of a follow-up study on the effect of mild uncertainty on general checking behavior in a sample of patients with OCD, compared with non-OCD anxiety control patients and healthy controls.

Chapter 5 reports two studies that investigated how repeated checking influences memory distrust over multiple checking episodes. In study 1, healthy undergraduates performed two sessions of the virtual checking task of van den Hout and Kindt (2003a), and study 2 tried to replicate the initial findings by asking healthy students to perform two sessions of the repeated checking task on a real-life kitchen stove.

Chapter 6 presents a study that examined the effect of engaging in real-life, OCD-like checking behavior for one week on obsession-related cognitions about the importance of checking and the overestimation of threat.

Finally, **chapter 7** is a general discussion in which the main findings of the empirical studies in this dissertation are summarized and combined. Furthermore, theoretical and clinical considerations are discussed.

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Chapter 2

Mild uncertainty promotes checking behavior in subclinical obsessive-compulsive disorder

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Abstract

Patients with OCD 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 super-imposed on general uncertainty. An experimental eye-tracking paradigm was developed to investigate whether mild uncertainty indeed induces checking behavior in people with high (OC+, *n* = 34), compared to people with low (OC-, *n* = 31), OC tendencies. Participants were presented 50 visual search displays, and 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 OCD respond with more checking behavior, which has implications for treatment.

Introduction

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 and/or mental acts (compulsions) to suppress the obsessions and prevent future misfortunes or harm (APA, 2000). These actions are typically repeated and prolonged beyond the point where the goal of the act is reasonably reached, and 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 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 (van den Hout & Kindt, 2003a, 2003b, 2004; Radomsky, Gilchrist, & Dussault, 2006; Hermans, Engelen, Grouwels, Joos, Lemmens, & Pieters, 2008; Dek, van den Hout, Giele, & Engelhard, 2010, Boschen & Vuksanovic, 2007; van den Hout, Engelhard, De Boer, Du Bois, & Dek, 2008; van den Hout, Engelhard, Smeets, Dek, Turksma, & Saric, 2009). 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 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 form of 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 (Tuna, Tekcan, & Topcuoglu, 2005; Boschen & Vuksanovic, 2007), 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 super-imposed on general uncertainty (Nedeljkovic & Kyrios, 2007). Thus, it may be hypothesized that even 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, and 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 to make their choice before actual checking than healthy controls, 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 OC tendencies would show enhanced checking behavior, as indexed by a higher search time and higher number of fixations in target-absent trials (*uncertain situation*), but not in target-present trials (*certain situation*).

Method

Participants

Four hundred and eighty students from Utrecht University were screened using the Obsessive-Compulsive Inventory-Revised (OCI-R; 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 (*M* age = 22.19, *SD* = 4.90, 28 women), and 32 in

the OC- group (*M* age = 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 cut-off score of 21 for differentiating with non-anxious controls (Foa et al, 2002). Of the current OC+ sample, 55.6 % reached this cut-off 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 (OCI-R). Obsessive-compulsive tendencies were measured with the Dutch translation (Cordova-Middelbrink, Dek, & Engelbarts, 2007) of the OCI-R (Foa et al., 2002). The OCI-R 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*). The OCI-R has good validity, test-retest reliability and internal consistency in clinical (Foa et al, 2002) and non-clinical 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 Figure 1). 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 0.41˚ × 0.41˚, and the gap size of the distracters was 0.21˚. The elements were white on a dark grey background, and 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. 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), and indexed how many fixations were made while searching through the field.

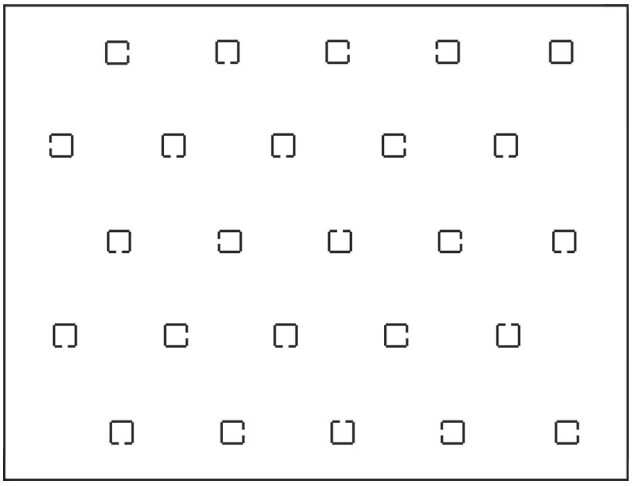

Figure 1. Example of a search display; the target is the closed symbol (upper-right corner; in the experiment, the elements were white on a dark gray background).

Apparatus

Search displays were presented with Matlab (MathWorks Benelux, 2007). Eye movements were recorded at 52Hz using a portable, EasyGaze™ 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. 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 (centre) data point. This procedure was repeated for all data points (accept 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 3 samples (58 ms).

Procedure

Participants were tested individually in a dimly light laboratory. They received verbal and written instructions about the task, before they provided written informed consent. Then, they were seated approximately 58cm in front of a 17-inch monitor (1280 x 1024 pixels). Head movements were restricted by the use of a chin and a

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 them 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 pressing the "space bar", 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 (target-*present*) or right (target-*absent*) arrow key. 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 respectively 19 and 28 errors on 50 trials, which was more than 2.5 *SD* of the Mean (errors, *M* = 5.87, *SD* = 5.96). Combined with their very fast RTs (absent trials, *M* = 1.3; *M* = 0.4), which were respectively 3.3 and 4 *SD*s 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 (*M* age = 21.69, *SD* = 4.18), with 34 OC+ participants and 31 OC- participants[1].

[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 (*M* = 5.35, *SD* = 1.48) than present trials (*M* = 3.19, *SD* = .89), $F(1,66) = 322.28$, $p < .001$, $\eta_p^2 = .83$. There was no main-effect of group; overall the OC+ and OC- group did not differ in search time, $F(1,66) = 2.09$, $p = .15$. However, the crucial group (OC+/OC-) x 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), $\eta_p^2 = .03$. With regard to number of fixations, findings did not change. There was a main effect of condition; participants used significantly more fixations in absent (*M* = 21.68, *SD* = 5.06) than present (*M* = 12.62, *SD* = 2.87) trials, $F(1,66) = 386.84$, $p < .001$, $\eta_p^2 = .86$. There was also a main effect of group; OC+ participants made more fixations than OC- participants, $F(1,66) = 4.46$, $p < .05$, $\eta_p^2 = .07$, and the crucial group (OC+/OC-) x condition (absent/present) interaction was significant, $F(1,66) = 3.73$, $p < .05$ (one-tailed), $\eta_p^2 = .06$.

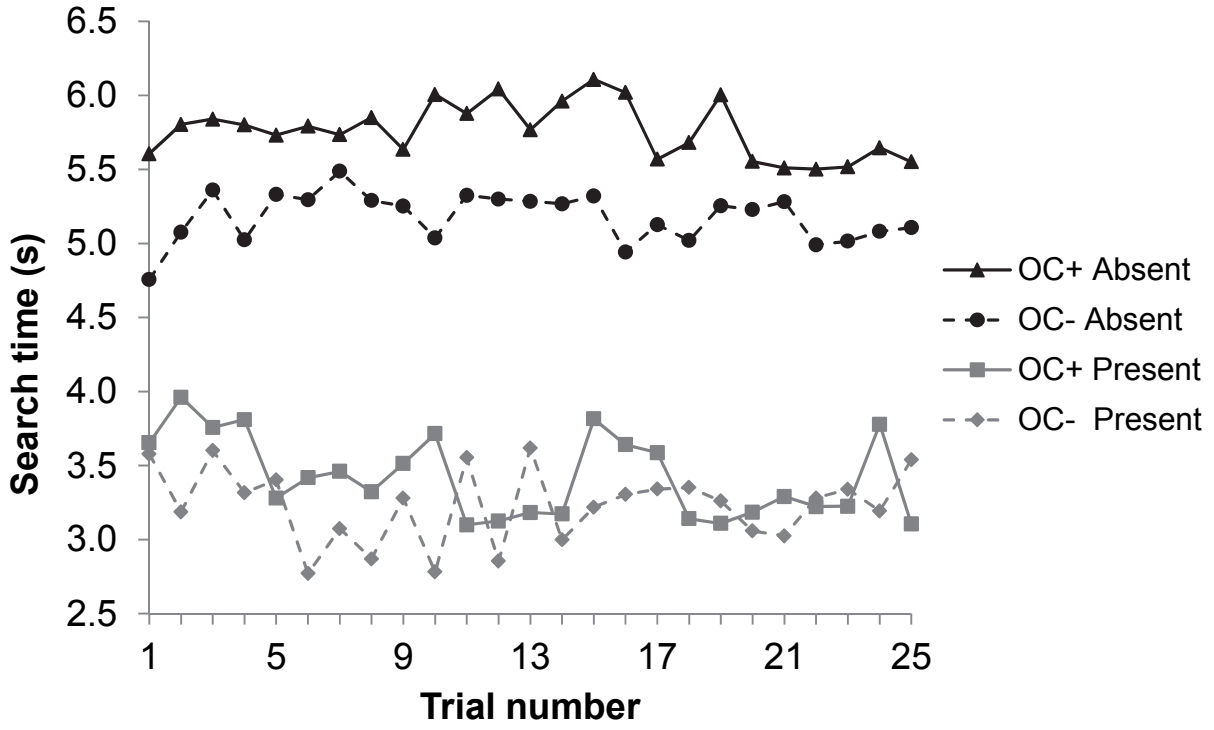

Figure 2. Mean search time (s) per trial in target-absent and -present trials for OC+ and OC– participants (i.e., high and low obsessive-compulsive tendencies, respectively).

Each trial was presented for 10s. If a participant did not respond within 10s, 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 non-responses in the OC- group.

Results are graphically 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 (ANOVA) 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 towards 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 (M = 5.5, SD = 1.28) than present trials (M = 3.26, SD = .78), $F(1,63) = 368.53$, $p < .001$, $\eta_p^2 = .85$. There was no main-effect of group; overall the OC+ and OC- group did not differ in search time, $F(1,63)$ =

3.18, p = .08. The crucial group (OC+/OC-) x condition (absent/present) interaction was significant, $F(1,63) = 2.83$, $p < .05$ (one-tailed), $\eta_p^2 = .04$. Pairwise comparisons showed that in target-present trials, OC+ participants (M = 3.37, SD = .8) did not differ from OC- participants (M = 3.15, SD = .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).

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 ANOVA pattern occurred for the number of fixations. A main effect of condition was evident; participants used significantly more fixations in absent (M = 21.92, SD = 4.7) than present (M = 12.74, SD = 2.72) trials, $F(1,63) = 406.01$, $p < .001$, $\eta_p^2 = .87$. There was a non-significant 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-) x condition (absent/present) interaction was significant, $F(1,63) = 2.93$, $p < .05$ (one-tailed), $\eta_p^2 = .04$.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 importantly, a higher number of fixations than OC- participants. Furthermore, only OC+ participants had non-responses, which indicated an even longer search time beyond the response limit. Since the number of non-responses 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, since 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 super-imposed 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 sub-clinical 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 in 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 (Grootheest, Cath, Beekman, & Boomsma, 2007; Nicolini, Arnold, Nestadt, Lanzagorta, & Kennedy, 2009). 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). Since 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) have 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 also be studied with the same paradigm. If a comparable pattern would indeed be found both in 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 non-clinical 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 HIV etc. Further, although cognitive behavior therapy (CBT) 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 CBT 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.

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Chapter 3

Uncertainty, checking, and intolerance of uncertainty in subclinical obsessive-compulsive disorder: An extended replication

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Abstract

Recently, Toffolo and colleagues (2013) showed that individuals with subclinical OCD (OC+) respond with more checking behavior to mildly uncertain situations than individuals with low OC tendencies (OC-). The present study aimed to replicate and extend these findings by measuring Intolerance of Uncertainty (IU), and including the whole range of OC tendencies in a correlation analysis. Participants filled out the Obsessive Compulsive Inventory Revised and Intolerance of Uncertainty Scale and performed a visual search task. This task contained 50 search displays, in which participants indicated whether a target was “present” or “absent”. Target-present trials were straight-forward, but target-absent trials were ambiguous, because participants had to rely on not having overlooked the target. Results revealed that target-absent trials induced more uncertainty than target-present trials. Furthermore, OC+ participants checked longer than OC- participants in target-absent but not target-present trials. This could not be explained by higher IU in OC+ participants. There were no differences in number of fixations in absent and present trials between the groups. Finally, when looking at the whole range of OC tendencies, there was a positive relation between OC tendencies and checking behavior. The findings (partly) replicated those of Toffolo et al. (2013) and add to their robustness.

Introduction

Uncertainty plays an important role in obsessive-compulsive disorder (OCD). Obsessive thoughts typically relate to uncertainty about frightening prospects (e.g., hurting a loved one), and compulsive acts are efforts to reduce this uncertainty (American Psychiatric Association, 2013). This clinical uncertainty is extreme: it is intense, intrusive and relates to issues that others are certain about (e.g., "can I trust myself that I will not stab my wife while doing the dishes?"). It also seems domain-specific; some patients are extremely uncertain about their competency and safety in driving, but not about visual perception, or the other way around. This extremity and domain-specificity of clinical uncertainty is obvious from the clinical picture (Rachman, 1997). However, more recently, it has become clear that patients with OCD also experience a milder, subclinical form of uncertainty, which needs more subtle testing to be revealed. This type seems more general and occurs in a wide range of domains and ambiguous situations, which is displayed, for instance, by less confidence in one's memory (Tuna, Tekcan, & Topcuoglu, 2005), perception (Hermans et al., 2008), concentration abilities (Nedeljkovic & Kyrios, 2007), and general knowledge (Dar, Rish, Hemesh, Taub, & Fux, 2000). Researchers argued that this elevated level of subclinical, general uncertainty may precede clinical OCD by acting as a vulnerability factor for the disorder (Nedeljkovic & Kyrios, 2007; Toffolo, van den Hout, Hooge, Engelhard, & Cath, 2013). Subclinical uncertainty may tempt individuals to seek reassurance by repeated checking in response to normal doubts. Subsequently, when people indeed respond with repeated checking, this may paradoxically increase uncertainty as shown by a great number of studies (e.g., Van den Hout & Kindt, 2003a, 2004; Radomsky, Gilchrist, & Dussault, 2006; Boschen & Vuksanovic, 2007; Dek, van den Hout, Giele & Engelhard, 2010). Therefore, in a previous study, Toffolo et al. (2013) hypothesized that in response to mildly uncertain situations, patients with OCD will use more checking behavior, because even mild uncertainty may bring the yet elevated level of general uncertainty to a point where repeated checking is needed to obtain certainty. The authors developed an experimental eye-tracking paradigm to test whether mild uncertainty indeed induces actual checking behavior in people with subclinical OCD, as opposed to more certain situations. Participants were presented 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 such 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”. However, target-absent trials were more ambiguous, because participants had to rely on not having overlooked the target. These trials were thus held to resemble “uncertain situations” and to induce feelings of uncertainty. Checking behavior was measured by the time participants searched through the display and by the number of fixations they made while searching. Results revealed that there were no differences in checking behavior in the target-present trials between individuals with high (OC+) or low (OC-) OC tendencies. However, in the target-absent trials, OC+ participants searched longer and used more fixations than OC- participants. Thus, in line with the hypothesis, they found that even in mildly uncertain situations, individuals with subclinical OCD used more checking behavior.

Although intriguing, the findings and interpretations raised some critical questions. First, the authors failed to include a manipulation check. Therefore, it remains unclear whether the target-absent trials led to more uncertainty than the target-present trials, and whether the groups differed in experienced uncertainty. Second, it is unclear *why* the alleged uncertainty promoted checking behavior in the OC+ group. A plausible contributing factor is Intolerance of Uncertainty (IU). IU is defined as the predisposition to react negatively to uncertainty, independent of its probability of occurrence and possible consequences (Ladouceur, Gosselin, & Dugas, 2000). Especially OC checkers show high IU, indicating they find uncertainty more distressing compared to OC non-checkers and healthy controls (Tolin, Abramowitz, Brigidi, & Foa, 2003), and also desire a higher level of certainty than healthy controls (Abramowitz, Khandker, Nelson, Deacon, & Rygwall, 2006). Therefore, it is possible that the OC+ group used more checking behavior in the target-absent trials, *because* they tolerated the experienced uncertainty less. To investigate this, we conducted an extended replication of Toffolo et al. (2013) that included manipulation checks and the Intolerance of Uncertainty scale (IUS). Finally, to investigate differences in checking behavior in both certain and uncertain situations, Toffolo et al. (2013) used two extreme groups: people who scored extremely high on OC tendencies (OC+) and people who scored extremely low on OC tendencies (OC-). The OC+ group closely resembled the OC tendencies of actual patients with OCD, with a mean score that was only slightly below the mean score of patients. However, it is unclear whether the OC- group is a good resemblance of the

normal population. Possibly, the results were not caused by an increased use of checking behavior of the OC+ group, but by the decreased use of checking behavior of the OC- group. Therefore, in the present study we not only analyzed the results for extreme groups, but also for the entire range of OC scores (from very low to very high). Hence, we could investigate whether there was indeed a positive correlation between OC tendencies and checking responses in both certain and uncertain situations.

In sum, the first aim of the present study was to critically replicate the previous findings of Toffolo et al. (2013). It was thus hypothesized that the OC+ group, compared with the OC- group, would show enhanced checking behavior, as indexed by a higher search time and number of fixations, in target-absent trials (*uncertain situation*), but not in target-present trials (*certain situation*). Secondly, we expected that the target-absent trials would provoke more uncertainty than target-present trials. Furthermore, since the OC+ group may have higher general uncertainty to begin with (e.g., Nedeljkovic & Kyrios, 2007) we expect them to experience more uncertainty than the OC- group in the target-absent trials. Additionally, OC+ participants might find the same uncertainty more distressing (Tolin et al, 2003), which could explain the different checking responses in target-absent and target-present trials. This led to the third hypothesis; OC+ participants will respond with more checking behavior than OC- participants in target-absent, but not target-present trials, but this will no longer be the case after controlling for IU. Finally, we tested whether this difference in checking behavior between absent and present trials is not only present when focusing on extreme groups, but also occurs over the entire range of OC tendencies. We expected a positive correlation between OC tendencies and checking behavior (both search time and fixations) in target-absent but not target-present trials. Hence, we expected the difference in checking behavior between absent and present trials to be positively correlated with OC tendencies.

Method

Participants

Six hundred and sixty students from Utrecht University and the University of Applied Sciences Utrecht were screened with the Obsessive-Compulsive Inventory Revised (OCI-R; Foa et al., 2002). All individuals who filled out their contact information were contacted by phone or e-mail to invite them to participate in this

study[1]. To obtain a sample that reflected the whole range of OCI-R scores for the correlation study, we divided the scores in five categories to ensure an equal distribution of scores. Twenty-two participants were recruited with an OCI-R score between 0-5, 23 participants had a score between 6-10, 22 participants had a score between 11-15, 22 participants had a score between 16-20 and 20 participants had a score of 21 and higher. OCI-R scores of this sample ranged from 1 to 42 (*M* = 13.59, *SD* = 8.87).

The replication study of Toffolo et al. (2013) required testing only the two extreme groups (OC-, OCI-R scores 0-5; OC+, OCI-R scores ≥ 20). To ensure sufficient power, we recruited extra OC+ and OC- participants for this analysis (from the original 660 screened students). A total of 56 participants were included in the OC- group (Mean age = 21.13, *SD* = 2.46, 48 females), and 55 participants in the OC+ group (Mean age = 20.51, *SD* = 2.19, 45 females). Scores in the OC- group ranged from 1 to 5 (*M* = 3.54, *SD* = 1.26). Scores in the OC+ group ranged from 20 to 42 (*M* = 27.07, *SD* = 6.15). This closely resembled the mean score of patients with OCD, namely 28.01 (*SD* = 13.53; Foa et al., 2002). All participants signed informed consent and received remuneration or course credit for their participation.

Material

Obsessive-Compulsive Inventory-Revised (OCI-R). Obsessive-compulsive tendencies were measured with the Dutch translation (Cordova-Middelbrink, Dek, & Engelbarts, 2007) of the OCI-R (Foa et al., 2002). The OCI-R contains 18 items concerning OCD characteristics, each measured on a 4-point Likert scale (e.g., *"I check things more often than needed",* 0 = not at all, 4 = extremely). The OCI-R has good validity, test-retest reliability and internal consistency in clinical (Foa et al, 2002) and non-clinical populations (Hajack, Huppert, Simons, & Foa, 2004).

Intolerance of Uncertainty Scale (IUS). Intolerance of Uncertainty was measured using the Dutch translation (De Bruin, Rassin, van der Heiden, & Muris, 2006) of the IUS (Freeston, Rheaume, Letarte, Dugas, & Ladouceur, 1994b). It contains 27 items measuring different aspects of intolerance of uncertainty in general and how much one agrees with these. For instance the idea that uncertainty is unacceptable. Items were rated on a 5-point Likert scale (e.g., *"Uncertainty stops me*

[1] Individuals who filled out the OCI-R but were not included in this study were either unable to be reached or did not want to participate.

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 (α = .91) and its the test-retest reliability is good (r = .78) (Dugas, Freeston & Ladouceur, 1997).

Visual Search Task. We used the same task as used by Toffolo et al. (2013). It consisted of one block of 50 individual search displays; each containing 25 elements (see Figure 1). 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 0.41˚ × 0.41˚, and the gap size of the distracters was 0.21˚. The elements were white on a dark grey background, and 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. The target-absent and present trials were presented in a random order to each participant.

As a manipulation check of feelings of uncertainty in both types of trials we added two questions at the end of the task: *"How certain did you feel when responding there <u>was</u> a target present in the field"* and *"How certain did you feel when responding there <u>was not</u> a target present in the field".* Both questions were rated on a 10-point Likert scale (*0=not certain, 9=very certain*).

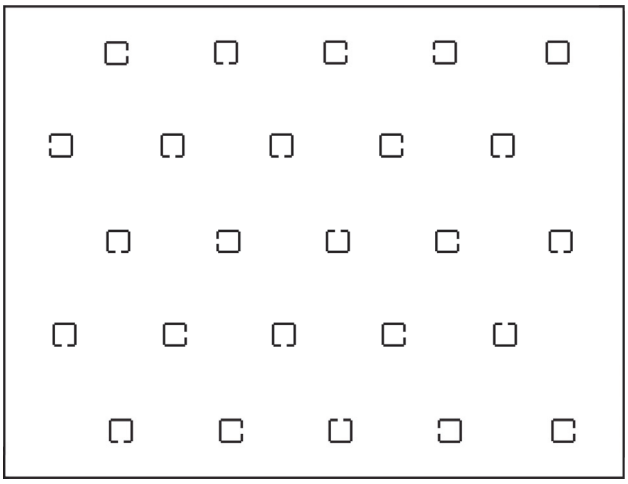

Figure 1. Example of a search display; the target is the closed symbol (upper-right corner; in the experiment, the elements were white on a dark gray background).

Measures. Checking behavior was operationalized by search time and the number of fixations. Search time was the time 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)* that indexed how many fixations were made while searching through the field.

Apparatus

Search displays were presented with Matlab (MathWorks Benelux, 2007). Eye movements were recorded at 52Hz using a portable, EasyGaze™ eye tracker (Design Interactive, Inc., Oviedo, FL). The eye movement data were analysed off-line. Fixation detection was done by a self-written Matlab program that marked fixations by an adaptive velocity threshold method. Adaptive velocity threshold methods are quite common nowadays (Engbert & Kliegl, 2003; Smeets & Hooge, 2003; Nyström & Holmqvist, 2010). Here we used an adaptive velocity threshold method that was developed to work with data from low frequency eye trackers (Hooge & Camps, 2013). We removed fixations having durations shorter than 58 ms (3 samples) from the analysis.

Procedure

Participants went through the same procedure as reported by Toffolo et al. (2013), with the only difference being that after the Visual Search Task they filled out the manipulation check questions and IUS. First, they received both verbal and written instructions about the study. Then, after filling out informed consent, participants were placed in a dimly lit laboratory room and seated approximately 58 cm in front of a 17 inch monitor (1,280 × 1,024 pixels; with the eye tracker placed beneath). Head movements were restricted by the use of a chin-and-forehead rest. When the eye tracker was calibrated, the task started with six practice trials. When participants understood the task, 50 search displays (trials) were presented. During each trial, participants were asked to indicate whether a target was present or not in the search display, by pressing the left (target-*present*) or right (target-*absent*) arrow key. Before each trial, a fixation point was presented in the centre of the screen. Immediately after pressing the “space bar”, the search display appeared. Participants were unaware of how many search displays contained a target. When participants

finished the computer task, they filled out the IUS using paper and pencil. Then, participants were debriefed and paid for their participation

Results

Data exclusion

Five participants were excluded from all analyses. Two were excluded, because they had made respectively 44 and 38 errors in 50 trials, which was 6.7 and 7.9 *SD*s above the mean errors (*M* = 4.96, *SD* = 4.95). One participant was excluded because he made 22 errors in both present and absent trials (3.4 *SD*s above the mean), combined with a fast search time (absent trials, *M* = 2.24) and very low number of fixations (absent trials, *M* = 7.28), respectively 2.4 and 2.7 *SD*s of the mean. It therefore seemed these 3 had not followed instructions correctly. One participant was excluded because of incomplete OCI-R data, and the fifth participant was excluded because she had participated in a comparable eye tracking experiment.

Furthermore, three participants were only excluded from the analyses of the number of fixations (but not from the other ones), because due to a malfunction of the eye tracker they had incorrect eye tracking data. Additionally, there were two participants (one OC+ and one OC- participant) with outliers on search time and number of fixations in the absent trials. The OC- participant had a mean search time of 10.7s (3.5 *SD*s above the mean) and a mean number of fixations of 41.3 (3.3 SDs above the mean). The OC+ participant had a search time of 10.2s (2.9 *SD*s above the mean) and a mean number of fixations of 36.04 (2.6 *SD*s above the mean). These values were transformed to values of 2.5 standard deviations above the mean, which was a search time of 9.25s and number of fixations of 36.58 for OC- and a search time of 9.59s and number of fixations of 35.69 for OC+ respectively. There were no participants with non-response trials.

Manipulation check

A two-way mixed analysis of variance (ANOVA) was performed to examine whether participants experienced more uncertainty in target-absent than in target-present trials (using the manipulation check questions). There was a main effect of condition on uncertainty; overall, participants were significantly less certain about their response in the target-absent trials (*M* = 6.22, *SD* = 1.68) than in the target-

present trials (*M* = 7.87, *SD* = 1.39), *F* (1,104) = 101.56, *p* < .001, η_p^2= .49. There was no main effect of group; OC+ participants did not differ from OC- participants on how much (un)certainty they experienced overall, *F* (1,104) < 1, *p* = .48. There was also no interaction effect between group and condition; the increase in uncertainty in the absent trials was comparable for the two groups, *F* (1,104) < 1, *p* = .77.

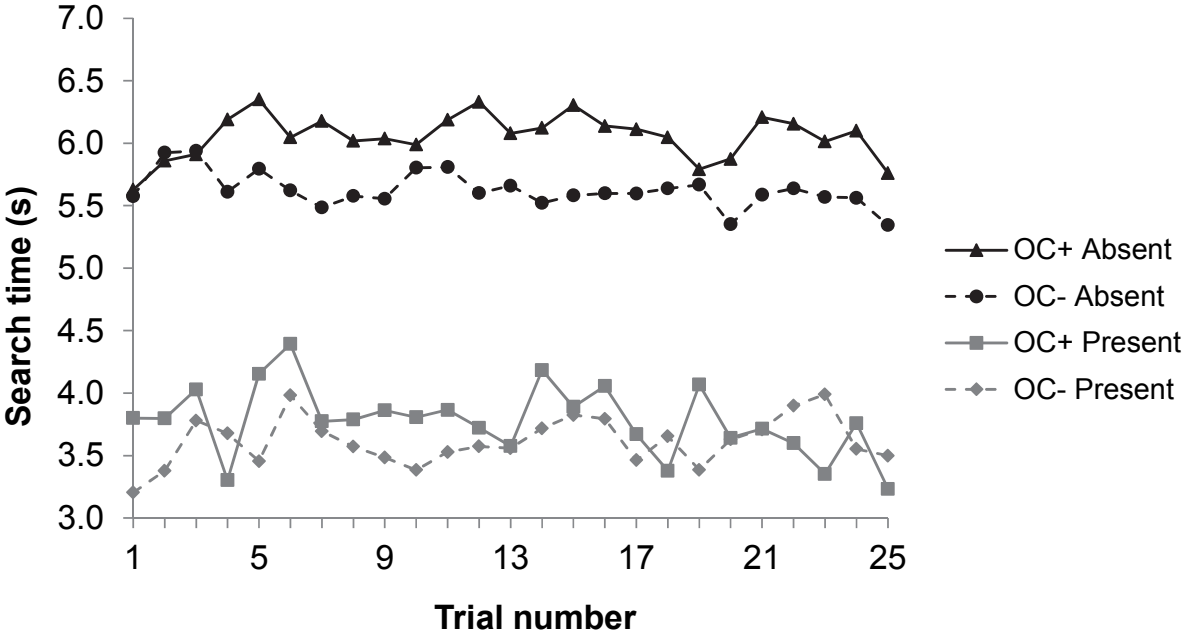

Figure 2. Mean search time (s) per trial in target-absent and -present trials for OC+ and OC- participants

Replication study

The final analyses of search time consisted of 109 participants, with 55 OC- participants and 54 OC+ participants. A two-way mixed analysis of variance (ANOVA) was used to compare the two groups on search time in 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 behaviour in the OC+ group). Results are presented in Figure 2, where average search time scores for each of the 25 target-present and target-absent trials are given by group.

Figure 2 indicates that participants searched longer in target-absent trials than in target-present trials. This was reflected in a main effect of condition on search time; both groups searched significantly longer in target-absent trials (*M* = 5.85, *SD* = 1.35) than in target-present trials (*M* = 3.71, *SD* = .79), *F* (1,107) = 826.82, *p* < .001, η_p^2 = .89. There was no main effect of group; overall, the OC- group did not differ

from the OC+ group in search time, F (1,107) = 1.75, p = .19. The crucial group (OC-/OC+) × condition (target-absent/target-present) interaction, however, was significant, F (1,107) = 2.82, p = .048 (one-tailed), η_p^2 = .03. Pairwise comparisons indicated that in target-present trials, the OC- group (M = 3.64, SD = .74) did not differ from the OC+ group (M = 3.78, SD = .84) on search time, t (107) < 1, p = .37, whereas in target-absent trials the OC+ group (M = 6.05, SD = 1.38) showed a trend in searching significantly longer than the OC- group (M = 5.66, SD = 1.30), t (107) = 1.51, p = .068 (one-tailed), d = .29.[2]

Even though there was a strong positive correlation between search time and number of fixations on target-present trials, r_s (106) = .91, p < .001, and target-absent trials r_s (106) = .91, p < .001, the ANOVA pattern for the number of fixations slightly differed. Again, a main effect of condition was found; participants used significantly more fixations in target-absent (M = 23.06, SD = 4.93) than target-present trials (M = 13.95, SD = 2.95), F (1,104) = 941.08, p < .001, η_p^2 = .90. There was no main effect of group; overall, the OC- group did not differ from the OC+ group in number of fixations, F (1,104) < 1, p = .51. However, only a non-significant trend was found for the group (OC-/OC+) × condition (target-absent/target-present) interaction, F (1,104) = 1.75, p = .09 (one-tailed), η_p^2 = .02. Thus, although the data pattern of the number of fixations seemed similar with OC+ participants using more fixations (M = 23.50, SD = 4.85) than OC- participants (M = 22.62, SD = 5.02) in the target-absent trials, this was not significant, t (104) < 1, p = .18 (one-tailed).

Finally, there were no differences in the number of errors made during the task between the OC- group (M = 4.87, SD = 2.51) and the OC+ group (M = 4.02, SD = 3.05), t (107) = 1.60, p = .11.

Intolerance of Uncertainty

OC+ participants scored significantly higher on IU (M = 74.74, SD = 11.66) than OC- participants (M = 60.40, SD = 13.67), t (107) = 5.89, p < .001, which may explain (part of) the differences between the groups on search time. To test this, the total IU score was added to the analysis. When conducting an ANCOVA on search time with IU as covariate, the crucial group (OC-/OC+) × condition (target-

[2] The main results (pattern of significant and non-significant results) on both search time and number of fixations did not differ when all participants were included in the analyses and when outliers were not transformed.

absent/target-present) interaction changed from F (1,107) = 2.82, p = .048 (one-tailed), η_p^2 = .03, to F (1,106) = 1.83, p = .09 (one-tailed), η_p^2 = .02, but still showed a non-significant trend.

Correlational analysis

The final correlation analysis consisted of 104 participants. Because the assumptions of linearity and homoscedasticity were violated, Spearman correlation analysis was used to investigate the relation between OC tendencies, IU, and both search time and number of fixations in target-absent and target-present trials and the difference scores between these trials. There is some evidence that several IUS-27 items are either worry- or GAD-specific (Gentes & Ruscio, 2011), and that the structure of the 12-item two-factor version of the IUS (with subscales Prospective Anxiety (PA) and Inhibitory Anxiety (IA); Carleton, Norton, & Asmundson, 2007) provides a better fit with both student and clinical samples. Especially the Prospective Anxiety scale seems an important predictor of OC tendencies (McEvoy & Mahoney, 2011). Therefore, the relation with IU was examined using not only the total score of the IUS-27, but also the score on both subscales of the IUS-12, which were derived from the original questionnaire. Since our hypotheses were depicted towards a positive correlation between the variables, one-tailed testing was used.

Correlations are presented in Table 1. There were significant positive correlations between the OCI-R and both search time and number of fixations in the target-absent trials, but not target-present trials. Furthermore, when looking at the difference scores between the target-absent and target-present trials on both search time and fixations we found (marginally) significant positive correlations with the OCI-R. Thus, even though these correlations were small, it suggests that the more OC tendencies were present, the more checking behaviour people used in uncertain *relative to* certain situations. Additionally, we found a significant positive correlation between the OCI-R and all three IU measures. However, there were no significant correlations between these IU measures and search time, number of fixations and both difference scores.

Table 1

Correlations between OCI-R, IU scores, Search time and number of fixations in both target-absent and target present trials.

	OCI-R	IUS-27	IUS-12: PA	IUS-12: IA	Search time absent trials	Search time present trials	Search time *difference* absent-present	Fixations absent trials	Fixations present trials
IUS-27	.36*								
IUS-12: PA	.33*	.73*							
IUS-12: IA	.35*	.83*	.44*						
Search time absent trials	.17*	-.03	.01	-.04					
Search time present trials	.10	-.08	.00	-.10	.82*				
Search time *difference* absent-present	.14‡	.00	-.02	-.01	.84*	.44*			
Fixations absent trials	.19*	-.02	.00	.01	.91*	.72*	.80*		
Fixations present trials	.13	-.08	.00	-.07	.72*	.91*	.35*	.75*	
Fixations *difference* absent-present	.16†	.06	.00	.07	.77*	.39*	.89*	.86*	.36*

‡ = p=.07 (one-tailed)
† = p=.06 (one-tailed)
* = p<.05 (one-tailed)

As depicted in Table 1, there were also significant correlations that were not related to the research question. These are all strong, positive correlations between search time and number of fixations in the target-absent and target-present trials, and seem to reflect stable individual differences in response time, irrespective of the experimental condition.

Discussion

Participants with high or low OC tendencies performed a visual search task in which a target was present/absent in half of the trials, with target-absent trials arguably inducing more uncertainty than target-present trials. In target-present trials the groups did not differ in checking behavior. Crucially, in the target-absent trials, which resembled mildly uncertain situations, OC+ individuals checked longer than OC- individuals. These findings replicate those of Toffolo et al. (2013) and add to their robustness. However, while Toffolo et al. (2013) also found that the OC+ group made more eye fixations than the OC- group in target-absent but not target-present trials, this was not replicated. Although a similar interaction pattern was visible for the number of fixations in the present study, this was not statistically significant (showing a trend). The number of fixations might be a less sensitive measure of checking behavior than search time in this visual search task, although highly correlated. Toffolo et al. (2013) found a mean difference in search time of 600 ms in the target-absent trials with a corresponding mean difference in number of fixations of 2. In the present experiment OC+ and OC- participants had a lower, but still significant, mean difference in search time of 400 ms that corresponded with a difference in number of fixations of 1. An increase in the number of fixations is thus less pronounced and therefore seems harder to detect. Furthermore, although a difference of 400 ms seems small, and we only found a small effect size, we do think these results are relevant. The difference of 400 ms namely means that participants already showed an increase in checking behavior of seven percent when only exposed to *mildly* uncertain situations, as opposed to the more uncertain situations they experience in daily life to which they might respond with even more checking behavior. Moreover, as Abramowitz, Fabricant, Taylor, Deacon, McKay, and Storch (2014) have hypothesized that OC-related phenomena among non-clinical analogue samples are often milder variants of those observed among individuals with an actual OCD

diagnosis, one may expect the effect on search time to be even larger in a clinical sample. However, actual empirical research is needed to test this.

Additionally, it may seem reasonable to expect that the target-absent trials evoke more uncertainty then the target-present trials, but this was not assessed in the earlier study. The present findings strongly support this assumption: both groups experienced subjectively less certainty in target-absent than in target-present trials. However, inconsistent with what was expected, OC+ people did not experience less certainty than OC- participants in target-absent trials. It thus seemed that the increased checking response of OC+ people in the absent trials could not be explained by the experience of *more* uncertainty than OC- people. However, in line with previous research (Abramowitz et al, 2006; Tolin et al, 2003), we found that the OC+ group showed a much higher IU than the OC- group. Interestingly, however, this did not seem to explain the findings. That is, when IU was entered as a covariate, the interaction between group (OC+/OC-) and condition (target-absent/target-present) on search time was no longer significant, but still showed a trend. Furthermore, the correlational analysis revealed that even though there was a medium, positive relation between OC tendencies and the degree of IU, the latter variable was not related to checking behavior in either certain or uncertain situations. It therefore seemed that *heightened intolerance* of the experienced uncertainty in the absent-trials by the OC+ group also could not explain why checking behavior was promoted in the OC+ group. However, possibly the OC+ group did find the same level of uncertainty more distressing than the OC- group (Tolin, Abramowitz, Brigidi, & Foa, 2003). Future research could therefore measure in vivo distress during the task to investigate this. Additionally, it could be interesting to examine Intolerance of Ambiguity (IA) in relation to OCD. IU and IA are both associated with the experience of discomfort and anxiety when one is confronted with uncertain situations, but IA refers exclusively to a static component embedded in the present. Individuals who are intolerant of ambiguity are unable to tolerate a *current* situation characterized by equivocal or ambiguous features (Grenier, Barrette, & Ladouceur, 2005), where IU refers to possible, unpredictable future events (Ladouceur et al., 2000). Until now, IA has hardly been used in research involving anxiety disorders. However, as this study indicates that people with subclinical OCD tend to respond differently to a present, mildly ambiguous situation, IA could possibly be a more plausible explanation for these findings.

As suggested by Toffolo et al. (2013), an alternative explanation can be derived from the work of Lazarov and colleagues (Lazarov, Dar, Liberman, & Oded, 2012a, 2012b, and Lazarov, Dar, Oded, & Liberman, 2010). They showed that people with high OC tendencies seem to lack a subjective conviction regarding internal states, and therefore have to rely on external proxies, such as rules and procedures. Following their line of reasoning, it seems plausible that the target-absent trials provoked checking in the OC+ group, because it forced them to rely on internal states (e.g., "Did I properly search through the field?", "Did I carefully attend to all squares?"), and not because the trials triggered some general uncertainty. On the contrary, the fact that the OC+ and OC- group did not differ on uncertainty levels in the target-absent trials may also have been caused by the formulation of the questions about (un)certainty. Specifically, these questions stated "how certain did you feel *when responding* the target was (not) present*"*. The question was thus depicted at ones certainty while *responding*, not while *searchin*g for the target. While OC+ people were searching in the target-absent trials, they may have felt more uncertain and therefore searched longer before responding (as shown by the results). However, they might have searched until they reached certainty about absence of the target, and therefore may have felt equally (un)certain as OC- people *when responding* the target was absent. Thus, to get a better insight in feelings of uncertainty during the trials, the questions may be stated differently.

Finally, when investigating the whole range of OC tendencies we demonstrated a positive relation between OC tendencies and checking behavior. The more OC tendencies people displayed, the longer they checked and the more eye fixations they made in uncertain but not certain situations. Importantly, these findings show that the difference in checking behavior between certain and uncertain situations is not only present when focusing on extreme groups, but occurs over the entire range of OC tendencies. However, since the observed correlations were small, only little variance of checking behavior was explained. Future studies could therefore also use other statistical methods (e.g., multi-level modelling) to examine checking behaviour and OC symptoms continuously over repeated trials.

Thus, while previous research showed that patients with OCD in general perform more checking behavior than healthy controls (Jaafari et al, 2011; Kim, Roh, Kim, & Cha, 2012), and that uncertainty induces greater *urges* to check (Alcolado & Radomsky, 2011), the present study combined these findings. It showed that yet mild

uncertainty, unrelated to obsessions, promotes actual checking behavior in OC+ but not OC- individuals. Hence, when a normal doubt occurs ("did I lock the door this morning") OC+ people may respond with more checking behavior than others. When this checking behavior has a perseverative nature, this will have the paradoxical effect of reinforcing uncertainty (e.g., van den Hout & Kindt, 2003a, 2004). Subsequently, people may get into a vicious circle of increased uncertainty and checking behavior, which eventually may culminate in clinical OCD. What remains unclear, however, is whether repeated checking to the same doubt, will further increase feelings of uncertainty every time. Future research, should therefore investigate whether people indeed get into this vicious circle by making people respond to the same doubt with repeated checking multiple times and measuring levels of uncertainty.

By replicating the findings of Toffolo et al. (2013) the eye-tracking paradigm has proven to be valid for investigating checking behavior in both certain and uncertain situations. It adds to earlier methods, such as the gas stove task developed by van den Hout and Kindt (2003a), by measuring actual behavior instead of using self-report measures. Additionally, it adds to the behavior task developed by Rotge et al. (2008) by dividing the task in a certain and uncertain situation. However the present study is limited by including healthy subjects. Therefore, a next step should be to investigate how actual patients with OCD will respond to the task. Given that there are already replicable differences between OC+ and OC- individuals and given that OC tendencies in clinical OCD are higher than in non-clinical OC+, it can reasonably be assumed that patient/control differences on the present task will be at least as large if not larger. Thus, it will be interesting to investigate whether patients with OCD will experience more uncertainty in the absent trials than healthy controls. Subsequently, to study the specificity of the effect for the realm of OCD, non OCD anxiety patients should also be investigated using this task.

In sum, the present study not only showed that OC+ people use more checking behavior than OC- people in target-absent but not target-present trials, but moreover, that the more OC tendencies one displays, the more one uses checking behavior in target-absent trials. This difference between trials seemed to be caused by the experience of less certainty in the target-absent than in target-present trials. However, no differences between OC+ and OC- groups were found in experienced certainty within the absent-trials. Finally, we observed that even though the OC+

group displayed higher IU, this does not explain why they use more checking behavior than the OC- group in the uncertain but not certain situations. All in all, the eye-tracking paradigm seems promising for future research to further investigate checking behavior in OCD.

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Chapter 4

Patients with obsessive-compulsive disorder check excessively in response to mild uncertainty

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Abstract

Patients with obsessive-compulsive disorder (OCD) not only respond to obsessions with perseverative checking, but also engage in more general checking, irrespectively of their obsessive concerns. This study investigated whether general checking is specific to OCD and more distinct when 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. Results showed that in target-present and target-absent trials patients with OCD searched longer and made more fixations than healthy and anxiety controls, but this difference was larger in target-absent trials. 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.

Introduction

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, 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 and colleagues (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 over-active 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. Moreover, 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 perform a visual search task, in which they have to indicate whether a target is “present” or “absent” (see Figure 1). The target-present trials are unambiguous; the response “present” is based on straightforward inspection of the target, which therefore reflect certain situations. Target-absent trials, however, are more ambiguous, because participants have to rely on not having overlooked the target. These trials are therefore held to induce mild uncertainty, and count 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 (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, *n* = 23), 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: van Groenestijn, Akkerhuis, Kupka, Schneider & Nolen, 1999; First, Spitzer, Gibbon & Williams, 1996). 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 being diagnosed with a psychotic disorder, current drug and/or alcohol abuse, using benzodiazepines on a regular basis, vision problems or non-fluency in Dutch, and healthy controls were excluded when they were diagnosed with any current psychiatric disorder.

All groups were matched on age, gender and education level. A three 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, because of a current eating disorder, current OCD-symptoms, drug abuse the day before participation, or not following 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

Clinical assessments. The self-rated version of the Yale-Brown Obsessive Compulsive Scale (Y-BOCS; Goodman et al., 1989) was used to assess OCD symptom severity in patients with OCD and the OCI-R (Foa et al., 2002) was administered to measure OC-tendencies in the control groups. The Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988), Beck Depression Inventory-II (BDI-II; Beck, Steer, Brown, 1996), and Intolerance of Uncertainty Scale (IUS; Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994) were administered to assess symptoms of anxiety, depression, and intolerance of uncertainty.

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: “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).

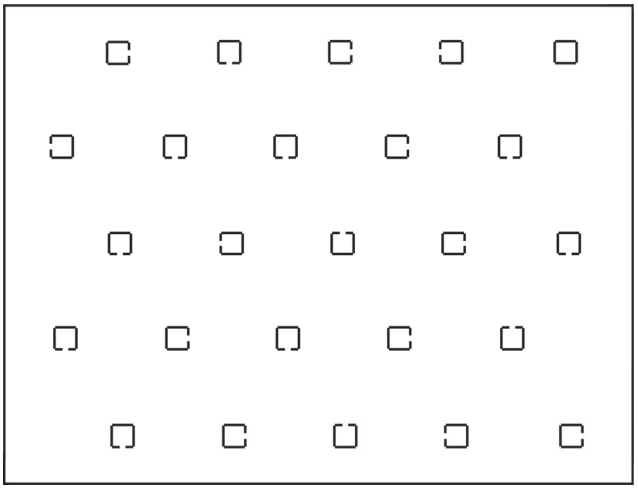

Figure 1. Example of a search display; the target is the closed symbol (upper right corner; could be placed in all locations on the display). In the experiment, the elements were white on a dark gray background.

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 58ms (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, participants filled out the questionnaires (Y-BOCS/OCI-R, BAI, BDI-II, and IUS), and were debriefed and paid for their participation.

Results

Table 1

Participant characteristics divided per group. For age, and all clinical ratings Mean scores are reported with SDs between parentheses.

	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)

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 non-clinical 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, t (36.79) = 6.27, p < .001, BDI-II, t (47.16) = 4.84, p < .001, t (55) = 5.98, p <.001, and IUS, t (57) = 3.51, p = .001, t (55) = 4.92, p < .001. Finally, patients with anxiety disorders scored higher than patients with OCD on anxiety symptoms, t (55) = 2.15, p = .036, but did not differ on other self-report measures.

Data exclusion

For 15 participants (5 OCD, 2 anxiety controls, 8 healthy controls) the eye-tracker 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. 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. These values were changed to M + 3 SDs, according to the recommendations given in chapter 5, pp. 153 of Field (2009).

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, η_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.

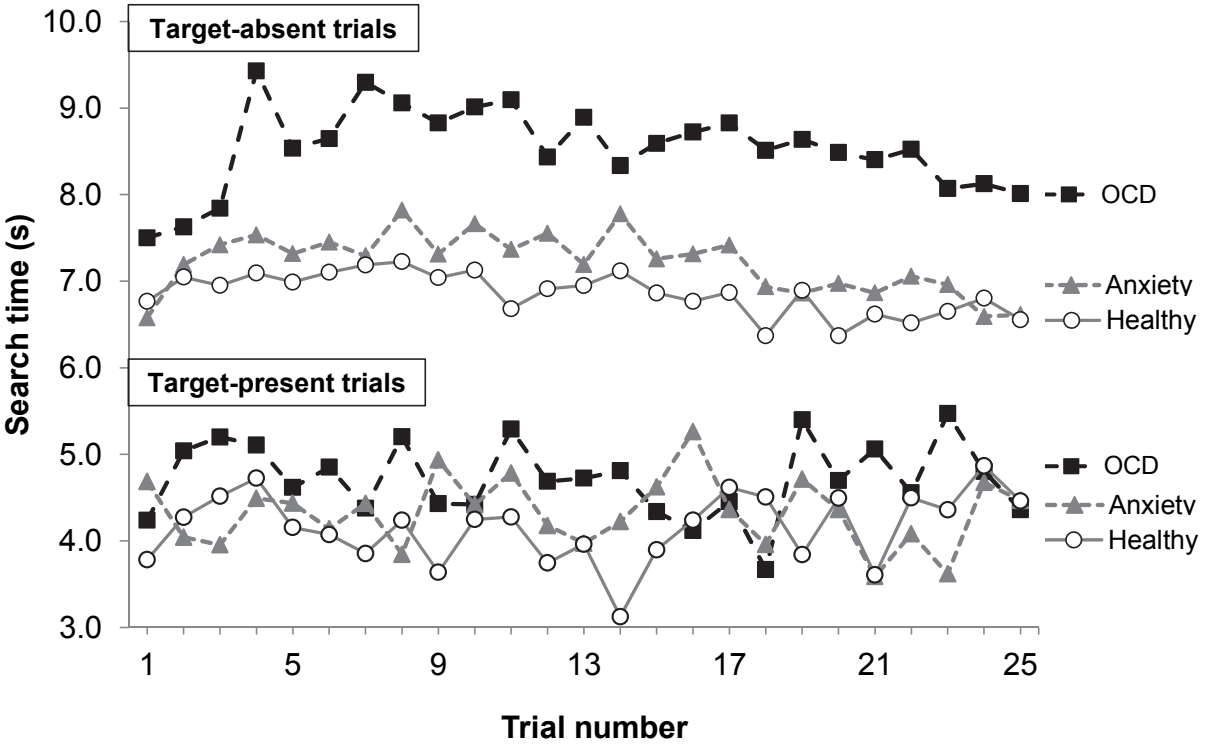

Figure 2. Mean search time (s) per trial in both target-present and target-absent trials for the patients with OCD (*n* = 31), anxiety controls (*n* = 26), and healthy controls (*n* = 31).

Main analyses

Results are graphically presented in Figure 2.[1] A mixed ANOVA compared the groups on search time (seconds) in target-present and target-absent trials. There were main effects of condition, F (1,85) = 304.63, p < .001, η_p^2 = .78, and group, F (2,85) = 4.15, p = .019, η_p^2 = .09. The crucial group × condition interaction was also significant, F (2,85) = 4.00, p = .022 , η_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. In target present trials, patients with OCD (M = 4.72, SD = 1.38) also searched (marginally) significantly longer than healthy (M = 4.16, SD = .95) and anxiety controls (M = 4.33, SD = .90) combined, p = .056, d = .43, but there was no difference between the control groups in both target-

[1] 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. There were no non-responses in the anxiety or healthy control groups.

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, η^2 = .08, 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.

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. 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. 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, 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, η^2 = .06, 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 situations that are unrelated to their obsessive concerns, and whether this is more distinct when 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. Crucially, in target-absent trials, in which all groups experienced less certainty than in target-present trials, the differences between the groups were larger. 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, irrespective of experienced obsessions or intolerance of uncertainty, is more distinct under conditions of (mild) uncertainty. Additionally, there were no differences in the number of errors made during the task. Thus, 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 for 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.

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 possible limitation of the present study is the heterogeneous OCD group; patients with OCD were included, regardless of their symptom dimensions. Because of the relatively small sample size, the effects could not be analyzed for the separate dimensions within this sample. Therefore, it is unknown 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. 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.

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. Furthermore, we believe it is the first study to show that the tendency of patients with OCD to use more checking behavior in general is more distinct under conditions of mild 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.

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Chapter 5

Check, check, double check: Investigating memory deterioration within multiple sessions of repeated checking

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Abstract

Extensive research has shown that repeated checking causes memory distrust. Therefore, it has been suggested that people may subsequently get into a vicious cycle of decreased memory confidence and increased checking behavior, which may play a role in the maintenance and development of OCD. This study investigated in two experiments how repeated checking influences memory distrust over multiple checking episodes. In experiment 1, 70 healthy undergraduates performed two sessions of a virtual checking task with a 30 minute break in between. In experiment 2, 41 healthy undergraduates performed two sessions of the checking task on a real kitchen stove and sink. Results of experiment 1 showed that memory confidence for checking the stove decreased after repeated checking in session 1, and remained low in session 2, but memory vividness and detail decreased in both sessions and recovered in between. In experiment 2, all three meta-memory ratings for checking the stove decreased after repeated checking in both sessions, but recovered in between. Although replication is needed, the findings of experiment 2 seem more informative. Therefore, repeated checking may decrease memory vividness and detail (and, in turn, presumably also decrease memory confidence) each time this counterproductive strategy is used, which may have implications for using this paradigm as a behavioral experiment in cognitive-behavioral therapy.

Introduction

Obsessive-compulsive disorder (OCD) is characterized by intrusive, frightening thoughts (obsessions; e.g., “did I stab my partner while doing the dishes?”) to which patients respond with repetitive behavior (compulsions; e.g., checking the knives and scissors in the house or calling their partner to ensure he or she is alive) to suppress these unwanted thoughts and prevent misfortunes from happening (American Psychiatric Association, 2013). Repeated checking is one of the most common compulsions in OCD (Ruscio, Stein, Chiu, Kessler, 2010), and these compulsions often constitute the major problem in the disorder (Rachman, 2002).

To explain why and when checking behavior becomes compulsive, Rachman (2002) proposed a self-perpetuating mechanism. He hypothesized that the interaction between an increased sense of responsibility, the perceived probability of harm and the anticipated seriousness of harm makes people engage in preventative checking behavior. However, because patients feel they can never be completely sure that a perceived threat has been adequately removed and because checking behavior may paradoxically inflate feelings of responsibility and memory uncertainty, this behavior will persist.

The idea that repeated checking is a counterproductive strategy that actually increases memory uncertainty has been investigated extensively over the past decade (e.g., Ashbaugh & Radomsky, 2007; Boschen & Vuksanovic, 2007; Coles, Radomsky, & Horng, 2006; Dek, van den Hout, Giele & Engelhard, 2010; Dek, van den Hout, Engelhard, Giele, & Cath, 2015; Linkovski, Kalanthroff, Henik, & Anholt, 2013; Radomsky & Alcolado, 2010; Radomsky, Dugas, Alcolado & Lavoie, 2014; Radomsky, Gilchrist, & Dussault, 2006; Van den Hout & Kindt, 2003a, 2004). In these studies, patients with OCD or healthy participants were asked to perform an OC-like checking task. Participants were instructed to turn on, turn off, and check a virtual or real life stove multiple times, and asked to rate their memory and meta-memory of their last check directly after the first and final checking trial. Results consistently indicated that after repeatedly checking the same stimulus, memory confidence, vividness and detail of the last check decreased remarkably. Interestingly, however, memory accuracy generally remained intact after repeated checking; it was often not affected (e.g., Van den Hout & Kindt, 2003a, 2004; Dek et al., 2010; Linkovski et al., 2013), or displayed a small, likely unremarkable, decrease that was much smaller

than the decrease in meta-memory ratings (Boschen & Vuksanovic, 2007; Coles et al., 2006; Radomsky, et al., 2006; Radomsky & Alcolado, 2010; Radomsky et al., 2014). Thus, although checking is intended to increase certainty, it ironically decreases it. In turn, decreased memory confidence may promote continued and/or renewed checking, which may lead to *even less* memory confidence, and so on (Alcolado & Radomsky, 2011; Radomsky et al., 2006). It therefore has been hypothesized that people may get into a vicious cycle of decreased confidence and increased checking behavior, which may play a role in the maintenance and development of OCD (Nedeljkovic & Kyrios, 2007).

Recent research showed that patients with OCD generally already tend to be more inclined to use checking behavior than people with no OC tendencies, independently of their obsessions. Jaafari et al. (2013) showed, for instance, that patients with OCD perform more checking behavior than healthy controls in a basic image-comparison task (comparing two images that were projected simultaneously and indicating whether they were identical or not). More specifically, OCD checkers were found to use more checking behavior in a virtual-reality task in which they could freely check multiple items in a virtual house (Kim, Roh, Kim, Cha, Rosenthal, & Kim, 2012), and in a delayed matching to samples task (comparing two images that were projected with a delay in between and indicating whether they were identical or not; Clair et al., 2013), compared with OCD non-checkers and healthy controls. Additionally, two recent studies indicated that people who are vulnerable for the development of OCD (people with high OC tendencies) responded with more checking behavior to mildly uncertain situations, as opposed to people with low OC tendencies (Toffolo, van den Hout, Hooge, Engelhard, & Cath, 2013; Toffolo, van den Hout, Engelhard, Hooge, & Cath, 2014). Therefore, even though it is still unknown what comes first (the tendency to use more checking behavior in general or OCD), it seems plausible that when people who are vulnerable for OCD in general use more checking, this may have the same paradoxical effect on memory confidence. This may subsequently lead to the vicious cycle of increased checking behavior and memory distrust, eventually contributing to the development of new OC symptoms.

When investigating this vicious cycle, it became clear that memory confidence reliably declines over the course of one checking episode (e.g., Van den Hout & Kindt, 2003a, 2003b, 2004; Radomsky, et al., 2006). But what is the time course of this decreased confidence? Does checking induced memory distrust disappear once

the checking episode is terminated? Or does distrust remain and promote renewed checking behavior, which further decreases memory confidence over time? Since those struggling with compulsive checking problems in OCD often repeatedly check the same objects, it is important to investigate whether memory confidence further deteriorates after multiple series/bouts of repeated checking. Therefore, the present study investigated this by conducting two experiments that used a modified version of the original OC-like checking task (van den Hout & Kindt, 2003a), similar to the one used by Boschen and Vuksanovic (2007). In each experiment, participants performed two bouts of the checking task with a 30 minute break in between. It was expected that during the first session of repeated checking, memory confidence, vividness and detail of checking the stove (relevant measures in experiment 1 and 2) would decrease; and that these lower levels of memory confidence, vividness and detail would persist and continue to decrease during the second checking session of the stove. No effects were expected during either of the two checking sessions for memory confidence, vividness, or detail of checking lights (experiment 1; irrelevant measure) or a sink (experiment 2; irrelevant measure). Finally, memory accuracy for checking the stove and the lights/sink was not expected to be affected during the task, or only show a very small decrease.

Experiment 1

In experiment 1, healthy undergraduates completed a modified version of the *virtual* gas stove task (van den Hout & Kindt, 2003a; Boschen & Vuksanovic, 2007), with two repeated checking sessions separated by a 30 minute break. In this within-subjects design all participants repeatedly checked the stove and had “relevant” (stove) and “irrelevant” (lights) pre- and post-tests in each checking session (see Procedure). Because of the irrelevant pre- and post-tests we could control for possible findings to be attributable to the passage of time and did not need to include a separate control group that engaged in irrelevant checking.

For half of the participants memory and meta-memory measures for checking of both the stove and lights were assessed before (pre-test) and after (post-test) the two checking series of the gas rings. However, to rule out possible outcome expectancy effects of the measures in the first session (people’s meta-memory ratings noticeably going down, which could influence people’s belief about the nature of the experiment) on the measures in the second session (people may anticipate

second memory assessments before and after repeated checking), the other half of the participants did not receive a post-test after repeated checking in the first session.

Method

Participants

Seventy undergraduate students (age, *M* = 21.81, *SD* = 2.84; 47 females) from Utrecht University and University of Applied Sciences Utrecht participated in this experiment and were given a small remuneration or course credits for their participation. Participants reported to be in good health and had a mean score of 15.71 (*SD* = 9.18) on OC tendencies, measured with the Obsessive-Compulsive Inventory Revised (OCI-R; Foa et al., 2002). This closely resembled average OC tendencies present in other non-clinical samples as found in a meta-analysis of 55 studies (weighted *M* = 14.9, *SD* = 11.3; see Appendix A of Abramowitz, Fabricant, Taylor, Deacon, McKay, & Storch, 2014).

Material

Virtual checking task. The virtual checking task (cf. Van den Hout & Kindt, 2003a) assesses the effects of repeated checking on memory and meta-memory ratings and involves operating gas rings on a virtual stove and operating dimmer switches on a set of virtual light bulbs. The present task was modified from its original form for the purposes of this experiment (see “Procedure” for details).

Memory and meta-memory ratings. Memory accuracy, confidence, vividness and detail were measured using a questionnaire developed in previous research on repeated checking (van den Hout & Kindt, 2003, 2004), which has been used extensively since (e.g., Radomsky et al., 2006; Coles et al., 2006; Boschen & Vuksanovic, 2007; Radomsy & Alcolado, 2010). The first item contains a schematic picture displaying the six gas rings of the stove or the six light bulbs on which participants indicate which three rings/bulbs they checked on the last trial. Memory accuracy is recorded as *the number of correct respsonses* (ranging from 0-3). Thereafter, memory confidence (“How confident are you that your answer [to the memory accuracy question] above is correct”), vividness (“How vivid is your recollection of your last check of the stove/lights”) and level of detail (“How detailed is your recollection of your last check of the stove/lights”) is assessed with three 100mm Visual Analogue Scales ranging from “not at all” to “very much”.

Obsessive-Compulsive Inventory-Revised (OCI-R). The Dutch translation (Cordova-Middelbrink, Dek, & Engelbarts, 2007) of the OCI-R (Foa et al., 2002) was used. The OCI-R is an 18-item self-report measure assessing participants' obsessive-compulsive tendencies. Each item is measured on a 5-point Likert scale (e.g., *"I check things more often than needed",* 0 = not at all, 4 = extremely). The OCI-R has good validity, test-retest reliability and internal consistency in clinical (Foa et al, 2002) and non-clinical populations (Hajack, Huppert, Simons, & Foa, 2004).

Procedure

Participants were tested individually in a soundproof laboratory room. After receiving both verbal and written instructions about the task they signed informed consent. The experiment consisted of two sessions of the virtual gas stove task separated by a 30 minute break. Participants were randomly assigned to one of two groups. Participants in the first group rated their memory and meta-memory at four time points: they filled out a pre- and post-test in both sessions of the checking task (see below). Participants in the second group rated their memory and meta-memory at three time points: they filled out only a pre-test in the first session and both a pre- and post-test in the second session.

The task started with a training phase, in which participants were trained to operate the virtual stove and lights using the computer mouse. The stove was operated by turning a rotary dial at the front of the stove on or off, and the lights could be turned on and off by using a sliding bar on the screen. Then a pre-test trial was conducted for both the stovetop and the lights (counterbalanced). First, participants were shown a schematic diagram of the six gas rings or the six light bulbs on which 3 stimuli were indicated that had to be turned on. Then they were asked to turn off the three gas rings or light bulbs that were on and finally to check that they were indeed turned off. After each trial (with the stove or the lights) participants completed the memory and meta-memory ratings.

Next, participants completed 14 checking trials. Each trial consisted of a random selection of three gas rings that had to be turned on, turned off and then checked that all rings were indeed off. Finally, participants in the first group completed the post-test trial of both the gas rings (first) and light bulbs (second), which were procedurally identical to the pre-test.

Following the first session, the experimenter entered the test room and told the participants that they were part of the control group, and therefore could just read a magazine or do some work for themselves during this phase. This false information about "the control group" was given so that participants would not be suspicious of the break time and guess the hypothesis in the experiment. After 30 minutes, participants were asked to complete a second session of the checking task. This session was similar to the first session, only without the training phase and including a post-test trial for both groups.

Finally, participants filled out the OCI-R and were debriefed and paid for their participation.

Results

Data exclusion

Participants who scored 0 on memory accuracy on the pre-test ratings were excluded from the analyses (n = 5) to ensure that following just one trial, all participants had sufficient memory to recall their actions. These participants reported to have checked either the exact opposite gas rings, to have only checked two (wrong) gas rings or all six gas rings, and reported to be uncertain of their answer to the accuracy question (certainty score < 50). It therefore seemed they had not been paying attention or had not understood the instructions. Additionally, three participants were excluded because of incomplete data, one participant was excluded because he had previously participated in a comparable checking experiment, and one participant reported being unable to concentrate during the experiment. The final analyses therefore consisted of 60 participants. Outliers on any of the outcome measures (n = 12) were transformed to M ± 2.5 SDs.

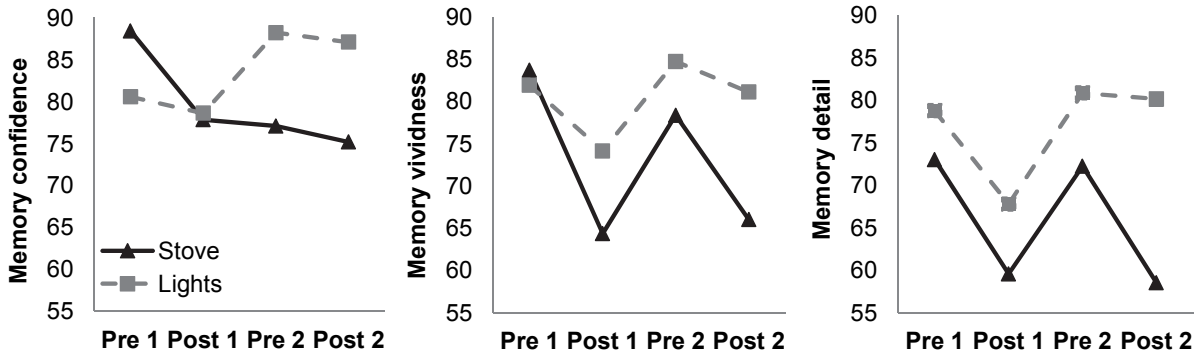

Figure 1. Meta-memory ratings of checking the stove and the lights pre- and post-repeated checking of the stove in both sessions of experiment 1 (n = 30).

Main hypotheses

To investigate changes of memory confidence, vividness and detail within and between the two checking sessions, we first analyzed only the results of group 1 (n = 30) whose memory and meta-memory was assessed at all four time point (see Figure 1).

Memory confidence

A 4×2 repeated measures Analysis of Variance (ANOVA) on memory confidence was conducted with time (first pre-test / first post-test / second pre-test / second post-test) and target (stove / lights) as independent variables. Data are graphically represented in Figure 1. There were no significant main effects of time, $F < 1$, $p = .50$ or target, $F(1,29) = 2.05$, $p = .16$. Crucially, the time × target interaction was significant, $F(3,87) = 3.36$, $p = .02$, $\eta_p^2 = .10$. Planned comparisons showed that deterioration of memory confidence was specific for checking the stove. In the first session, there was a trend for a decrease in memory confidence from pre- (M = 88.40, SD = 15.56) to post-test (M = 77.83, SD = 22.99) when checking the stove, $t(29) = 2.01$, $p = .05$, $d = .54$. There was no change in memory confidence from the post-test in the first session to the pre-test in the second session, $t < 1$, $p = .91$. However, the pre-test in the second session (M = 77.07, SD = 26.77) still showed a significant decrease in memory confidence compared to the first pre-test, $t(29) = 2.27$, $p = .03$, $d = .52$. The further decrease in the second session from pre- to post-test (M = 75.17, SD = 28.66) was not significant, $t < 1$, $p = .75$. When checking the lights, memory confidence did not change or showed a trend for increasing, ps > .08.

Memory vividness and detail

Changes over time in memory vividness and detail in group 1 were analyzed with two 4×2 repeated measures ANOVAs with time (first pre-test / first post-test / second pre-test / second post-test) and target (stove / lights) as independent variables. For memory vividness and detail, respectively, there were significant main effects of time, $F(3,87) = 4.24$, $p = .002$, $\eta_p^2 = .15$; $F(3,87) = 4.55$, $p = .005$, $\eta_p^2 = .14$, and target, $F(1,29) = 10.00$, $p = .004$, $\eta_p^2 = .26$; $F(1,29) = 20.05$, $p < .001$, $\eta_p^2 = .41$, and the crucial time × target interactions were also (marginally) significant, $F(3,87) = 2.89$, $p = .04$, $\eta_p^2 = .09$; $F(3,87) = 2.63$, $p = .055$, $\eta_p^2 = .08$ (see Figure 1).

Planned comparisons showed a significant decrease in memory vividness when checking the stove from pre- (M = 83.70, SD = 15.53) to post-test (M = 64.37, SD = 27.74) in the first session, t (29) = 3.85, p = .001, d = .86, which recovered at the pre-test of the second session (M = 78.37, SD = 22.26), t (29) = -2.44, p = .02, d = -.56. Thus, crucially, there was no difference between memory vividness at the pre-test of the first and second session, t (29) = 1.57, p = .13. Within the second session, however, memory vividness showed a marginally significant decrease from pre- to post-test (M = 66.03, SD = 30.24), t (29) = 2.00, p = .055, d = .46. When checking the lights, memory confidence did not change, ps > .14, or showed an increase from the post-test in the first session to the pre-test in the second session, t (29) = 2.17, p = .04, d = .51.

Deterioration of memory detail was similar in the first session for checking the stove and the lights. There was a significant decrease in memory detail from pre- (M = 73.03, SD = 25.71) to post-test (M = 59.57, SD = 29.3) in the first session when checking the stove, t (29) = 2.68, p = .01, d = .49, and a trend when checking the lights, t (29) = 2.01, p = .054, d = .44. However, there was a significant recovery of memory detail from the post-test in the first session to the pre-test in the second session when checking both the stove, t (29) = 2.23, p = .03, d = .44, and the lights, t (29) = 2.58, p = .02, d = .54. Therefore, when checking the stove, the pre-test in the second session (M = 72.27, SD = 28.24) did not show a significant difference compared with the first pre-test, t < 1, p = .87. In session two, there was again a significant decrease in memory detail from pre- to post-test (M = 58.53, SD = 31.71) when checking the stove, t (29) = 2.22, p = .04, d = .45, but not when checking the lights, t < 1, p = .87.

Memory accuracy

A 4×2 repeated measures ANOVA with time (first pre-test / first post-test / second pre-test / second post-test) and target (stove / lights) as independent variables was used to investigate changes over time in memory accuracy. There was no main effect of target, F (1,29) = 1.20, p = .28, but memory accuracy did differ over time, F (3,87) = 5.48, p = .002, η_p^2 = .16. The interaction between time and target was also significant, F (3,87) = 3.49, p = .02, η_p^2 = .11. Planned comparisons showed that within the first session and between the first and second session, memory accuracy for checking the stove did not change ps $\geq$ .096. However, within the

second session, memory accuracy did show a small, but significant decrease from pre- (M = 3.00, SD = .00) to post-test (M = 2.77, SD = .57), t (29) = 2.25, p = .03, d = .57. Memory accuracy for checking the lights decreased significantly from the pre- (M = 2.80, SD = .41) to post-test (M = 2.47, SD = .73) within the first session, t (29) = 2.57, p = .02, d = .56, and increased again at the beginning of the second session (M = 3.00, SD = .00), t (29) = 4.00, p < .001, d = 1.03. It did not change during the second session, t (29) = 1.36, p = .18.

Secondary analyses

Secondly, the results of both groups together (n = 60) were analyzed to investigate whether the change differed between groups (with and without first post-test), and thus, whether the post-test rating in the first session influenced results in the second session.

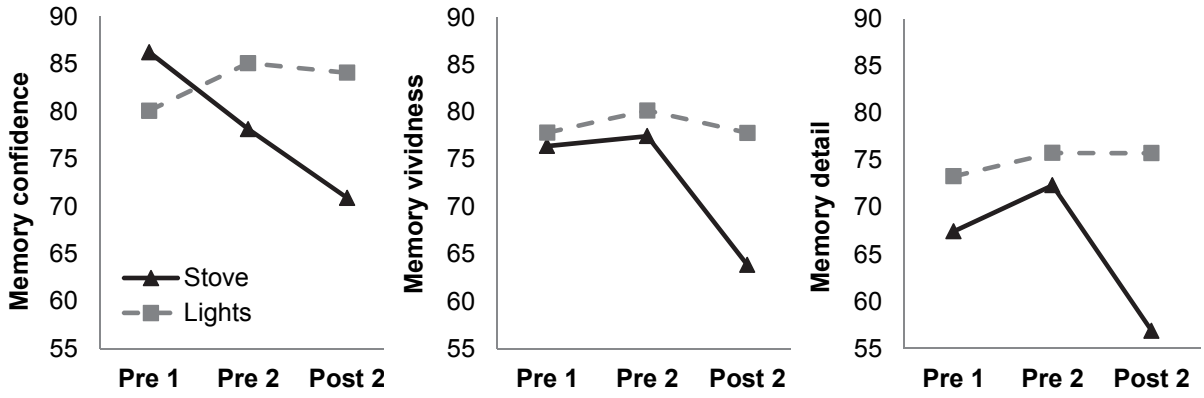

Figure 2. Meta-memory ratings of checking the stove and the lights at pre-test in session 1 and at pre- and post-test in session 2 of experiment 1 (n = 60).

Memory confidence

Changes over time in memory confidence were analyzed with a 3×2×2 mixed Analysis of Variance with time (first pre-test / second pre-test / second post-test) and target (stove / lights) as within factors and group (one / two) as between factor. There was no significant main effect of group, F (1,58) = 1.39, p = .24, nor significant interactions between group and time, F < 1, p = .62, group and target, F < 1, p = .85, and between group, time and target, F < 1, p = .48. This indicated that there were no differences between the two groups. Therefore, the results were not influenced by the post-test rating in the first session, and the pattern of significant and non-significant results of memory confidence was similar when including both groups.

Figure 2 suggests that repeated checking of the stove had a different effect over time on both targets. Indeed this was reflected in a significant time × target interaction, F (2,116) = 6.77, p = .002, η_p^2 = .10. Planned comparisons showed that deterioration of memory confidence was specific for checking the stove. Overall, there was a significant decrease in memory confidence between the first (M = 86.23, SD = 18.03) and the second (M = 78.12, SD = 24.68) pre-test when checking the stove, t (59) = 2.35, p = .02, d = .38, but no difference when checking the lights, t (59) = 1.36, p = .18. However, this did not decrease significantly further within the second session when checking the stove (second post-test M = 70.88, SD = 31.81), t (59) = 1.54, p = .13, or when checking the lights, t < 1, p = .77.

Memory vividness and detail

Changes over time in memory vividness and detail were analyzed with two 3×2×2 mixed Analysis of Variance with time (first pre-test / second pre-test / second post-test) and target (stove / lights) as within factors and group (one / two) as between factor. For memory vividness, the main effect of group was marginally significant, F (1,58) = 3.99, p = .05, but memory detail did not show a main effect of group, F (1,58) = 2.27, p = .14. There were no significant interactions between group and time, F < 1, p = .41; F < 1, p = .45, group and target, F < 1, p = .76; F (1,58) = 2.07, p = .16, or between group, time and target, F (2,116) = 1.42, p = .25; F < 1, p = .40, for both memory vividness and detail respectively. This indicated that the crucial interactions between target and time were not influenced by group (i.e., the post-test rating in the first session). The pattern of significant and non-significant results for memory vividness and detail were similar when including both groups.

Again, the crucial time × target interaction was significant for both memory vividness, F (2,116) = 5.59, p = .005, η_p^2 = .09, and memory detail, F (2,116) = 9.09, p < .001, η_p^2 = .14 (see Figure 2). Planned comparisons showed no significant change in memory vividness and detail respectively between the first and second pre-test when checking the stove, t < 1, p = .71; t (59) = 1.58, p = .12, nor when checking the lights, t < 1, p = .38; t < 1, p = .32. However, within the second session there was a significant decrease in memory vividness and detail from pre- to post-test when checking the stove, t (59) = 3.51, p = .001, d = .53; t (59) = 3.99, p < .001, d = .54, but not when checking the lights, t < 1, p = .44; t < 1, p = .99.

Memory accuracy

Changes over time in memory accuracy were analyzed with a 3×2×2 mixed Analysis of Variance with time (first pre-test / second pre-test / second post-test) and target (stove / lights) as within factors and group (one / two) as between factor. There was a significant main effect of group, F (1,58) = 8.35, p = .005, η_p^2 = .13 and a significant interaction between group and target, F (1,58) = 6.52, p = .01, η_p^2 = .10. However, although the groups did differ on their accuracy ratings overall and for the separate targets, they did not differ over time, F < 1, p = .57, and, most importantly, the time × target interaction was not influenced by group, F < 1, p = .47.

Interestingly, the crucial time × target interaction was not significant when both groups were included, F < 1, p = .77, indicating that memory accuracy did not change over time or differ between targets (see Table 1).

Table 1

Memory accuracy ratings (M number of items correct; SD between brackets) of checking the stove and lights at pre-test in session 1 and at pre- and post-test in session 2 for all participants in experiment 1.

Target	Session 1	Session 2	
	Pre-test	Pre-test	Post-test
Stove	2.77 (.56)	2.97 (.18)	2.75 (.57)
Lights	2.72 (.45)	2.83 (.42)	2.68 (.65)

Discussion, Experiment 1

The pattern of significant and non-significant results did not differ between the two groups (with or without post-test in the first session), which indicated that results in group 1 were not an artifact of participants' beliefs about the nature of the experiment and anticipation of memory assessments during the second session. In general, repeatedly checking the stove did not influence (or increase) meta-memory ratings of checking the lights. However, only during the first session, memory detail for checking the lights (irrelevant measure) tended to be decreased. Because this has never been found in previous studies (Van den Hout & Kindt, 2003a, 2003b, 2004; Radomsky et al., 2006; Coles et al., 2006, Boschen & Vuksanovic, 2007; Dek et al., 2010; Radomsky & Alcolado, 2010; Linkovski et al., 2013; Radomsky et al.,

2014), or on any of the other meta-memory ratings of checking the lights, this may well be a chance or spurious finding. Memory accuracy ratings showed some mixed results. During the first session, memory accuracy for checking the lights showed a small, but significant decrease, which increased again and did not change during the second session. In contrast, memory accuracy for checking the stove did not change during the first session, but showed a very small, but significant decrease during the second session. These mixed findings on accuracy were surprising, but the decreases were very small and within expectations. It therefore seems that memory accuracy was not meaningfully altered by repeated checking.

In line with previous findings (e.g., Van den Hout & Kindt, 2003a, 2003b, 2004; Radomsky, et al., 2006), participants' memory confidence, vividness and detail of checking the stove decreased after repeatedly checking the stove during the first session. Subsequently, as expected, memory confidence remained low after the break, but surprisingly did not decrease further during the second session of repeated checking. The finding that memory confidence remained at a decreased level suggests a floor effect. These results may be taken as a first indication that after repeated checking, memory distrust not only emerges temporarily, but remains over time and may therefore promote renewed checking behavior (Alcolado & Radomsky, 2011; Radomsky et al., 2006; Nedeljkovic & Kyrios, 2007).

However, contrary to the hypotheses, memory vividness and detail recovered after the break to their initial level, before decreasing again during the second checking session. This suggests that the decreased memory confidence that remained over time could not be explained by decreased memory vividness and detail over time. Thus, although increased familiarity with the checked items during the first session may have rendered the recollections to become less vivid and detailed, which in turn led to deflated memory confidence directly after the session (van den Hout & Kindt, 2003a), this familiarity did not last after the 30 min. break. It therefore seems that although their memory of the first check was clear again at the beginning of the second session, participants did not trust their memory. However, further research is needed to better understand these mixed findings and investigate whether decreased memory vividness and detail really does not explain decrease memory confidence over multiple sessions of repeated checking.

Therefore, a second experiment was conducted, which was aimed at replicating and improving the first one. Although a strong design was used in the first

experiment, the ecological validity was relatively low: virtual stimuli were used on a computer screen in a laboratory cubicle. This potentially limits the generalizability of the findings, particularly because a key factor in checking behavior is responsibility and the probability of threat (Rachman, 2002). Thus, instead of using a virtual stove and lights, a fully operational kitchen stove and sink were used in the second experiment to increase responsibility and create a real perceived threat resulting from one's poor performance (Radomsky et al., 2006). This improved design is in line with Radomsky and Rachman (2004) who argued that "the meaning of the task is just as important as the meaning of the stimuli" (p. 145). Since no differences were found between the two groups in the first experiment, participants in experiment 2 all received a pre- and post-test in both sessions. Hypotheses in experiment 2 were the same as in experiment 1.

Experiment 2

Method

Participants

Forty-one undergraduate students (age, *M* = 25.42, *SD* = 8.41; 35 females) from Concordia University participated in exchange for course credits. Scores on both self-report measures of OCD were within the non-clinical range (OCI-R, *M* = 13.73, *SD* = 12.44; see experiment 1; VOCI, *M* = 41.40, *SD* = 38.97; which was similar to the average score (36.37, *SD* = 26.56) of a student sample in Thordarson, Radomsky, Rachman, Shafran, Sawchuk, & Hakstian, 2004).

Measures

Memory and meta-memory ratings. Participants filled out the same ratings of memory accuracy, confidence, vividness and detail as in experiment 1. However, to rate memory accuracy for checking the sink, participants were asked to mark three X's on a list of the six possible checking items (instead of a schematic picture) to indicate which three items they checked.

OCD tendencies. In addition to the OCI-R (Foa et al., 2004; see experiment 1), participants completed the Vancouver Obsessional Compulsive Inventory (VOCI; Thordarson, et al., 2004) to assess an extensive range of OCD symptoms, including compulsive checking. Each of the 55 items is measured on a 5-point Likert scale ranging from 0 = "not at all" through 4 = "very much" (e.g., "I feel compelled to check

letters over and over before mailing them"). The VOCI has excellent validity and test-retest reliability for clinical (Thordarson et al, 2004) and non-clinical populations (Radomsky Ouimet, Ashbaugh, Lavoie, Parrish, & O'Connor, 2006).

Procedure

Participants received both verbal and written instructions and signed informed consent in a testing room. Then they were taken to the laboratory's fully functional kitchen. Similar to experiment 1, the experiment consisted of two session of the checking task with a 30 minute break in between. Participants were randomly assigned to be first trained on how to operate the electric stove followed by the sink in a standardized and ritualized manner, or to be trained in reverse order. They were all trained to "open/turn-on", "close/turn-off" and "check" both the complete set of knobs on the stove and the knobs (hot/cold) and tap on the sink (in a counterbalanced order). During the task, all stove knobs were removed and participants were given one knob that they were asked to use for operating all burners. Consistent with previous work in a laboratory kitchen, the lights in the kitchen were adjusted so that indicator lights on the stove were not easily observable. This was done to ensure that there would be no visual cues that could inform participants that the burners were properly, fully turned off. The stove knobs were referred to by numbers one through six, and a diagram of the numbered stove knobs was posted on the wall above the stove to remind participants which number corresponded to which knob. The sink items were referred to as "hot" (to be turned either to half or full), "cold" (to be turned either to half or full), and "tap" (to be set either to the left or the right). Then, when all operations were clear, participants were left in the kitchen by themselves, and the experimenter communicated instruction over a walkie-talkie (two-way radio) from a separate testing room. After each instruction was followed ("open/turn-on", "close/turn-off" or "check"), participants informed the experimenter by saying "done/OK" through the walkie-talkie that they had completed the operations. During the task, the experimenter could monitor through a one-way observation window whether the participant indeed performed all the operations.

Then, to obtain baseline pre-repeated checking ratings, a pre-test trial for both the stove (relevant pre-test) and the sink (irrelevant pre-test) was conducted (counterbalanced; participants who were trained first on the stove performed the first

pre-test on the sink and vice versa). They were asked to “turn on”, then “turn off”, and finally to “check” a set of three knobs on the stove according to the procedures they had just learned. Then participants were guided out of the kitchen into the testing room where their memory and meta-memory ratings were assessed. Hereafter, participants returned to the kitchen and performed the pre-test trial for the sink (or the stove if their first pre-test checking trial was conducted on the sink). They were asked to “open”, “close” and “check” three sink elements, after which they were also asked to provide pre-test ratings regarding their memory of checking the sink (again in the testing room).

Next, participants were asked to complete 14 sets of additional trials on the stove. Each trial included instructions to “turn on”, “turn off”, and “check” a randomized set of three knobs (“e.g., “Please turn on knobs 1, 3, and 4” etc.). There were two randomized orderings of 14 sets of three knobs.

Then, participants performed a post-repeated checking trial on the stove, followed by a post-test assessment of their memory and meta-memory (relevant post-test; identical to the pre-test), and then a post-test trial of the sink, also followed by a post-test assessment (irrelevant post-test; identical to the pre-test).

After this first session, the experimenter entered the testing room and told the participant that he/she had now time to read a magazine or do some (home-)work for themselves until a second task started. Participants were told that the wait would last up to 30 minutes, and were asked to stay in the testing room for that period of time. Following the waiting period, participants completed the second session of the checking task, which was similar to the first session (without the training phase).

Finally, participants completed the VOCI and OCI-R (counterbalanced) before being debriefed from the experiment.

Results

Data exclusion

The final analyses consisted of 39 participants, because two participants were excluded. One was excluded, because of connection problems with the walkie-talkies and the other was unable to finish the task, because she became highly anxious of burning her hair during the task. Outliers on any of the outcome measures (n = 9) were transformed to M ± 2.5 SDs.

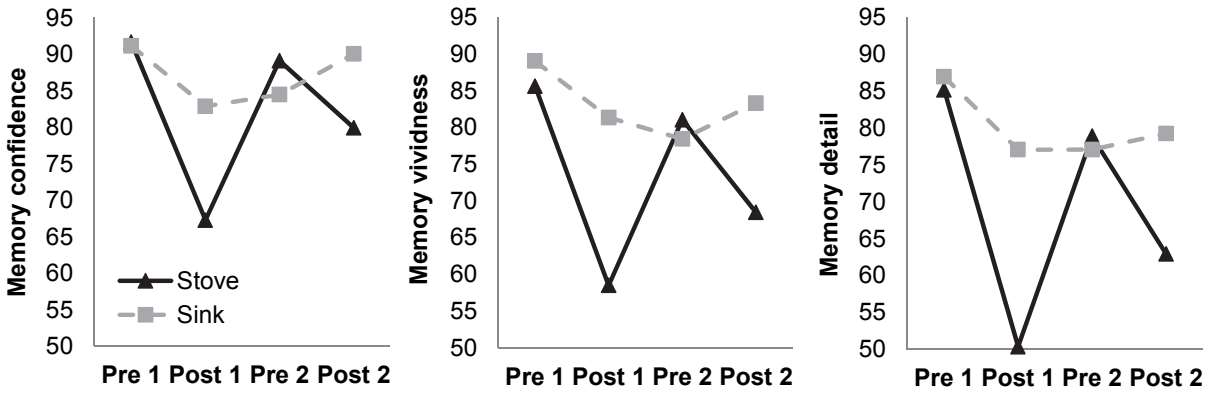

Figure 3. Meta-memory ratings of checking the stove and sink pre- and post-repeated checking of the stove in both sessions of experiment 2.

Memory confidence[1]

Findings are given in Figure 3. A 4×2 repeated measures ANOVA on memory confidence was conducted with time (first pre-test / first post-test / second pre-test / second post-test) and target (stove / sink) as independent variables. There were significant main effects of time, F (3,114) = 16.35, p < .001, η_p^2 = .30, and target, F (1,38) = 6.37, p = .016, η_p^2 = .14. The time × target interaction was also significant, F (3,114) = 7.23, p < .001, η_p^2 = .16. Planned comparisons showed that in both sessions, memory confidence for checking the stove significantly decreased from pre- to post-test; session 1 (pre-test, M = 91.66, SD = 12.19; post-test, M = 67.28, SD = 29.40) , t (38) = 5.50, p < .001, d = 1.08, session 2 (pre-test, M = 89.10, SD = 15.33; post-test, M = 79.92, SD = 24.90), t (38) = 2.31, p = .027, d = .44. However, in between sessions this decreased confidence recovered, t (38) = 5.17, p < .001, d = .93, resulting in a similar level of memory confidence at the beginning of session 2 as at the beginning of session 1, t (38) = 1.04, p = .31. Unexpectedly, memory confidence for checking the sink also showed a small but significant decrease from pre- (M = 91.15, SD = 11.26) to post-test (M = 82.87, SD = 16.23) in session 1, t (38)

[1] To investigate whether participants who scored higher on OC symptoms would recover less in between sessions, an explorative correlation analysis was conducted on OC symptoms and the recovery in memory confidence, vividness and detail from the post-test in session 1 to the pre-test in session 2. Pearson's correlation analysis showed that there were no significant correlations between the VOCI/OCI-R scores and the difference scores (post-test 1 to pre-test 2) on memory confidence, vividness and detail, -.13 < rs < .10, ps > .42.

= 3.37, p = .002, d = .59, but subsequently remained at the same level or showed a trend for increasing, ps > .076.

Memory vividness and detail

Two 4 (time) × 2 (target) repeated measures ANOVAs on memory vividness and detail showed similar result patterns as for memory confidence. For memory vividness and detail, respectively, there were main effects of time, F (3,114) = 16.20, p < .001, η_p^2 = .30; F (3,114) = 26.55, p < .001, η_p^2 = .41, and target, F (1,38) = 16.89, p < .001, η_p^2 = .31; F (1,38) = 25.89, p < .001, η_p^2 = .41, and significant interactions, F (3, 114) = 12.25, p < .001, η_p^2 = .24; F (3, 114) = 15.39, p < .001, η_p^2 = .29 (see Figure 3). As such, planned comparisons showed that memory vividness and detail of checking the stove decreased from pre- to post-test in both session 1, t (38) = 6.43, p < .001, d = 1.30; t (38) = 8.33, p < .001, d = 1.50, and session 2, t (38) = 3.70, p = .001, d = .48; t (38) = 4.82, p < .001, d = .57, which recovered in between the sessions, t (38) = 5.62, p < .001, d = .87; t (38) = 7.08, p < .001, d = 1.06. Pre-test ratings of memory vividness for checking the stove in session 1 and 2 did not differ, t (38) = 1.46, p = .152, and only showed a non-significant trend towards a decrease for memory detail, t (38) = 1.88, p = .068. Unexpectedly, memory vividness and detail of checking the sink also showed a small decrease from pre- to post-test in session 1, t (38) = 3.08, p = .004, d = .50; t (38) = 3.62, p = .001, d = .58, but subsequently remained at the same level, ps > .148.

Memory accuracy

Changes over time in memory accuracy were also analyzed with a 4 (time) × 2 (target) repeated measures ANOVA. There were no main effects of time, F (3,114) = 1.46, p = .23, or target, F (1,38) = 2.03, p = .16, and no interaction effect between time and target, F (3,114) = 1.00, p = .40. This showed that memory accuracy remained at the same level over time and did not differ between targets (Table 2).

Table 2

Memory accuracy ratings (M number of items correct; SD between brackets) of checking the stove and sink at pre- and post-test of both sessions in experiment 2.

Target	Session 1		Session 2	
	Pre-test	Post-test	Pre-test	Post-test
Stove	2.92 (.27)	2.87 (.41)	2.95 (.22)	2.95 (.22)
Sink	2.92 (.35)	2.79 (.62)	2.79 (.41)	2.95 (.22)

Discussion, Experiment 2

In this experiment the ecological validity of the checking task was improved by using a real stove and sink. As expected, results showed that in both sessions of the task repeated checking of the stove decreased memory confidence, vividness and detail of checking this item, while memory accuracy remained intact. However, after the checking series was terminated in session 1, meta-memory ratings recovered and were similar at the beginning of the second session as at the beginning of the first session. Since there was no reason to expect a different effect of repeated checking on meta-memory ratings in both sessions, this was not analyzed initially. However, when looking at Figure 3, the decrease in memory confidence, vividness and detail of checking the stove post repeated checking seems smaller in session 2 than in session 1. This would contradict current theory, because, if anything, one may expect the effect of repeated checking to be larger in session 2, because the checking behavior has likely become more automatic (Dek, van den Hout, Giele, & Engelhard, 2014; Dek et al., 2015). Therefore, we performed an additional analysis to investigate this, which showed that the data pattern over time for both targets actually did not differ between sessions.[2]

Meta-memory ratings of checking the sink, showed a much smaller, but also significant decrease from pre- to post repeated checking of the stove in session 1compared to the decrease in meta-memory ratings of checking the stove, after which it remained at the same level. The unexpected decrease in the first session (which was also not present in the second session) has not been found in previous

[2] A 2 (target) × 2 (session) × 2 (time) repeated measures MANOVA on memory confidence, vividness and detail showed that the crucial 3-way interaction was not significant, F (3,36) = 1.18, p = .33.

research, because the effect of repeated checking is domain-specific (e.g., Boschen & Vuksanovic, 2007; Radomsky & Alcolado, 2010; Radomsky et al., 2006; Radomsky et al., 2014; van den Hout & Kindt, 2003a, 2003b, 2004). When looking at the present findings, it seems that the decrease in meta-memory ratings of checking the sink was caused by unusual high ratings at pre-test. For instance, the pre-test meta-memory ratings of the irrelevant measure in experiment 1 were consistently around 80, compared with ratings around 90 in the present experiment. Furthermore, a recent study that also assessed meta-memory ratings of the sink in a similar checking task found pre-test ratings of memory confidence, vividness and detail of approximately 80 as well (Radomsky et al., 2014, experiment 2). Therefore, the fact that people were extremely confident at the beginning of the present experiment may well be a chance finding.

General Discussion

Two experiments were conducted to investigate how a vicious cycle of decreased memory confidence and repeated checking behavior would develop over time. The results were mixed. In experiment 1 it seemed that memory distrust remained after the first checking episode was terminated, but that this surprisingly could not be explained by decreased memory vividness and detail: these ratings recovered before decreasing again during a second checking bout. In experiment 2 all three meta-memory ratings of checking the stove were affected by repeated checking in the same way: repeated checking caused memory distrust in both sessions, but this recovered in between. Because of these mixed findings, one may argue that the data preclude definitive answers about the time course of memory deterioration over multiple sessions of repeated checking. Still, the findings of experiment 2 seem more informative. Van den Hout and Kindt (2003a) argue that repeated checking may increase familiarity of the checked stimuli, which in turn causes a decrease in vividness and detail of later recollections, because the checking behavior gradually becomes more automatic and requires less attentional control (see Dek et al., 2014 for data to substantiate this argument). Subsequently, when the memory is less clear and contains fewer details this leads to deflated confidence of these recollections. It is therefore theoretically difficult to explain why people did not trust their clear memory of checking the stove at the beginning of the second session in experiment 1, as only memory confidence remained over time and

memory vividness and detail recovered after the break. Hence, although replication is needed, we are inclined to lean more towards the results of experiment 2, which were also obtained by using a more ecologically valid paradigm that created a real perceived threat resulting from one's poor performance in the task.

Despite the mixed findings, this study does have some potentially important implications. It shows that repeated checking may cause memory distrust every time this counterproductive strategy is used. Possibly, the proposed vicious cycle of repeated checking and decreased memory confidence does not hold between checking episodes, but is mainly visible within a checking episode. After 2-5 checks, individuals already demonstrate memory deterioration of the checked stimuli (Coles, et al., 2006), which consequently only increases because they continue to check (Boschen & Vuksanovic, 2007). Thus, when patients with OCD start checking repeatedly, this may soon lead to memory distrust, which in turn promotes continued checking, paradoxically leading to even greater memory distrust within that episode. The checking episode is subsequently only terminated when it feels "just right" (Leckman, Walker, Goodman, Pauls, & Cohen, 1994) or by using arbitrary stop-rules, such as counting the repetitive acts until they have reached a certain number of checks (see van den Hout & Kindt, 2004). Once the checking episode has ended, memory distrust may fade. Therefore, memory deterioration may not persist over time, but simply be triggered by the natural tendency of patients with OCD to use more checking behavior in uncertain situations (Toffolo, et al., 2013, 2014). Additionally, previous research showed that both individuals with high checking tendencies as well as patients with OCD report lower memory confidence prior to repeated checking compared with low checkers or healthy subjects (Ashbaugh & Radomsky 2007; Boschen & Vuksanovic, 2007). Therefore, it may be that this initial distrust in memory is what motivates patients to begin to check repeatedly.

A possible limitation of the present study is that only healthy undergraduates were included. Previous research demonstrated that meta-memory ratings of patients with OCD were affected by repeated checking in the same way, and thus showed a similar decline in memory confidence as healthy controls (Boschen & Vuksanovic, 2007; Radomsky et al., 2014). However, observations in the present study may suggest that patients with OCD respond differently to multiple sessions of this paradigm than the healthy students did. During the second session of the present study, participants seemed to be less motivated and rushed through the checking

procedure and answering of the (meta-) memory questions. During debriefing, they often reported boredom during the second session, and that they did not pay as much attention to the questions and their answers, because they knew what was coming. For patients, however, a second session of repeated checking in this experiment may actually provoke more anxiety and increase threat perceptions, because the setting is more relevant to their disorder. Therefore, their behavior and attention during the second session may be different than displayed by healthy undergraduates, and possibly lead to larger meta-memory declines. An explorative analysis on OC symptoms and task effects in experiment 2 (see footnote 1) did not indicate that participants who scored higher on OC symptoms recovered less in between sessions. However, this may be due to the relatively low overall scores on OC symptoms in this sample compared with actual patients. Therefore, to gain a better understanding of the relationship between OCD and task effects, future research should include patients with OCD to investigate whether they respond differently to multiple sessions of this checking paradigm. In addition, future studies could further investigate the development of memory distrust over time by including more checking episodes and increasing the time between sessions. Possibly, when individuals are asked to engage in more repeated checking episodes for a longer period of time, the checking behavior may become so automatic that decreases in memory confidence may already be observed at the beginning of later checking episodes. Finally, to prevent the loss of interest during the second checking episode the incentive or feelings of responsibility could be increased. For instance, participants could be told that their checking behavior would be videotaped and that they would receive a bonus remuneration if they did not make any errors during the task. To increase feelings of responsibility the paradigm of Boschen and Vuksanovic (2007) could be used, in which participants are told that another participant (confederate) in an adjoining room would receive a “mild, non-harmful electric shock” each time the participant did not completely turn off the stove or made an error during the checking task.

As both experiments found robust indications that repeated checking may lead to decreased memory vividness and detail every time, this paradigm may be used as a behavioral experiment in Cognitive-Behavior Therapy for patients with checking compulsions (Radomsky, Shafran, Coughtrey, & Rachman, 2010). To educate patients about the paradoxical effects of checking, one may use a behavioral

experiment similar to the present paradigm to assess the contrasting effects on their perceived memory vividness and detail (and, in turn, presumably also on confidence) when completing a round of compulsive checking as opposed to checking only once. This may alter their belief that repeated checking is needed to become certain again, and help them resist the urge to check. Behavioral experiments provide powerful ways to accomplish therapeutic gains and the wide spread use of various behavioral experiments in clinical practice justifies critical empirical testing of their usefulness, not necessarily by full scale RCTs, but by carefully designed experimental tests. Whether or not varieties of the present paradigm serve as useful behavioral experiments in clinical practice warrants further exploration.

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Chapter 6

Safety behavior increases obsession-related cognitions about the severity of threat

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Abstract

This study investigated whether checking behavior, the most common safety behavior in obsessive-compulsive disorder (OCD), contributes to the development of OCD symptoms. Ninety healthy undergraduates spent a week between a pre- and post-test either actively engaging in clinically representative checking behavior on a daily basis (experimental group, *n* = 30); monitoring their normal checking behavior (monitor group, *n* = 30); or received no instructions on checking behavior (control group, *n* = 30). Cognitions about the severity of threat increased from pre- to post-test in the experimental group, but not in the monitor and control group. Cognitions about the importance of checking decreased in the monitor group. The results indicate that checking behavior contributes directly to the exacerbation of OCD symptoms. Together with the findings of previous studies, this suggests that safety behavior may be involved in the development of anxiety disorders and OCD. Potential mechanisms of how engaging in safety behavior increases threat perception are discussed.

Introduction

Safety behavior is common in both anxiety- and obsessive compulsive related disorders (American Psychiatric Association, 2013), and refers to actions aimed at preventing or minimizing a feared outcome (Salkovskis, 1991). Patients with social phobia, for instance, avoid eye contact because they fear rejection, patients with panic disorder quickly sit down when they feel their heart beat rising to avoid a heart attack, and patients with obsessive compulsive disorder (OCD) frequently check gas stoves, light switches, or electrical outlets, because they fear the catastrophe of their house burning down under their responsibility. Although these behaviors seem useful to patients and provide anxiety relief in the short term, they actually play a pivotal role in the maintenance of pathological anxiety in the long term (Clark, 1999; Salkovskis, Thorpe, Wahl, Wroe, & Forrester, 2003). Most importantly, safety behaviors cause a misattribution of safety, which prevents the acquisition of information that disconfirms inaccurate threat beliefs (Salkovskis, 1991), and divert attentional recourses away from this information (Sloan & Telch, 2002). For instance, in patients with OCD, the non-occurrence of their house burning down may erroneously be attributed to the repeated checking of the gas stove (i.e., safety behavior).

In addition to their role in the maintenance of symptoms, safety behavior seems to contribute directly to the *exacerbation* and *development* of anxiety and OCD symptoms. To illustrate, individuals with hypochondriasis may increase health anxiety by constantly checking their body (e.g., feeling for lumps, inspecting skin spots; see Abramowitz, Schwartz, & Whiteside, 2002), and patients with checking compulsions paradoxically enhance memory uncertainty by perseverative checking (Boschen & Vuksanovic, 2007). Recently, Engelhard, van Uijen, van Seters, and Velu (in press) showed that even in healthy individuals, the use of safety behavior leads to threat expectations to objectively safe stimuli. In a conditioning experiment, participants who displayed safety behavior (i.e., they could avoid a potential subsequent shock) to a safety cue (a stimulus that had never been paired with shock) subsequently had higher threat expectations to this cue than participants who were not given the opportunity to avoid. Thus, safety behavior seems to increase anxiety not only by misattributing safety to the execution of this behavior, but also by directly attributing danger to safe situations.

The possibility that safety behavior exerts a causal influence on anxiety was recently investigated in two studies. First, Deacon and Maack (2008) investigated the effects of safety behavior on the fear of contamination in healthy participants with either high or low levels of contamination fear. After a week-long baseline period, participants spent one week actively engaging in a wide range of contamination-related safety behaviors on a daily basis (e.g., washing and disinfecting hands excessively, trying to avoid touching public door handles), followed by a second week-long baseline period. Independent of initial levels of contamination fear, participants reported increased contamination anxiety following the safety behavior manipulation. However, because this study lacked a control condition that did not perform any safety behavior, it remained unclear what the effect of the manipulation was. Therefore, in a subsequent study, healthy participants were divided in two groups, a safety behavior group and a monitor-control group (Olatunji, Etzel, Tomarken, Ciesielski, & Deacon, 2011). In between two week-long baseline periods in which both groups monitored their normal use of safety behaviors, participants in the safety behavior condition were asked to spent one week engaging in a large array of health-related safety behaviors on a daily basis, whereas participants in the control condition kept monitoring their usual safety behavior. Results showed that, compared with the control condition, participants in the safety behavior condition reported higher levels of health anxiety, hypochondriacal beliefs and avoidant responses to health related behavioral tasks. Thus, even in healthy individuals, the mere act of engaging in health-related safety behaviors for one week increased health anxiety.

Although hypochondria was not classified as an anxiety disorder in the DSM-IV, and OCD has been separated from the anxiety disorders in the DSM-5 (American Psychiatric Association, 2013), there appears to be quite some overlap between these disorders and anxiety disorders (Deacon & Abramowitz, 2008). Thus, despite the distinct characteristics of the safety behaviors associated with these disorders, the role that safety behaviors may play in the development of OCD and anxiety disorders is expected to be functionally equivalent (Rachman 2002; Telch & Lancaster, 2012). However, checking behavior, the most commonly observed safety behavior in patients with OCD (i.e., in 80% among those with lifetime OCD; Ruscio, Stein, Chiu & Kessler, 2010), has unique features that include rigidity and repetitiveness. The present study was therefore conducted to experimentally

investigate whether this more rigid and ritualistic safety behavior (i.e., checking) contributes to the development of OCD symptoms.

According to the self-perpetuating mechanism of compulsive checking (Rachman, 2002), the amount of checking behavior a person performs is determined by the sense of responsibility, probability of harm, and anticipated seriousness of the harmful outcome. Conversely, Rachman (2002) predicts that an increase in checking behavior will lead to an increase in the sense of responsibility, probability of harm, anticipated seriousness of the harmful outcome, and, additionally, a decrease in memory confidence. Since previous research has shown that people with OCD symptoms not only use checking behavior in response to their obsessions, but also have the tendency to display more checking behavior in mildly uncertain situations that are unrelated to obsessions (Toffolo, van den Hout, Engelhard, Hooge, & Cath, 2014; Toffolo, van den Hout, Hooge, Engelhard, & Cath, 2013), checking behavior itself may contribute to the development of the disorder. When people are habitually more inclined to use checking behavior, this may not only increase uncertainty levels (e.g., van den Hout & Kindt, 2003), but also have a direct effect on obsessional beliefs such as the perceived likelihood and severity of threat. Therefore, we conducted a study similar to the one by Olatunji et al. (2011), in which participants in the experimental condition engaged in a large number of checking-related safety behaviors for seven consecutive days, to simulate the natural behavior of patients with checking OCD. Although patients with OCD often repeatedly check the same objects, their rigidity and the repetitiveness of their behavior may also become visible in mere checking rituals. This often involves checking a series of objects in a certain order, every time they leave the house or go to bed, for instance. In the present study we chose to include this last type of checking behavior, because it seemed more plausible that healthy participants would comply to this and be able to incorporate it into their daily life for a period of one week.

As mentioned earlier, contrary to Deacon and Maack (2008), Olatunji et al. (2011) did include a control condition that monitored daily safety behavior. However, as Olatunji et al. (2011) discuss, it is unknown whether merely monitoring one's safety behavior affects behavior and subsequent outcome measures. Prior research suggests that self-monitoring of psychopathological symptoms in treatment decreases anxiety and negative behavior, and increases positive behavior and approach (see Craske & Tsao, 1999). To eliminate the potential influence of safety

behavior monitoring, the present study included an additional control condition, in which participants did nothing between the pre- and post-test. Inclusion of a no-monitoring control condition made it possible to isolate the effect of the checking behavior manipulation from potential monitoring effects. Therefore, contrary to Deacon and Maack (2008) and Olatunji et al. (2011), we did not include week-long baseline periods before and after the checking behavior manipulation, but only used a pre- and post-test. It was hypothesized that compared with the monitor and control groups, participants in the experimental group would show a pre- to post-test increase in OCD-related cognitions about the importance of checking, the perceived likelihood and severity of a catastrophe (i.e., threat overestimation), and general obsessive beliefs about inflated responsibility and exaggerated threat perceptions. Based on previous findings of Deacon and Maack (2008) and Olatunji et al. (2011) it was also expected that these effects would be specific to OCD-related cognitions, and that the manipulation would not affect general anxiety.

Method

Participants

Ninety participants (mean age 22.36, *SD* = 3.39; 73 women) were recruited at Utrecht University and the University of Applied Sciences Utrecht, and randomly assigned to the experimental (*n* = 30), monitor (*n* = 30), or control group (*n* = 30). Individuals with a current psychiatric disorder were excluded from participation. Participants received remuneration or course credit for their participation.

Measures

Checking Cognitions Scale (CCS). Based on the Contamination Cognitions Scale used in a similar study by Deacon and Maack (2008), this questionnaire was developed for the present study to assess the effect of checking behavior on OCD-related cognitions about the importance of checking and the perceived likelihood and severity of threat when one does not check things around the house (see Supplemental materials). It consists of 21 questions about 7 items that are often involved in OCD-related checking behavior, such as the gas stove, windows and doors, and electrical plugs. For each item, participants rate the importance of checking (e.g., “I think that checking if the stove is off before I leave the house or go to bed is…”, rated from “not at all important” to “very important”); the likelihood of a

dangerous situation happening (e.g., “How likely is it that a dangerous situation will emerge when you do not check if the stove is off before leaving the house or going to bed?”, rated from “very unlikely” to “very likely”); and the severity of a dangerous situation happening (e.g., “How severe would the possible consequences be if you do not check if the stove is off before leaving the house or going to bed?”, rated from “not at all severe” to “very severe”) on 0-100 visual analogue scales (VAS). The overall CCS score was calculated by averaging ratings across all 21 items (cf. Deacon & Maack, 2008). Even though importance of checking, likelihood of threat and severity of threat ratings were moderately to highly correlated (see Table 2), subscales were calculated by averaging ratings across the seven items of each subscale to gain insight in the separate constructs of the CCS. The CCS had excellent internal consistency at both time points (α’s = .89 and .93), and high test-retest reliability (r = .87; calculated using the pre- and post-test of the control group). Subscales showed very good internal consistency too, with importance of checking α’s = .80 and .88, likelihood of threat α’s = .78 and .88, and severity of threat α’s = .81 and .86.

Obsessive Beliefs Questionnaire-44 (OBQ-44) Responsibility and Threat Estimation (RT) scale. A Dutch translation of the 16-item RT-subscale of the OBQ-44 (Obsessive Compulsive Cognitions Working Group [OCCWG], 2005) assessed participants’ beliefs about preventing harm from happening to oneself or others, beliefs about the consequences of inaction, and responsibility for bad things happening, and was used as a dependent variable. This scale accounts for more variance in OCD-related beliefs than the other belief domains of the OBQ (OCCWG, 2005). Participants rate their agreement with each statement on a 7-point Likert scale (e.g., ‘‘Harmful events will happen unless I am very careful’’, 1 = disagree very much, 7 = agree very much). Internal consistency was excellent at both time point (α’s = .84, and .90).

Obsessive-Compulsive Inventory-Revised (OCI-R). The Dutch translation (Cordova-Middelbrink, Dek, & Engelbarts, 2007) of the OCI-R (Foa et al., 2002) was used to check for pre-test differences in obsessive compulsive tendencies. The OCI-R contains 18 items concerning OCD characteristics, each measured on a 4-point Likert scale (e.g., “I check things more often than necessary”, 0 = not at all, 4 = extremely). The OCI-R has good test-retest reliability and validity in both clinical (Foa

et al, 2002) and non-clinical populations (Hajack, Huppert, Simons, & Foa, 2004). Internal consistency was very good (α = .83).

Beck Anxiety Inventory (BAI). The BAI (Beck, Epstein, Brown, & Steer, 1988) was used to measure effects of the manipulation on general anxiety. It assesses to which extent participants experienced 21 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). It showed excellent internal consistency at both time points, (α's = .83 and .88).

Checklist. The Checklist was developed as a manipulation check and to inspect pre-test differences in checking behavior (see Supplemental materials). The Checklist contains six categories of situations in which people may perform checking behavior, and each category contains several items that could be checked when participants were in that situation (e.g. "checking if the door was locked", or "checking if your laptop was unplugged"). The categories were "Before leaving the house", "Before going to bed", "When being/having been away", "After being in the kitchen", "After using the bathroom/cosmetic appliances", and "Other situations". Respondents noted whether or not they had performed each of the 59 checking behaviors that day by indicating "yes" or "no". A third option, "not applicable (N/A)" was provided in case participants did not have the opportunity that day to perform that particular checking behavior (e.g., if the participant never used a hairdryer). The percentage of "yes" responses of the total number of items that could have been checked (sum of "yes" and "no" responses) was calculated. Test-retest reliability was very good (r = .85; calculated using the pre- and post-test of the control group).

Procedure

Participants were tested individually in a soundproof laboratory room during both sessions. During the first session, participants gave written informed consent after receiving verbal and written instructions about the study. Participants received a package with five questionnaires (the CCS, OCI-R, OBQ-44 RT, BAI, and Checklist) and filled these out.

Then the manipulation followed. Participants in the experimental group were given a plasticized list with all the checking items of the Checklist in present tense (e.g., "Before leaving the house: Check if the door is locked"). Participants were told that the researcher was interested in to what extent people can engage in *more*

checking behavior of everyday objects than they normally do on a daily basis, for one week. They were instructed to perform all the checking behavior on the list at every possible opportunity during the upcoming week. They were asked to check every item once more than they would usually do. For instance, if the participant would usually check whether the door was locked when leaving the house once, they were now asked to check this twice. If the participant usually never checked whether the door was locked, they were now asked to check this once. The experimenter went over the list together with the participant to ensure he/she understood when and how they could check each item (e.g., checking the gas stove could involve carefully looking whether the burners were off or physically touching or turning the knobs). Next, participants were given one Checklist for each day during the week between the first and second laboratory session. They were asked to complete a Checklist at the end of each day before going to bed, and indicate for each item whether they had checked it in the past 24 hours. To increase compliance, participants were asked to set a daily alarm on their phone as a reminder.

The monitor group was told that the researcher was interested in to what extent people usually check everyday objects on a daily basis, for one week. They were also handed a Checklist for each day during the week between the first and second laboratory session, and asked to complete one at the end of each day before going to bed. Participants were instructed not to change their behavior in any way, and to “just do what you would normally do and record it on this form every day”. The experimenter went over the Checklist together with each participant and asked them to set a daily alarm on their phone as a reminder. The control group did not receive any further instructions.

The second session took place approximately one week later (6-8 days). Participants in the experimental and monitor group handed in their daily Checklists. All participants again filled out the CCS, OBQ-44 RT, BAI, and Checklist. Additionally, participants in the experimental and monitor group indicated on a 0 (not at all) to 100 (exclusively) VAS to what extent they had given socially desirable answers when filling out the daily Checklists, and on a 0% - 100% VAS, which percentage of the behavior they had filled out on the daily Checklists they had actually performed. Participants were thoroughly debriefed, and participants in the experimental group were encouraged to return to their normal frequency of checking behavior. Participants were handed a letter with contact information of the researchers, and

asked to contact them in case they would keep thinking about the study or have any further questions (*n* = 0). Finally, participants were thanked and paid for their participation.

Results

Table 1

Mean (SD) participant characteristics and dependent variables by condition.

		Experimental group (*n* = 30)	Monitor group (*n* = 29)	Control group (*n* = 30)	Total (*N* = 89)
OCI-R		11.90 (10.14)	8.59 (5.83)	10.90 (6.75)	10.48 (7.85)
Checklist	Pre	29.08 (13.86)	25.53 (15.97)	28.51 (14.66)	27.73 (14.75)
	Post	77.63 (19.06)	18.76 (14.53)	26.56 (15.08)	41.23 (30.88)
CCS	Pre	37.19 (12.14)	31.15 (15.49)	34.72 (13.37)	34.39 (13.78)
	Post	41.31 (16.81)	28.97 (16.08)	34.02 (13.80)	34.83 (16.25)
CCSimp	Pre	50.74 (15.10)	42.13 (18.32)	51.96 (20.79)	48.34 (18.53)
	Post	53.41 (20.36)	36.34 (18.32)	47.73 (22.75)	45.94 (21.55)
CCSlik	Pre	27.50 (12.60)	19.99 (13.99)	22.37 (13.81)	23.32 (13.69)
	Post	30.99 (16.70)	21.14 (15.64)	23.79 (15.53)	25.35 (16.33)
CCSsev	Pre	33.32 (15.49)	31.34 (20.10)	29.82 (15.26)	31.50 (16.92)
	Post	39.53 (18.80)	29.44 (20.20)	31.00 (16.06)	33.37 (18.74)
OBQ-44	Pre	36.57 (10.85)	34.45 (11.71)	35.30 (12.09)	35.45 (11.46)
	Post	36.90 (12.89)	34.21 (12.47)	32.93 (13.07)	34.69 (12.78)
BAI	Pre	9.27 (6.75)	6.83 (5.08)	9.03 (5.11)	8.39 (5.75)
	Post	9.57 (7.96)	4.62 (4.20)	8.13 (5.57)	7.47 (6.41)

Note. OCI-R = Obsessive-Compulsive Inventory-Revised; CCS = Checking Cognitions Scale; CCSimp = CCS importance subscale; CCSlik = CCS likelihood subscale; CCSsev = CCS severity subscale; OBQ-44 = Obsessive Beliefs Questionnaire-44 Responsibility/Threat estimation Scale; BAI = Beck Anxiety Inventory; Pre = Pre-test; Post = Post-test.

Randomization and Manipulation Checks

One outlier (CCS post-test; control group) was changed into *M* + 3*SD*s (Field, 2009), and one participant in the monitor group was excluded from analyses, because afterwards she reported recently being diagnosed with generalized anxiety disorder. One-way ANOVAs[1] were performed to check for pre-test differences between groups. Groups did not differ in obsessive-compulsive tendencies (OCI-R), $F(2,86) = 1.39$, $p = .26$, or checking behavior (Checklist), $F(2,86) = 0.48$, $p = .62$, at the pre-test, see Table 1. Also, no pre-test differences were found on any of the dependent variables, largest $F(2,86) = 2.54$, $p = .09$. To check whether the manipulation was effective, we examined whether the amount of items participants checked (Checklist) changed from pre- to post-test, and whether the experimental and monitor group differed in scores on the Checklists they filled in each day during the week between the pre- and post-test. Overall, there was a pre- to post-test increase in the amount of items checked, $F(1,86) = 82.18$, $p < .001$, $\eta_p^2 = .49$, which differed between conditions, $F(2,86) = 146.58$, $p < .001$, $\eta_p^2 = .77$, see Table 1. The effect of Condition was also significant, $F(2,86) = 42.13$, $p < .001$, $\eta_p^2 = .50$. Planned comparisons showed an increase in the experimental group, $t(29) = 13.42$, $p < .001$, $d = 2.92$; a decrease in the monitor group, $t(28) = 3.49$, $p = .002$, $d = 0.44$; and no change in the control group, $t(29) = 1.30$, $p = .20$. This change in Checklist scores differed between the experimental and monitor group, $t(44.30) = 13.47$, $p < .001$, $d = 3.47$; the experimental and control group, $t(38.66) = 12.89$, $p < .001$, $d = 3.33$; and there was a trend for a difference between the monitor and control group, $t(57) = 1.89$, $p = .05$, $d = 0.51$. On each day during the week between the pre- and the post-test, participants in the experimental group ($M = 74.42$, $SD = 18.34$) checked more items than participants in the monitor group ($M = 18.24$, $SD = 13.86$), $t(57) = 13.24$, $p < .001$, $d = 3.45$.

No participants were excluded from analyses because of giving socially desirable answers when filling in the daily Checklists. A low percentage of socially desirable answers was reported by participants in both the experimental ($M = 22.47\%$, $SD = 24.22$) and monitor group ($M = 10.31\%$, $SD = 11.84$), and they indicated to have performed most of the checking behavior that they had filled in on

[1] For *F*-tests we reported effect size η_p^2, whereby 0.02 indicates a small effect, 0.13 a medium effect, and 0.26 a large effect. For *t*-tests we reported effect size Cohen's *d,* whereby 0.2 indicates a small effect, 0.5 a medium effect, and 0.8 a large effect.

the daily Checklists (experimental group *M* = 89.37%, *SD* = 8.41; monitor group *M* = 91.34%, *SD* = 14.70).

Table 2

Pearson r correlations between questionnaires at the pre-test. Df = 89.

	CCSimp	CCSlik	CCSsev	OCI-R	OCI-Rc	OBQ	BAI	Checklist
CCS	.80**	.86**	.87**	.31*	.26*	.28*	.24*	.52**
CCSimp		.48**	.47**	.26*	.29*	.12	.20	.54**
CCSlik			.77**	.27*	.22*	.28*	.23*	.42**
CCSsev				.26*	.13	.32*	.18	.35*
OCI-R					.56**	.48**	.66**	.30*
OCI-Rc						.22*	.26*	.26*
OBQ-44							.48**	.25*
BAI								.28*

*$p < .05$; **$p < .001$

Note. CCS = Checking Cognitions Scale; CCSimp = CCS importance subscale; CCSlik = CCS likelihood subscale; CCSsev = CCS severity subscale; OCI-R = Obsessive-Compulsive Inventory-Revised; OCI-Rc = Obsessive-Compulsive Inventory-Revised checking subscale; OBQ = Obsessive Beliefs Questionnaire-44 Responsibility/Threat estimation Scale; BAI = Beck Anxiety Inventory.

Main Analyses[2]

Table 2 shows that there were moderate to strong significant correlations between most questionnaires at the pre-test. Correlations with the OCI-R checking cognitions subscale were added separately as an additional check of the validity of

[2] Exploratively it was examined whether the checking behavior manipulation would have an effect on general checking behavior in an unrelated task. The visual search task of Toffolo et al. (2013) was administered both at pre- and post-test, because this induced and measured checking behavior. In this task participants had to report whether a target was present or absent in a search field (see Toffolo et al., 2013 for details of the task). A 2 (Time) x 2 (Trial type: target-absent vs. target-present trials) x 3 (Condition) mixed ANOVA was performed to compare groups on pre- to post-test changes in search time (checking behavior) in both target-absent and target-present trials. Although overall, participants searched longer in absent- than present-trials, $F(1,82) = 572.94$, $p < .001$, $\eta_p^2 = .88$, and there was an overall decrease in search time from pre- to post-test, $F(1,82) = 14.48$, $p < .001$, $\eta_p^2 = .15$, the crucial interaction effects were not significant, $ps > .26$.

the CCS and Checklist. To test the study hypotheses, a series of 2 (Time: pre-test vs. post-test) x 3 (Condition: experimental vs. monitor vs. control) mixed ANOVAs[1] were conducted to examine the effect of the safety behavior manipulation on checking cognitions (CCS), obsessive beliefs (OBQ-44 RT), and general anxiety symptoms (BAI).

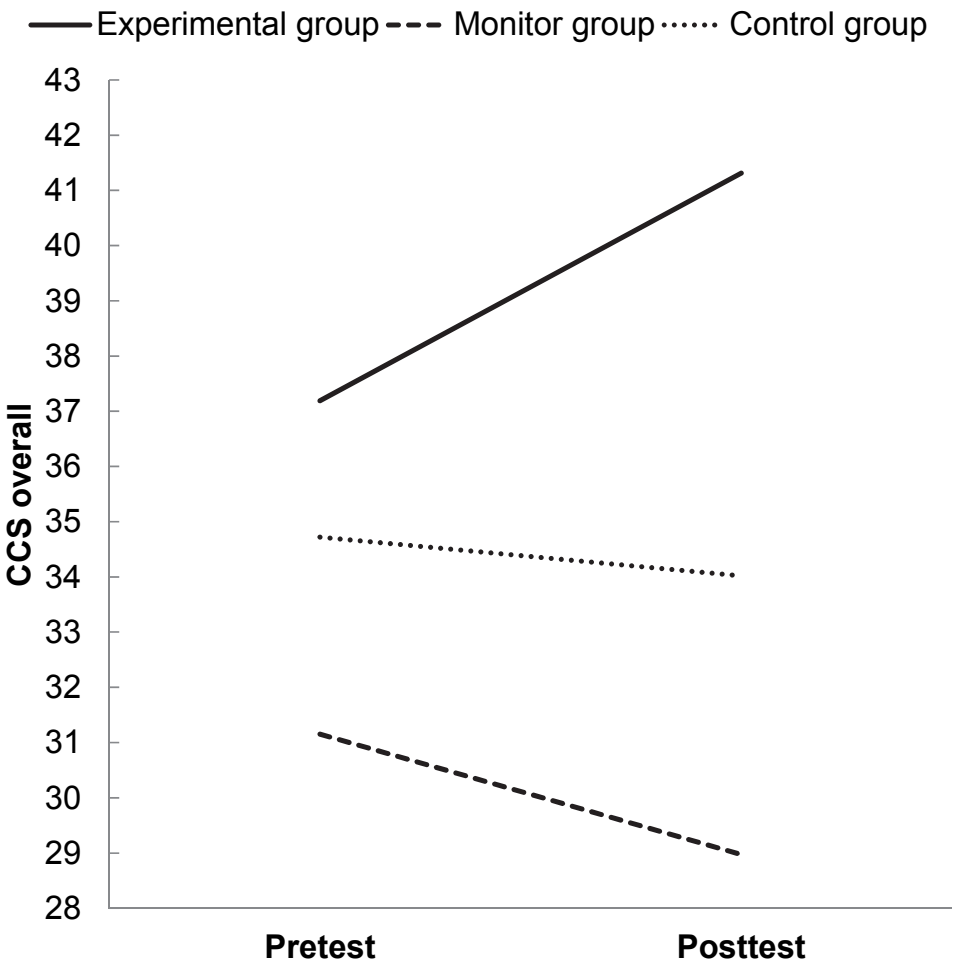

Figure 1. Checking Cognitions Scale (CCS) scores at pre- and post-test for each condition.

Checking Cognitions Scale (CCS).

There was no main effect of Time, $F(1,86) = 0.27$, $p = .60$, and a trend of Condition, $F(2,86) = 3.10$, $p = .05$, $\eta_p^2 = .07$. The crucial Time x Condition interaction was significant, $F(2,86) = 5.62$, $p = .005$, $\eta_p^2 = .12$, see Figure 1. Planned comparisons showed a pre- to post-test increase in the experimental group, $t(29) = 2.40$, $p = .02$, $d = 0.28$, a trend for a decrease in the monitor group, $t(28) = 1.97$, $p = .06$, $d = 0.14$, and no change in the control group, $t(29) = 0.56$, $p = .58$. The change

in CCS scores differed between the experimental and monitor group, $t(49.11) = 3.08$, $p = .003$, $d = 0.80$; and the experimental and control group, $t(58) = 2.27$, $p = .03$, $d = 0.59$; but not between the monitor and control group, $t(57) = 0.89$, $p = .38$. Hence, consistent with our hypothesis, performing OCD-related checking behavior for one week increased participants' checking-related cognitions.

CCS subscale importance of checking showed a decrease over Time, $F(1,86) = 3.99$, $p = .049$, $\eta_p^2 = .04$, a main effect of Condition, $F(2,86) = 4.01$, $p = .02$, $\eta_p^2 = .09$, and a Time x Condition interaction, $F(2,86) = 4.52$, $p = .01$, $\eta_p^2 = .10$, see Figure 2, left panel. There was a pre- to post-test decrease in the importance of checking in the monitor group, $t(28) = 3.12$, $p = .004$, $d = 0.32$, a trend for decrease in the control group, $t(29) = 1.95$, $p = .06$, $d = 0.19$, and no change in the experimental group, $t(29) = 1.17$, $p = .25$. The likelihood subscale showed a trend for an increase over Time $F(1,86) = 3.48$, $p = .07$, $\eta_p^2 = .04$, a trend of Condition, $F(2,86) = 3.08$, $p = .05$, $\eta_p^2 = .07$, and no Time x Condition interaction, $F(2,86) = 0.47$, $p = .63$, see Figure 2, middle panel. On the severity subscale, there was a trend for an increase over Time, $F(1,86) = 3.44$, $p = .07$, $\eta_p^2 = .04$, no main effect of Condition, $F(2,86) = 1.23$, $p = .30$, and a Time x Condition interaction, $F(2,86) = 5.74$, $p = .005$, $\eta_p^2 = .12$, see Figure 2, right panel. Checking cognitions about the severity of threat increased from pre- to post-test in the experimental group, $t(29) = 2.72$, $p = .01$, $d = 0.36$, but did not change in the monitor, $t(28) = 1.43$, $p = .17$, and control group, $t(29) = 0.92$, $p = .37$.

Obsessive Beliefs Questionnaire-44 (OBQ-44) Responsibility and Threat Estimation (RT) scale.

There were no main effects of Time, $F(1,86) = 0.70$, $p = .41$, and Condition, $F(2,86) = 0.48$, $p = .62$, nor was the Time x Condition interaction significant, $F(2,86) = 0.83$, $p = .44$. Thus, in contrast with the findings on the CCS and with our expectations, the experimental group did not show a pre- to post-test increase in obsessive beliefs about inflated responsibility and exaggerated threat perceptions compared to the monitor and control group.

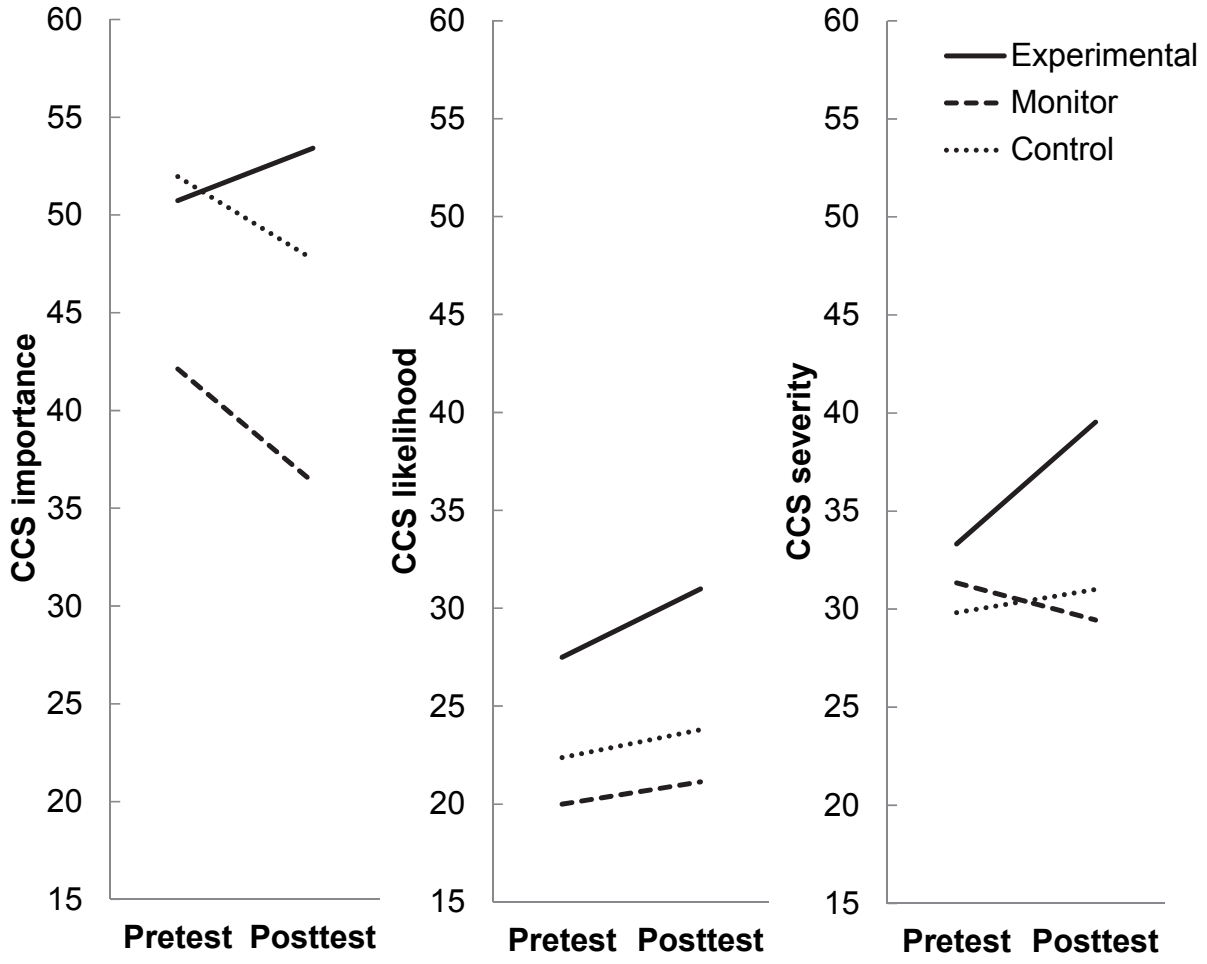

Figure 2. Checking Cognitions Scale (CCS) subscales importance of checking (left panel), likelihood of threat (middle panel), and severity of threat (right panel) at pre- and post-test for each condition.

Beck Anxiety Inventory (BAI).

There was a main effect of Condition, $F(2,86) = 3.55$, $p = .03$, $\eta_p^2 = .08$, and an overall decrease in BAI scores between pre- and post-test, $F(1,86) = 4.79$, $p = .03$, $\eta_p^2 = .05$. There was a trend for this to differ between conditions, $F(2,86) = 2.85$, $p = .06$, $\eta_p^2 = .06$. This pattern of differences between conditions was further investigated with exploratory post-hoc tests. These indicated a decrease in the monitor group, $t(28) = 2.78$, $p = .01$, $d = 0.47$, but no change in the experimental, $t(29) = 0.35$, $p = .73$, and control group, $t(29) = 1.68$, $p = .10$, see Table 1. The change in BAI scores differed between the experimental and monitor group, $t(57) = 2.14$, $p = .04$, $d = 0.56$, but not between the experimental and control group, $t(48.58) = 1.19$, $p = .24$, and the monitor and the control group, $t(57) = 1.38$, $p = .18$. This was in line with the

expectation that the effect of the checking behavior manipulation would be OCD-specific, and thus would not increase general anxiety.

Discussion

Increasing daily checking behavior of everyday objects for one week increased overall checking-related cognitions measured with the CCS, which assessed cognitions about the importance of checking and the likelihood and severity of threat (i.e., threat overestimation). Moderate to strong correlations between these constructs of the CCS indicated that they were closely related, and the overall scale showed excellent internal consistency. Nonetheless, to gain insight into how checking behavior influenced the separate constructs, these were also analyzed individually. This showed that, although the data pattern of the experimental group seemed similar for all three constructs, the increase in overall checking-related cognitions was accounted for by an increase in cognitions about the severity of threat. Additionally, cognitions about the importance of checking decreased in the monitor group, but did not change in the experimental and control group. No changes in cognitions about the perceived likelihood of threat were found in any of the groups. There were no changes in general obsessive beliefs about inflated responsibility and exaggerated threat perceptions for any of the conditions. General anxiety decreased from pre- to post-test for all groups.

The finding that increasing one's daily checking behavior exacerbates checking-related cognitions about the severity of threat fits with previous studies showing that engaging in safety behavior increases anxiety and threat beliefs. Engaging in health-related safety behavior increased health anxiety and hypochondriacal beliefs (Olatunji et al., 2011), and cleaning-related safety behavior exacerbated threat perception and contamination anxiety (Deacon & Maack, 2008). Together, these findings suggest that safety behavior contributes directly to the exacerbation of anxiety and OCD symptoms, and may thus be involved in the development of anxiety disorders and OCD.

Engaging in checking behavior did not change participants' general obsessive beliefs about inflated responsibility and exaggerated threat perceptions, measured with the OBQ-44 RT scale. It seems likely that the checking behavior manipulation was not potent enough to influence these beliefs. In comparison with the CCS, which was designed to measure specific checking-related cognitions, the OBQ-44 RT scale

addresses more overarching cognitions about responsibility and threat perceptions. This scale appears to be a more stable measure of beliefs that are related to trait anxiety and psychopathology in general, instead of specifically to OCD (Cougle & Lee, 2014; Myers, Fisher, & Wells, 2008; Tolin, Worhunsky, & Maltby, 2006). Considering that the OBQ-44 has low sensitivity to treatment change (Anholt, van Oppen, Cath, Emmelkamp, Smit, & van Balkom, 2010), it seems plausible that general beliefs about inflated responsibility and exaggerated threat perceptions were not affected by increasing checking behavior for one week. Perhaps if participants engaged in excessive checking behavior for many weeks, these beliefs would increase.

General anxiety did not increase in any of the groups, which suggests that engaging in checking behavior specifically increased OCD-related checking cognitions. However, it should be noted that some researchers argue that the BAI mainly assesses panic symptomatology rather than anxiety in general (Cox, Cohen, Direnfeld, & Swinson, 1996; Leyfer, Ruberg, & Woodruff-Borden, 2006), even though it continues to be widely used as a measure to assess general anxiety (e.g., Abramowitz, Khandker, Nelson, Rygwall, & Deacon, 2006) and was also administered in the studies of Deacon and Maack (2008) and Olatunji et al. (2011). Future studies could consider using other measures of anxiety such as the State Trait Anxiety Inventory (STAI; Spielberger, 1983) or Depression, Anxiety, and Stress Scale (DASS; Henry & Crawford, 2005) to further investigate the influence of checking behavior on general anxiety symptoms. The overall decrease in BAI scores seems to be caused by the monitor group. In addition to a decrease in general anxiety, the monitor group showed a pre- to post-test decrease in the amount of items they checked daily, and a decrease in cognitions about the importance of checking. In comparison, the control group did not show any changes. It thus appears that monitoring daily checking behavior decreased the amount of checking behavior participants engaged in, which in turn may have decreased cognitions about the importance of checking and general anxiety. This is in line with previous research, which suggests that self-monitoring causes a decrease in negative behavior and psychopathological symptoms (see Craske & Tsao, 1999). Additionally, when looking at the findings of Olatunji et al. (2011), it seems that monitoring safety behavior might have decreased threat perception and health anxiety, and increased approach behavior in their study as well.

A possible explanation of the present findings comes from recent studies that challenge the idea that compulsions are mainly a response to obsessions to reduce the likelihood that a feared outcome will take place (e.g., Cougle & Lee, 2014; Gillan & Robbins, 2014; Robbins, Gillan, Smith, de Wit, & Ersche, 2012). Based on theories of moral reasoning and cognitive dissonance, it is argued that obsessive beliefs may be an epiphenomenon of OC symptoms. Moral reasoning is the conscious mental activity of altering information about people and their behavior in order to come to a moral judgment or decision. This is usually a post-hoc process, in which one searches for evidence to support an initial intuitive reaction (Haidt, 2007). In addition, cognitive dissonance theory states that individuals are motivated to reduce a conflict that arises when their behavior is not in line with their belief, by altering their belief so that it corresponds with their behavior (Festinger, 1957; Festinger & Carlsmith, 1959). When translating these theories to OCD it was suggested that compulsions create cognitive dissonance (Cougle & Lee, 2014; Gillan & Robbins, 2014). Obsessive thoughts may then arise to resolve the discrepancy between the individuals' cognitions and their otherwise incomprehensible compulsive behaviors. Thus, obsessive beliefs could simply reflect post-hoc attempts to justify compulsive urges and behavior ("I am triple checking the electrical outlets and lights around the house, therefore I must be very responsible", or "I am checking the stove repeatedly, therefore it must be highly likely that something very bad will happen otherwise"). Individuals with OCD may thus come to overestimate threat or perceive themselves as having an exaggerated sense of responsibility to explain their compulsive urges and to put their cognitions in line with their behavior. This is in line with recent findings that anxiety patients use their own behavior as information about the safety of a situation (Gangemi, Mancini, & van den Hout, 2012, van den Hout et al., 2014). In the present study it is therefore possible that individuals in the experimental group began to perceive potential threat in the environment as more severe to justify their checking behavior. However, more research is needed to investigate this. The present study only involved checking many objects "once more than typical" in several situations, to create ritualistic behavior similar to checking behavior observed in patients with OCD (i.e., OCD checkers may display a ritual of checking many items once in a particular order before leaving the house, for instance). However, many patients with OCD also perform more repetitive compulsive behavior, such as checking the stove or the light switches many times in a row. Therefore, future

research could, for instance, focus on fewer checking tasks to check more often (e.g., the ones that are most frequently used by patients with OCD) to further investigate how compulsive checking behavior influences obsessive cognitions.

Our findings provide further insight into the role of checking behavior in the maintenance and development of OCD. The finding that increased checking behavior causes an increase in OCD-related cognitions about the severity of threat fits with Rachman's (2002) self-perpetuating mechanism of compulsive checking. It was recently found that people with OCD have the tendency to engage in more checking behavior in mildly uncertain situations (Toffolo et al., 2014; Toffolo et al., 2013). This may thus not only increase uncertainty levels (van den Hout & Kindt, 2003), but also directly increase threat beliefs. Because these results were obtained in a sample of healthy subjects, it seems plausible that pre-compulsive (i.e., normal) episodes of checking contribute to the development of compulsive checking by increasing uncertainty and perceived threat (Rachman, 2002).

A possible limitation of the study is that the main findings were measured with a self-constructed and therefore non-validated questionnaire (the CCS). The checking behavior manipulation and manipulation check (i.e., the items of the Checklist) were created for the present study as well. However, both lists were developed by the authors who have clinical and research expertise with OCD and anxiety disorders, and in close collaboration with a highly experienced clinical psychologist. The questions were based on cognitions frequently reported by patients with OCD in the clinical practice. Reliability of both measures was good: the CCS and Checklist showed good test-retest reliability, and the CCS and its subscales had very high internal consistency. Moderate to strong correlations between the CCS, CCS subscales, and Checklist, and validated scales (the OCI-R, OCI-R checking subscale, OBQ-44 RT, and BAI) suggest that the self-constructed measures are valid. Finally, a comparable self-constructed CCS was used by Deacon & Maack (2008), and they also devised their own safety behavior manipulation, as did Olatunji et al. (2011). However, future research is necessary to validate the self-constructed measures that were used in this study. A final limitation is that participants in the experimental group may have guessed the hypothesis and acted accordingly. However, post-test enquiry about the goal of the experiment did not reveal an expectancy bias.

In conclusion, checking behavior appears to increase OCD-related cognitions about the severity of threat, which, together with results from previous studies, suggests that safety behavior contributes directly to the exacerbation of anxiety and OCD symptoms, and may thus be involved in the development of anxiety disorders and OCD. Although future research should further examine the underlying mechanisms of how safety behavior increases threat perception (e.g. cognitive dissonance theory in relation to OCD (Cougle & Lee, 2014; Gillan & Robbins, 2014) and behavior as information (Gangemi et al., 2012; van den Hout et al., 2014), it seems possible that normal episodes of checking increase perceived threat and uncertainty, and in that way contribute to the development of compulsive checking.

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Chapter 7

General discussion

This dissertation aimed at investigating the reciprocal relationship between checking behavior and cognitive symptoms in OCD, which may help to explain how OCD develops or is maintained. The first aim was to examine whether mild uncertainty, thematically unrelated to extreme obsessive concerns, stimulates general checking behavior in OCD. The second aim was to investigate whether checking behavior directly contributes to the exacerbation of OCD symptoms. In this final chapter the main findings of the empirical studies will be summarized and discussed, together with some limitations and directions for future research. Finally, theoretical and clinical implications that follow from the findings will be presented.

Mild uncertainty → Checking behavior

Previous research showed that patients with (checking) OCD are generally more inclined than healthy individuals or patients with other primary OCD symptoms to engage in checking behavior, irrespectively of their obsessive concerns (e.g., Clair et al., 2013; Jaafari et al., 2013; Kim et al., 2012; Rotge et al., 2008). This demonstrated that increased checking behavior may not only be viewed as "output" resulting from obsessive uncertainties, but may also be present in other situations. However, it remained unknown what triggers this general checking behavior. The first three studies of this dissertation (**chapter 2, 3, and 4**) were therefore aimed at investigating whether mild uncertainty that is unrelated to obsessions would promote checking behavior in OCD. In these studies, a novel eye-tracking paradigm was presented in which participants performed a visual search task, and indicated whether a target was present or absent within a search display. Target-present trials were self-evident, because the response "present" could be based on the perception of the target. However, in target-absent trials mild uncertainty was induced, because participants had to rely on not overlooking the target. The first two studies included undergraduate students with either high (OC+) or low (OC-) OC tendencies. The first study (Toffolo, van den Hout, Hooge, Engelhard, & Cath, 2013) showed that in target-absent trials OC+ participants searched longer and fixated more often (i.e. used more checking behavior) than OC- participants. In target-present trials no differences were found between the groups. Study 2 (Toffolo, van den Hout, Engelhard, Hooge, & Cath, 2014) strengthened these findings by replicating the results on search time, and showing that target-absent trials indeed induced more uncertainty than target-present trials. However, there were no differences between the groups in

experienced (un)certainty within the task. Furthermore, by including participants with scores on the whole range of OC tendencies (from very low to very high; measured with the Obsessive-Compulsive Inventory Revised) this study demonstrated a positive relation between OC tendencies and checking behavior in target-absent trials. Thus, the more OC tendencies were reported, the longer and more precisely people checked when uncertainty was induced. The third study, which used the same eye-tracking paradigm, included patients with OCD and compared their checking behavior on the visual search task with that of matched patients with anxiety disorders (non-OCD) and matched healthy controls (Toffolo, van den Hout, Engelhard, Hooge, & Cath, 2015). In both target-present and target-absent trials patients with OCD engaged in more checking behavior than healthy and anxiety controls. Moreover, the difference in checking behavior between patients with OCD and the two control groups was larger in target-absent trials than in target-present trials. Anxiety controls did not differ from healthy controls in checking behavior throughout the task. Therefore, mild uncertainty appears to *specifically* promote checking in patients with OCD. Interestingly, in all three studies no differences were found between groups in the number of errors made in the task. Thus, although individuals with (subclinical) OCD engaged in more checking behavior than people with low OC tendencies / healthy or anxiety controls, this did not increase their accuracy. This shows that the nature of the performed checking behavior of patients with OCD in this task resembled the irrationality of compulsive checking; it has no “natural terminus” and is continued, because patients feel uncertain about the outcome of their behavior (Rachman, 2002).

The findings of these three studies add to previous research by demonstrating that patients with OCD not only use more checking behavior in general, irrespective of their obsession-related anxiety (e.g., Clair et al., 2013; Jaafari et al., 2013; Kim et al., 2012; Rotge et al., 2008), but importantly, that this is exacerbated when uncertainty is induced. It also adds to research by Arntz, Voncken, and Goosen (2007), who asked participants to complete a pill-sorting task in either a high or low responsibility condition. They found that OCD patients engaged in more checking behavior than both anxiety and healthy controls under conditions of high responsibility for harm to others. However, our studies show that for OCD-related checking to arise it is not necessary that full-blown OCD cognitions about harm and guilt occur, but that very mild uncertainty is sufficient to promote checking.

Furthermore, the three studies are in line with a recent review by Abramowitz et al. (2014) about the relevance of analogue studies for understanding obsessions and compulsions. They argue that OC-related phenomena among subclinical populations may be milder variants of those observed among patients with OCD, which was demonstrated in the present studies. Namely, the first two studies that included healthy participants (Toffolo et al., 2013, 2014) showed that in target-absent trials search time of individuals with high OC tendencies was respectively 12% and 7% higher than search time of individuals with low OC tendencies, whereas the search time in target-absent trials of patients with OCD was 25% higher than search time of healthy controls in the third study (Toffolo et al., 2015a).

Interestingly, the increased checking behavior in target-absent trials of the OCD group could not be explained by the experience of *more* uncertainty than the control groups, because the groups did not differ in the degree to which the target-absent trials induced uncertainty. Furthermore, in study 2 intolerance of the experienced uncertainty could also not explain the findings, and in study 3 both clinical groups experienced enhanced intolerance of uncertainty, but this was only related to more checking behavior in patients with OCD. Therefore, alternative explanations were sought. A first explanation comes from research showing that patients with OCD have trouble relying on internal states, such as perception, memory, or bodily sensations (i.e., patients feel they cannot be certain of what they see, feel or remember). Lazarov, Liberman, Hermesh, and Dar (2014) recently demonstrated that patients with OCD *specifically* have reduced access to and less confidence in their internal states (compared with healthy and anxiety controls), and therefore rely on external proxies, such as rules and procedures. Moreover, access to internal states seems even more attenuated when doubt is elevated (Lazarov, Cohen, Liberman, & Dar, 2014). Hence, mild uncertainty in target-absent trials may have forced participants to rely on internal states (“Did I properly search through the field?”, “Didn’t I overlook the target?”), which led them to engage in increased checking behavior that may have functioned as external proxy.

A second explanation for the findings that patients with OCD checked longer and more precisely in mildly uncertain situations may be linked to indecisiveness as described in OCD (Salkovskis, 1998). Empirical research shows that patients with OCD take longer and require more information than non-anxious controls before making a rational, general (low-risk) or OCD-relevant decision (e.g., Dittrich,

Johansen, Landro, & Fineberg, 2011; Foa et al., 2003), which is particularly pronounced when a situation is *perceived* as more risky (Foa et al., 2003). Additionally, OC tendencies are positively correlated with indecisiveness, especially when feedback about their performance is not routinely provided (Sarig, Dar, & Liberman, 2012). Therefore, the induced uncertainty in target-absent trials may have triggered this indecisiveness in patients with OCD, because responding that a target is "absent" may have been perceived as more risky for making mistakes by overlooking the target, and target-absent trials did not provide direct feedback on the correctness of their response. This may have led to more checking behavior in patients with OCD to increase certainty about their response (i.e. acquire more information) and to overcome their decision-making difficulties. Hence, general checking behavior of patients with OCD may be promoted by mild uncertainty, because it requires them to rely on themselves and may lead to indecisiveness.

Checking behavior → Uncertainty and OCD-related cognitions

The second aim of this dissertation was to investigate whether checking behavior has a direct effect on other OCD symptoms. Extensive research has shown that repeated checking causes memory distrust, which is the very thing that may trigger checking and that is intended to be reduced by this behavior (e.g., Boschen & Vuksanovic, 2007; Coles, Radomsky, & Horng, 2006; Dek, van den Hout, Giele & Engelhard, 2010; Radomsky, Dugas, Alcolado & Lavoie, 2014; Radomsky, Gilchrist & Dussault, 2006; van den Hout & Kindt, 2003a, 2003b, 2004). In turn, increased memory distrust (or decreased memory confidence) may promote continued and/or renewed checking, which may cascade into a mutually reinforcing cycle of decreased confidence and increased checking, which may play a role in the maintenance and development of OCD (Nedeljkovic & Kyrios, 2007). However, until now, studies have investigated the paradoxical effect of only one repeated checking session on memory uncertainty, and therefore, it remained unknown what the time course of the decreased memory confidence would be. Would checking-induced memory distrust disappear once the checking episode is terminated, and only increase again after another session of repeated checking? Or would distrust remain and promote renewed checking behavior, which further decreases memory confidence over time? Therefore, in **chapter 5** we investigated in two experiments how repeated checking influences memory distrust over multiple checking episodes (Toffolo, van den Hout,

Radomsky, & Engelhard, 2015). In experiment 1, undergraduate students performed two sessions of a modified version of the *virtual* OC-like checking task (similar to the one used by Boschen & Vuksanovic, 2007, and slightly different from the task as presented by van den Hout & Kindt, 2003a) with a 30-min. break in between. In experiment 2, another group of undergraduate students performed two sessions of the OC-like checking task on a *real* kitchen stove (similar to the task used by Radomsky et al., 2006). The findings of the two experiments were mixed. In experiment 1, memory distrust seemed to remain after the first checking episode was terminated. Surprisingly, this could not be explained by decreased memory vividness and detail, because these ratings recovered before decreasing again during a second checking episode. In experiment 2, in which a more ecologically valid methodology was used, all three meta-memory ratings of checking the stove were affected by repeated checking in the same way: repeated checking caused memory distrust in both sessions, but this recovered in between. Although replication may be needed to give a definite answer to our question, the results of experiment 2 seem more informative, as explained in **chapter 5**. Hence, repeated checking seems to cause memory distrust every time this counterproductive strategy is used, which may fade once the checking episode has ended.

The final study (van Uijen & Toffolo, 2015), reported in **chapter 6**, adds to these findings. In this study, healthy undergraduates were asked to perform OC-like checking behavior for one week (experimental group). Their obsession-related cognitions about the importance of checking, and the likelihood and severity of threat before and after this week were compared with the obsession-related cognitions of two healthy control groups: one group only monitored their checking behavior for one week (monitor group), and one group did not receive any further instructions during the testing week (control group). It was demonstrated that engaging in OC-like checking behavior for one week increased overall obsession-related cognitions in the experimental group. When taking a closer look at the separate constructs, it was found that the increase in overall obsession-related cognitions was accounted for by an increase in cognitions about the severity of threat. Thus, checking behavior not only increases memory uncertainty (Toffolo et al., 2015b), but also specific OCD-like cognitions about threat severity when checking behavior would not be executed. Therefore, checking behavior seems to directly contribute to the exacerbation of several OCD symptoms.

Noteworthy is that the monitor group showed a pre- to post-test *decrease* in the number of items they daily checked, in cognitions about the importance of checking and in general anxiety, which was not observed in the control group. It thus appears that monitoring daily checking behavior decreases the amount of checking behavior participants engage in, which may lead them to devalue the importance of checking and decrease their general anxiety, which may have implications for treatment (see below).

Combining the findings: Theoretical implications

Combining the findings of the final two studies with the findings of the first three studies of this dissertation may give some new insights in how general checking behavior may contribute to the development of OCD. Because patients with OCD and people who may be vulnerable for the development of OCD (i.e. OC+ individuals) respond to uncertain situations with increased checking behavior (Toffolo et al., 2013, 2014, 2015a), this likely has the paradoxical effect of enhancing uncertainty every time compulsive perseveration is displayed (Toffolo et al., 2015b). Previous research showed that memory certainty diminishes rather quickly; after 2-5 checks individuals already show memory deterioration of checked stimuli (Coles et al., 2006). Hence, checking-induced memory distrust may be triggered by the natural tendency of patients with OCD to use more checking behavior in uncertain situations. However, if an incidental doubt only pops up once and is followed by repeated checking, the increased uncertainty may fade again. But if the same intrusive doubt (e.g., “Did I unplug the coffee machine?”) is followed by repeatedly checking the electrical plug on multiple occasions, this can maintain uncertainty on all those occasions. Moreover, this may also increase obsessive thoughts about the overestimation of threat when the checking behavior would not be executed (van Uijen & Toffolo, 2015). In turn, this may put the individual at risk of getting into a vicious cycle of increased checking behavior and memory distrust, which may contribute to the development of OCD. Therefore, the transition from mild OC symptoms to clinical pathology may be elicited by the use of checking behavior to increase certainty, a safety behavior that is counterproductive and may lead to extreme uncertainty, obsessive cognitions and endless checking, characterizing full-blown OCD.

To investigate this theory, future research could examine whether in the natural course of OCD, the emergence of extreme uncertainties is indeed preceded by repeated checking behavior in response to milder forms of uncertainty, and moreover, whether abstaining from checking behavior, even when only mild uncertainties arise, would help to prevent the development of extreme obsessive concerns. As suggested by Toffolo et al. (2013), these future studies could focus on monitoring patients with OCD after completion of treatment. A meta-analysis showed that even after an adequate treatment course moderate OCD symptoms persist within one third of patients (Eddy, Dutra, Bradley, & Westen, 2004) and another study showed that after successful CBT treatment about 35% of patients relapsed within the first year (Braga, Cordioli, Niederauer, & Manfro, 2005). Furthermore, many patients experience changes in the nature of their obsessions over time (Skoog & Skoog, 1999). For instance, worries about leaving the door and windows unlocked may be replaced by worries about electrical outlets catching fire. Therefore, following patients with OCD after treatment may offer the opportunity to examine the natural course of OCD problems and their recurrence, and enable one to investigate whether patients respond to uncertain situations and new obsessive concerns with checking behavior.

An alternative theory about the role of compulsive behavior (including checking) in OCD comes from two recent papers (Cougle & Lee, 2014; Gillan & Robbins, 2014). The authors argue that obsessions may not be *driving* compulsions, but rather are *consequences* of compulsions. They suggested that compulsions create cognitive dissonance, and obsessions may then arise to resolve the inconsistency between the individuals' cognitions and their otherwise inexplicable behavior. Following this theory, obsessions could then be viewed as post-hoc rationalizations to justify compulsive urges and behavior (e.g., "I am checking the doors and windows around the house repeatedly, therefore it must be highly likely that something very bad may happen otherwise"), which may also help to explain our finding that checking behavior increased OCD-related cognitions about the severity of threat (van Uijen & Toffolo, 2015). However, even if obsessions and obsessive cognitions serve as post-hoc rationalizations of compulsive behavior, this does not mean that they cannot also drive compulsions, which was supported by empirical studies. For instance, Arntz et al. (2007) showed that enhanced feelings of responsibility led patients with OCD to engage in more checking behavior than

healthy and anxiety controls, and the urge to carry out compulsive checking declined in patients with OCD when responsibility was taken away (Lopatka & Rachman, 1995). Thus, obsessive cognitions cannot simply be regarded as troublesome by-products of compulsions, because they also fuel compulsive behavior. Therefore, we emphasize the reciprocal relationships between OCD symptoms that may play a role in the development and maintenance of this condition.

The overall findings of this dissertation fit nicely with a new and fresh theory of psychopathology: the network theory (Borsboom & Cramer, 2013). This network approach argues that symptoms of psychological disorders should not be interpreted as a function of a latent cause or construct, but that functionally connected symptoms *are* the disorder. This is contrary to the conceptualization of medical diseases in which the latent cause can be separated from the (functionally connected) symptoms. For instance, a person with lung cancer (latent construct) may experience symptoms such as chest pain, hoarseness, shortness of breath, coughing up blood, and feeling weak and tired. In this instance, the symptoms are viewed as measurements of the latent disease, lung cancer, which can be diagnosed separately by uncontrolled growth of abnormal cells in the lungs that divide rapidly and form tumors. However, in psychopathology no such thing is possible; the disorder is not distinct from its symptoms, but *consists of* its symptoms (note however, that some people may be more prone to the development of certain psychiatric disorders due to underlying vulnerabilities). For instance, Major Depression (MD) cannot be diagnosed in the absence of symptoms such as depressed mood, self-reproach, insomnia, fatigue or concentration problems, and similarly, someone cannot be diagnosed with OCD without experiencing any form of obsessions and/or compulsions. Furthermore, symptoms of psychopathology do not occur together at random, but certain symptoms are more often co-occurring than others and are functionally connected. Therefore, the network theory conceptualizes psychological disorders as networks of causally connected symptoms that are mutually interacting and often reciprocally reinforcing one another (Borsboom & Cramer, 2013). Hence, in MD, a sudden loss of a loved-one may cause the following chain of symptoms: chronic stress → depressed mood → insomnia → fatigue → concentration problems, but fatigue may also cause depressed mood and depressed mood can directly lead to concentration problems. Thus, psychopathology symptoms may be viewed as causally interconnected symptoms that form reciprocal relationships. This is exactly what the findings of this

dissertation show: uncertainty → checking and checking → uncertainty / obsessive cognitions in OCD. Hence, our findings support a network perspective on OCD, which indicates that obsessions and compulsions should not merely be viewed as inert symptoms of an underlying disorder, but as mutually reinforcing one another (van den Hout, 2014). Therefore, the empirical findings of this dissertation may serve as a clear example of how experimental psychopathology research and this theoretical framework can complement each other.

Clinical implications

Recently, some researchers have argued that compulsive behavior may be at the core of the OCD pathological process and should be the main target of treatment (e.g., Clair et al., 2013; Gillan & Robbins, 2014; Robbins, Gillan, Smith, de Wit, & Ersche, 2012). This is contrary to what is assumed by the cognitive theory of OCD that views obsessive anxiety and cognitions as the core feature of the disorder and the main focus of treatment (e.g., Rachman, 1997; Salkovskis, 1985, 1999). Our findings suggest that it may not be one or the other, but that there is rather mutual reinforcement between checking and OCD cognitions. Checking compulsions cannot simply be viewed as "output" of obsessive concerns, because these compulsions are also present in the absence of obsessive concerns and seem to have a direct, detrimental effect on feelings of uncertainty and obsessive cognitions. However, obsessive cognitions can also not be put aside in treatment and be simply viewed as troublesome by-products of compulsions, because these seem to reinforce checking behavior (e.g., Arntz et al., 2007). Note however, that research showed that obsessive cognitions may decrease regardless of whether the treatment has a specific cognitive component (Whittal, Thordarson, & McLean, 2005) and furthermore, that behavioral therapy (exposure and response prevention; ERP) may be more effective than cognitive therapy for treating OCD (Olatunji et al., 2013). More specifically, because our findings suggest that compulsive behavior may play a more important role in the development and maintenance of *checking OCD* than assumed by cognitive theories, behavioral treatments that are focused on changing checking behavior may be most promising for treating this OCD subtype. However, ERP also has some pitfalls: many patients are often unwilling or anxious to quit their compulsive behavior, which leads to substantial refusal and dropout rates (e.g., Foa et al., 2005; Stanley & Turner, 1995), and treatment effectiveness has not improved

over the years (Whittal, Robichaud, Thordarson, & McLean, 2008). Therefore, ERP interventions should be made more tolerable to improve treatment outcomes, because simply instructing patients with OCD to completely refrain from performing compulsive rituals may not be sufficient. Furthermore, adding interventions that are directly aimed at changing the compulsive behavior, instead of merely quitting this behavior rigorously, may help to improve treatment efficacy.

First, refraining from compulsive checking in ERP can be made more tolerable when it is not only explained to patients that their repetitive behavior is useless, but moreover, that it has direct negative effects. Educating patients about the paradoxical effects of checking and encouraging them not to give in to checking temptations, even when only mildly uncertain situations arise, may help them to better understand the rationale behind ERP. Additionally, the paradigm of the repeated checking task used in chapter 5, could serve as a behavioral experiment to make patients experience that repeated checking causes memory distrust. As described by Shafran, Radomsky, Coughtrey and Rachman (2013) patients with checking compulsions may be asked to compare the impact of checking on their memory confidence, vividness and detail when they repeatedly check the same object as opposed to checking only once. Most patients will experience that after repeated checking they become increasingly confused and uncertain about whether an object is switched off, and the minority of patients who do not find their memory confidence to be effected by compulsive checking typically find no difference in their meta-memory after one check compared with repeated checking. The behavioral experiment may therefore allow patients to conclude that repeated checking is counterproductive or does not benefit their memory and takes up time that could be spend more usefully. In turn, this may increase their motivation to refrain from compulsive rituals and help patients resist the urge to check.

Secondly, instead of merely instructing patients to refrain from compulsive rituals there may be other ways to change compulsive checking. An unexpected, but important implication that can be derived from our findings is that self-monitoring can already have a positive effect on psychopathological symptoms (Craske & Tsao, 1999; van Uijen & Toffolo, 2015). At the start of ERP treatment it may therefore be advisable to ask patients to simply monitor their checking behavior for one or two weeks, because this may already decrease checking behavior and cognitions about the importance of checking. Additionally, our research showed that patients with OCD

are in general more inclined to use checking behavior, which is exacerbated when uncertainty is induced, but unrelated to personal obsessive concerns. This fits well with the findings of Gillan et al. (2011, 2014), who showed that excessive compulsive-like, habitual behaviors develop in patients with OCD in the absence of any prior obsessions. Hence, the checking behavior observed in our studies may be viewed as automatic, habitual behavior, on which patients with OCD appear to overly rely in uncertain situations. Furthermore, automatization also seems to be involved in compulsive checking, as recent research showed that through repetition checking behavior gradually becomes more automatic and requires less attentional control (Dek, van den Hout, Engelhard, Giele, & Cath, 2015). Additionally, the habitual quality of perseverative checking behavior was demonstrated in recent research that showed that due to increased familiarity with repeatedly checked stimuli, the ability to stop reactions to these stimuli (i.e. response inhibition) is reduced (Linkovski, Kalanthroff, Henik, & Anholt, 2015). Patients with OCD often have insight into the irrationality of their compulsive actions; they want to stop, but because their compulsions have become automatic and habitual they cannot exert control over the urge to act (Gillan & Robbins, 2014). Therefore, interventions that are specifically designed for changing habitual behavior may also be beneficial for the treatment of compulsive checking.

One of the most promising strategies for habitual behavior change is the use of implementation intentions (Gollwitzer, 1999), which is often used, and proven effective, to change unwanted habits such as recycling (Holland, Aarts, & Langedam, 2004), smoking (Webb, Sheeran, & Luszczynska, 2009), and unhealthy eating (e.g., Adriaanse, Vinkers, de Ridder, Hox, & de Wit, 2011). Implementation intentions facilitate people's goal attainment by specifying *when* and *how* the behavior that is necessary to obtain a goal is performed. Instead of only describing a desired end-state, implementation intentions consist of detailed "if-then" plans, which specify a critical cue and link this to a goal-directed response (Gollwitzer, 1999). For instance, "if I am watching TV, then I will eat an apple". As easy as this strategy may seem, formulating a good plan is rather complicated. To change existing habitual behaviors, the plan has to target the right personally relevant trigger of the unwanted behavior in order to truly challenge the habitual cue-response association (Adriaanse, de Ridder, & de Wit, 2009). Therefore, a recent study combined implementation intentions with cue-monitoring, which entails closely observing the unwanted behavior in relation to

specific situational and motivational circumstances and reflecting upon the critical cues that trigger the unwanted responses (Verhoeven, Adriaanse, de Vet, Fennis, & de Ridder, 2014). Cue-monitoring was found to enhance insight into one's personal triggers for unwanted behavior and to decrease unhealthy snacking behavior. Moreover, when cue-monitoring was combined with implementation intentions as a metacognitive strategy (which not only involves *planning*, but also training individuals to *monitor* whether the plan is effective, and to *evaluate* whether to repeat the original plan or to formulate a new, more suitable one) this reduced unhealthy snacking over a two-month period and resulted in a lower caloric intake than forming goal intentions or regular implementation intentions (Verhoeven et al., 2015, in review). Hence, especially implementation intentions as metacognitive strategy combined with cue-monitoring appear to be effective in changing habitual behavior.

When translating this to OCD, the unwanted, habitual behavior is the compulsive checking. Because the checking is often executed automatically, the patient is not always aware of the critical cue that triggers this response. Therefore, the "self-monitoring" that was proposed earlier may be combined with more specific "cue-monitoring" to enhance insight into one's personal triggers. After identifying the triggers, the automatic, habitual behavior has to be interrupted and replaced with more appropriate and less disruptive behavior. This is comparable with "habit reversal treatment" for nervous tics, which consists of monitoring/registering the tics and replacing it with a competing response (Azrin & Nunn, 1973; Azrin, Nunn, & Frantz, 1980). For instance, if one always checks the stove 12 times with his/her right hand when entering the kitchen, a more appropriate behavior may be checking the stove one time with one's left hand. Changing the hand that executes the checking requires more attentional control, which may facilitate halting the automatic routine. Thus, the implementation intention would then be "if I enter the kitchen, then I will check the stove one time with my left hand". After forming a plan, the patient can be taught how to monitor the effectiveness of the plan and to evaluate whether to repeat or formulate a new plan. It is important to note however, that forming multiple plans at once is ineffective when changing unwanted behavior (Verhoeven, Adriaanse, de Ridder, de Vet, & Fennis, 2013), and therefore this strategy can only be used to change one habitual checking response at the time. Because patients with checking OCD often perform checking rituals at multiple occasions and with multiple objects this may seem inefficient. However, especially at the beginning of treatment it may be

a helpful strategy to show patients that their checking behavior can be changed to a less unsettling and time-consuming behavior and that they do not have to let go of their checking behavior completely. Furthermore, once a checking ritual has been targeted with an implementation intention and the new desired behavior has been established as an automatic habitual response, another checking ritual can be addressed with this strategy. Therefore, implementation intentions may provide a new and promising way to change checking compulsions and increase therapeutic gains. However, critical empirical testing of their usefulness is required before implementing it in clinical practice.

Conclusions

In sum, this dissertation showed that patients with OCD not only use more checking behavior in general, irrespective of experienced obsessions or intolerance of uncertainty, but importantly, that this is exacerbated when (mild) uncertainty is induced. Moreover, this checking behavior seems specific to OCD and may be explained by indecisiveness and the lowered ability of patients with OCD to rely on internal states. Additionally, our findings demonstrated that checking behavior directly contributes to the exacerbation of other OCD symptoms: it increases memory uncertainty and specific obsession-related cognitions about the severity of threat. By demonstrating these reciprocal relationships between checking and cognitive symptoms in OCD it became clear that checking behavior is more than just “output” of obsessive concerns and may play a role in the development of new OCD problems. Furthermore, the reciprocal relationship between checking and uncertainty fits nicely with the network approach of psychopathology, which conceptualizes psychological disorders as networks of symptoms that mutually interact and reinforce one another. Finally, although more research is needed to further explore the functional relationship between obsessions and compulsions, strategies that are aimed at changing checking behavior directly, such as using the repeated checking task as behavioral experiment, monitoring checking behavior, and the use of implementation intentions, may be promising for improving treatment effectiveness.

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Nederlandse samenvatting

(Dutch summary)

“Heb ik de deur op slot gedaan?”, “Is het gasfornuis wel uitgedraaid?”, “Heb ik de stekker van het strijkijzer uit het stopcontact getrokken?”. Dit zijn normale gedachten die bij iedereen wel eens opkomen. En zelfs heftigere gedachten zoals “Ik zou tijdens het autorijden zo het stuur om kunnen gooien” of “Ik zou die man zo voor de trein kunnen duwen” kunnen zich bij iedereen zomaar opdringen. Meestal zul je hier geen acht op slaan, je misschien even wat ongemakkelijk voelen of een keertje terug lopen naar de deur om te voelen of deze echt op slot zit. Bij mensen met een obsessieve-compulsieve stoornis (OCS; ook wel “dwangstoornis”) is dat echter wel anders. Voor hen zijn deze gedachten zeer verontrustend en roepen ze hevige angst en onzekerheid op. Ze kunnen de gedachten dan ook niet zomaar uit hun hoofd zetten en één check van bijvoorbeeld de deur is vaak niet voldoende om zichzelf gerust te stellen. Hierdoor spenderen ze vaak uren per dag met het herhaaldelijk controleren van zaken om hen heen en kunnen zij zich vervolgens nog steeds onzeker voelen of een mogelijk gevaar daadwerkelijk geweken is.

Wat zijn de kenmerken van OCS?

OCS komt bij ongeveer 1-2% van de bevolking voor (Ruscio, Stein, Chiu, & Kessler, 2010). Het is een heterogene stoornis die gekenmerkt wordt door obsessies (dwanggedachten) en compulsies (dwanghandelingen), waarbij de meeste patiënten beide typen symptomen ervaren (American Psychiatric Association; APA, 2013). Obsessies zijn ongewenste, zich opdringende en steeds terugkerende gedachten, beelden of impulsen die patiënten angstig en ongerust maken. De persoon probeert de obsessies te onderdrukken, te negeren of te neutraliseren met een andere gedachte of handeling, ofschoon deze meestal ervaren worden als oncontroleerbaar (Rachman, 1981). De inhoud van de obsessies kan bestaan uit verontrustende, aanstootgevende of soms onrealistische onderwerpen die betrekking hebben op besmetting, twijfels, schade toebrengen aan jezelf of anderen, religie, onacceptabele seksuele handelingen, geweld of ordelijkheid en symmetrie (Clark, 2004). Compulsies daarentegen zijn herhaalde handelingen (bijv. wassen, controleren, of ordenen) of mentale acties (bijv. tellen, of woorden en nummers in je hoofd herhalen) die bedoeld zijn om de obsessie te onder controle te houden, persoonlijk ongemak te verminderen, en toekomstige ongelukken te voorkomen. De patiënt zelf beschouwt de compulsies vaak ook als overdreven (vooral tijdens rustige momenten), wat persoonlijke weerstand oproept. Echter, de drang om de handelingen uit te voeren is

zo sterk dat de patiënt meestal toch toegeeft en de handeling moet uitvoeren (Rachman & Shafran, 1998). De meest voorkomende compulsies zijn controleren en wassen.

Hoe zouden we OCS kunnen verklaren?

Hoe kan het dat de één opdringende gedachten gewoon weg kan wuiven terwijl die bij een ander maar door zijn hoofd blijven spoken? Hoe kan het dat de één zichzelf gemakkelijk gerust kan stellen en een ander de deuren, ramen en stekkers in zijn huis maar blijft controleren zonder zichzelf echt te vertrouwen? Deze vragen kunnen verband houden met het *ontstaan* van de stoornis (wat is de herkomst van OCS en hoe verergert het?) of met het *voortbestaan* hiervan (wanneer OCS zich heeft ontwikkeld, wat voor processen zijn dan verantwoordelijk voor de hardnekkigheid van de stoornis?). In veel theorieën over het ontstaan en voortbestaan van OCS wordt de nadruk gelegd op de rol van obsessies en worden compulsies als een soort bijproduct gezien, als reactie op de obsessies. Het cognitieve model van Salkovskis (1985), later verfijnd door Rachman (1997), stelt bijvoorbeeld dat obsessies veroorzaakt worden door catastrofale misinterpretaties van normale zich opdringende gedachten, impulsen of beelden (“intrusies”). De patiënt ziet intrusies niet als onbedoeld en nietszeggend (terwijl ze dit wel zijn), maar geeft er een persoonlijke significantie aan: ze worden bijvoorbeeld geïnterpreteerd als belangrijk, onthullend en/of bedreigend. Het feit dat de gedachte opkomt zegt iets over de persoon (“ik ben een slecht mens”) of het hebben van de gedachte wordt gezien als gelijkstaand aan het daadwerkelijk uitvoeren ervan. Deze misinterpretaties gaan gepaard met angst en spanning, wat vervolgens leidt tot compulsief gedrag om de gedachte te onderdrukken of situaties of objecten te vermijden en zo ongelukken te voorkomen.

Het is echter maar de vraag of obsessies altijd vooraf gaan aan compulsies. Spelen compulsies niet ook een belangrijke rol bij het ontstaan en voortbestaan van deze stoornis? Overtuigende onderzoeksbevindingen suggereren dat we compulsies inderdaad niet zomaar aan de kant kunnen schuiven. Vooral het herhaaldelijke karakter van de compulsies doet meer kwaad dan goed, het herhalen werkt averechts: terwijl het herhaaldelijke checkgedrag gebruikt wordt om onzekerheid te verminderen, blijkt dat dit juist het paradoxale effect heeft van het vergroten van onzekerheid (o.a. Van den Hout & Kindt, 2003a, 2003b, 2004). Hoe vaker een

handeling herhaald wordt, hoe minder aandacht eraan gegeven hoeft te worden. En hoe minder aandacht je aan de handeling geeft, hoe minder goed je oplet en onthoudt of je het wel goed gedaan hebt. Deze onzekerheid kan vervolgens het checkgedrag weer versterken wat leidt tot een vicieuze cirkel van verhoogde onzekerheid en checkgedrag. Dit helpt te verklaren hoe OCS blijft *voortbestaan*, en laat zien dat compulsief gedrag zelf ook direct kan bijdragen aan het verergeren van OC-symptomen.

Echter, compulsief gedrag speelt mogelijk ook een rol bij het *ontstaan* van de stoornis. Recentelijk hebben Gillan en collega's (2011, 2014) laten zien dat patiënten met OCS meer vertrouwen op gewoontes dan gezonde mensen en hier ook meer aan vast houden. Dit suggereert dat compulsies niet altijd worden uitgevoerd als doelgerichte pogingen om dreiging te voorkomen, maar dat deze ook gezien kunnen worden als excessieve gewoontes die getriggerd worden ongeacht de wenselijkheid van de consequenties. Daarnaast laten deze studies zien dat excessieve, compulsief-achtige, automatische gedragingen kunnen ontstaan zonder dat er sprake is van obsessies. Tevens hebben verschillende onderzoeken laten zien dat patiënten met OCS over het algemeen meer checkgedrag uitvoeren in de afwezigheid van obsessieve zorgen en angst (Clair et al., 2013; Jaafari et al., 2013; Kim et al., 2012; Rotge et al., 2008). Compulsief gedrag zou dus niet alleen gezien moeten worden als reactie op obsessieve onzekerheden: compulsies zorgen ook voor het voortduren van de stoornis, ze lijken samen te hangen met de neiging van patiënten met OCS tot gewoontegedrag en patiënten lijken over het algemeen, ongeacht obsessies, meer checkgedrag uit te voeren. Maar wat versterkt dit checkgedrag eigenlijk? En draagt de neiging tot checkgedrag direct bij tot het ontstaan van andere OCS symptomen?

Wat is het doel van dit proefschrift?

In dit proefschrift wilden we de rol van checkgedrag in het ontstaan van OCS verder ontrafelen door de wederkerige relaties tussen checkgedrag en cognitieve symptomen van OCS te onderzoeken. Het eerste doel was om te onderzoeken of milde onzekerheid, losstaand van heftige obsessieve zorgen, algemeen checkgedrag kan stimuleren bij patiënten met OCS. Ten tweede was dit proefschrift erop gericht om te onderzoeken of checkgedrag direct bijdraagt aan het verergeren van cognitieve symptomen van OCS. Wanneer we een beter beeld hebben van wanneer

patiënten met OCS precies checkgedrag gebruiken, en wat voor schadelijke effecten dit gedrag zou kunnen hebben, kunnen we vervolgens onderzoeken of het niet uitvoeren van checkgedrag, zelfs wanneer alleen milde onzekerheden opkomen, helpt om het ontstaan van extreme, obsessieve zorgen te voorkomen.

Wat zijn de bevindingen van dit proefschrift?

Dit proefschrift kan eigenlijk opgedeeld worden in twee delen. In het eerste deel (**hoofdstuk 2, 3 en 4**) hebben we het effect van milde onzekerheid op checkgedrag onderzocht. We hebben een nieuw eye-tracking paradigma voor OCS ontwikkeld, waarbij participanten een visuele zoektaak uitvoerden op de computer en hierin aangaven of een “target” (een vierkantje) *aanwezig* (target-present) of *afwezig* (target-absent) was in een veld met “afleiders” (vierkantjes met een opening aan een van de vier zijkanten; afhankelijk van de aanwezigheid van de target waren dit er 24 of 25). De target kon zich overal in het veld bevinden en het was onbekend voor de participanten hoeveel van de 50 zoekvelden (“trials”) een target zou bevatten (50%). Target-present trials waren straight-forward, omdat de response “aanwezig” gebaseerd kon worden op de perceptie van de target. Echter, de target-absent trials riepen milde onzekerheid op, omdat participanten erop moesten vertrouwen dat zij de target niet over het hoofd hadden gezien. Checkgedrag werd vervolgens gemeten met de zoektijd van de participanten en het aantal fixaties dat zij in het veld maakten (gemeten met een eye-tracker). Aan de studies uit hoofdstuk 2 en 3 namen gezonde studenten deel met ofwel veel (OC+) of weinig (OC-) trekken van OCS. Dit was gemeten met een vragenlijst vooraf. Er werd verwacht dat alleen in de milde onzekere situaties (target-absent trials) de OC+ groep meer checkgedrag zou vertonen dan de OC- groep. In **hoofdstuk 2** vonden we dit inderdaad: in target-absent trials zochten OC+ participanten langer en fixeerden vaker (i.e. gebruikten meer checkgedrag) dan OC- participanten, terwijl er in target-present trials geen verschillen waren tussen de groepen. In **hoofdstuk 3** werden deze eerste bevindingen verstevigd doordat de bevindingen op zoektijd werden gerepliceerd en we lieten zien dat target-absent trials inderdaad meer onzekerheid opriepen dan target-present trials. We vonden echter geen verschillen tussen de groepen wat betreft de mate van (on)zekerheid die zij ervoeren tijdens te taak. Doordat we participanten hadden geïncludeerd met scores over de gehele reikwijdte van OC trekken (van heel weinig tot heel veel trekken) konden we daarnaast aantonen dat er

een positieve relatie is tussen OC trekken en checkgedrag in target-absent trials. Dus, hoe meer OC trekken iemand had, hoe langer en preciezer iemand controleerde wanneer milde onzekerheid werd geïnduceerd. Na deze bevindingen hebben we in **hoofdstuk 4** hetzelfde paradigma voorgelegd aan patiënten met OCS en hebben we hun checkgedrag op de visuele zoektaak vergeleken met dat van patiënten met angststoornissen (géén OCS) en gezonde controle-participanten. De drie groepen waren gelijk in man-vrouw verhouding, leeftijd en opleidingsniveau. We vonden dat zowel in target-present als in target-absent trials patiënten met OCS meer checkgedrag gebruikten dan gezonde en angstige controles. Echter, zoals verwacht, was het verschil in checkgedrag tussen patiënten met OCS en de twee controlegroepen groter in target-absent trials dan in target-present trials. Angstcontroles verschilden niet van gezonde controles in checkgedrag in de hele taak. Hierdoor lijkt milde onzekerheid specifiek checkgedrag te stimuleren in patiënten met OCS. Opvallend was dat in alle drie de studies er geen verschillen gevonden werden tussen de groepen wat betreft het aantal fouten dat zij maakten tijdens de taak. Dus, ook al gebruikten personen met (subklinische) OCS meer checkgedrag dan personen met weinig OC trekken/gezonde of angstige controles, dit vergrootte niet hun accuraatheid. Dit toont aan dat de aard van het uitgevoerde checkgedrag van patiënten met OCS in de taak vergelijkbaar is met de irrationaliteit van compulsief checken; het heeft geen natuurlijk einde en duurt voort omdat patiënten zich onzeker voelen over de uitkomst van hun gedrag (Rachman, 2002). De bevindingen van deze drie studies dragen bij aan eerdere onderzoeksbevindingen, omdat ze laten zien dat patiënten met OCS niet alleen over het algemeen meer checkgedrag gebruiken, ongeacht hun obsessieve angst, maar belangrijker nog, dat dit versterkt wordt wanneer onzekerheid is geïnduceerd.

In het tweede deel (**hoofdstuk 5 en 6**) hebben we onderzocht of checkgedrag een directe invloed heeft op andere OC-symptomen. Zoals gezegd laat uitgebreid onderzoek zien dat herhaald checkgedrag het vertrouwen in het geheugen verlaagt (o.a. van den Hout & Kindt, 2003a, 2003b, 2004). Echter, tot nu toe werd steeds het paradoxale effect van slechts één herhaaldelijke checksessie op geheugenonzekerheid onderzocht, waardoor het onduidelijk is wat het verloop van deze geheugenonzekerheid is. Zal de door checken geïnduceerde geheugenonzekerheid verdwijnen nadat de checksessie is afgerond, en alleen weer toenemen na een nieuwe herhaaldelijke checksessie? Of, zal de onzekerheid blijven

bestaan en hierdoor nieuw checkgedrag stimuleren, wat de geheugenonzekerheid over tijd verder zal doen toenemen? In **hoofdstuk 5** hebben we daarom in twee experimenten onderzocht hoe herhaaldelijk checken geheugenonzekerheid over meerdere checksessies beïnvloedt. In experiment 1 voerden studenten twee sessies van een virtuele OC-achtige checktaak uit, waarin ze steeds een aantal gasringen van een virtueel fornuis moesten aanzetten, uitzetten en controleren (vergelijkbaar met de taak van Boschen & Vuksanovic, 2007 en van den Hout & Kindt, 2003a). Tussen de twee sessies in zat een pauze van 30 minuten waarin de participanten een tijdschrift konden lezen of huiswerk konden maken. In experiment 2 voerde een andere groep studenten ook twee sessies uit van de OC-achtige checktaak, maar dit keer op een echt, elektrisch fornuis (vergelijkbaar met de taak van Radomsky, Gilchrist, & Dussault, 2006). De bevindingen van de twee experimenten waren verschillend. In experiment 1 leek geheugenonzekerheid te blijven bestaan nadat de eerste checksessie was afgebroken. Verrassend genoeg kon dit niet worden verklaard door verminderde levendigheid en details van het geheugen, omdat deze maten volledig herstelden voordat ze weer afnamen tijdens de tweede checksessie. In experiment 2, waarin een meer ecologisch valide methode werd gebruikt (er was sprake van echt gevaar wanneer participanten het fornuis aan lieten staan), werden alle drie de meta-geheugenmaten (zekerheid, levendigheid en detail) op dezelfde manier beïnvloed door herhaaldelijk checken: herhaaldelijk checken zorgde voor verminderd vertrouwen in het geheugen in beide sessies, maar herstelde zich tussen de sessies in. Hoewel replicatie door deze gemixte bevindingen gewenst is, lijken de resultaten van experiment 2 meer informatief, zoals beschreven in **hoofdstuk 5**. Herhaaldelijk checkgedrag lijkt dus het vertrouwen in het geheugen te verminderen telkens wanneer deze contraproductieve strategie wordt gebruikt.

De laatste studie, beschreven in **hoofdstuk 6**, draagt bij aan deze bevindingen. In deze studie werden gezonde studenten gevraagd om gedurende één week een hele reeks van OC-achtig checkgedrag uit te voeren (experimentele groep). Een tweede groep (monitorgroep) werd gevraagd om alleen hun normale checkgedrag gedurende één week te monitoren/registreren en een derde groep (controlegroep) kreeg geen opdracht gedurende de testweek. Van alle groepen werd voorafgaand en na afloop van de testweek gemeten hoe *belangrijk* zij het checken van bepaalde zaken in en om het huis vonden, en wat de *kans* en *ernst* zou zijn van mogelijk gevaar wanneer er niet gecheckt zou worden (obsessie-gerelateerde

cognities). De studie liet zien dat het uitvoeren van OC-achtig checkgedrag gedurende één week de obsessie-gerelateerde cognities als geheel deed toenemen. Wanneer we preciezer naar de verschillende constructen keken vonden we dat de toename in algehele obsessieve cognities werd veroorzaakt door een toename in cognities over de *ernst* van het gevaar. Dus, checkgedrag zorgt niet alleen voor een toename in geheugenonzekerheid (**hoofdstuk 5**), maar ook voor een toename in specifieke OC-achtige gedachten over de ernst (overschatting) van het gevaar wanneer het checkgedrag niet zou worden uitgevoerd. Hierdoor lijkt het erop dat checkgedrag een directe bijdrage levert aan de versterking van verschillende OC-symptomen. Noemenswaardig is echter ook de onverwachte bevinding dat de monitorgroep een afname liet zien in het aantal items dat zij gedurende de week hadden gecontroleerd, in cognities over het belang van checken en in algemene angst. Het lijkt er dus op dat het slechts registreren van checkgedrag de mate van checkgedrag doet afnemen waardoor dit mogelijk ook minder belangrijk gevonden wordt. Deze bevindingen hebben mogelijk implicaties voor behandeling (zie hieronder).

Wat betekent dit voor de theorie en de praktijk?

Wanneer we de bevindingen van de eerste drie studies met de bevindingen van de laatste twee studies in dit proefschrift combineren, kunnen we tot nieuwe inzichten komen over hoe algemeen checkgedrag bij kan dragen aan het ontstaan van OCS. Het checkgedrag dat patiënten met OCS uitvoeren in milde onzekere situaties (**hoofdstuk 2, 3, en 4**) kan mogelijk hetzelfde paradoxale effect hebben van het verhogen van onzekerheid telkens wanneer dit checkgedrag wordt uitgevoerd (**hoofdstuk 5**). Daarnaast kan het ervoor zorgen dat obsessieve gedachten over de ernst van mogelijk gevaar toenemen (**hoofdstuk 6**). Eerder onderzoek heeft laten zien dat onzekerheid over het geheugen relatief snel optreedt; al na 2-5 checks laten mensen een verminderd vertrouwen in het geheugen zien (Coles, Radomsky, & Horng, 2006). Dus: de natuurlijke drang van patiënten om meer checkgedrag uit te voeren, m.n. in onzekere situaties, kan al snel zorgen voor een verhoogde geheugenonzekerheid. Hierdoor lopen zij het risico om in de vicieuze cirkel terecht te komen van steeds toenemend checkgedrag en geheugenonzekerheid, wat bij kan dragen aan de ontwikkeling van OCS. Het is dus mogelijk dat de overgang van milde OC-symptomen naar een klinische stoornis o.a. wordt veroorzaakt door het gebruik

van checkgedrag om zekerheid te verkrijgen. Toekomstig onderzoek zou hier uitsluitsel over moeten geven.

Daarnaast passen de bevindingen van dit proefschrift mooi binnen een nieuwe, frisse theorie over psychopathologie: de netwerktheorie (Borsboom & Cramer, 2013). Deze theorie beschouwt psychische stoornissen als een netwerk van causaal verbonden symptomen die elkaar onderling beïnvloeden en vaak wederkerig versterken. Bij een Depressie bijvoorbeeld, kan het verlies van een geliefde voor de volgende kettingreactie zorgen: verdriet → chronische stress → depressieve stemming → slapeloosheid → vermoeidheid → concentratieproblemen. Echter, vermoeidheid kan ook tot een depressieve stemming leiden en een depressieve stemming kan op zijn beurt ook direct leiden tot concentratieproblemen. De verschillende symptomen zijn dus met elkaar verbonden en vormen wederkerige relaties. Dit is ook wat de bevindingen van dit proefschrift laten zien: onzekerheid → checken en checken → onzekerheid en obsessieve cognities. Onze bevindingen ondersteunen dus een netwerkperspectief op OCS, wat laat zien dat obsessies en compulsies niet gezien moeten worden als losstaand, maar als elkaar onderling versterkende symptomen.

De bevindingen van dit proefschrift hebben ook enkele klinische implicaties. Exposure en Response Preventie (ERP) is een van de meest effectieve behandelingen voor OCS waarbij patiënten worden blootgesteld aan hun angsten en hierbij hun compulsies niet mogen uitvoeren. Patiënten zouden deze voor hen vaak lastige therapie mogelijk beter kunnen tolereren wanneer hen niet alleen verteld wordt dat hun herhalende handelingen nutteloos zijn, maar vooral dat deze ook directe nadelige effecten hebben (zoals het verhogen van onzekerheid en obsessieve gedachten). Ter ondersteuning kan het paradigma van de checktaak uit **hoofdstuk 5** gebruikt worden als gedragsexperiment, waardoor patiënten zelf ervaren dat zij onzekerder zijn over hun geheugen na herhaald checken dan na één check. Dit zou hun motivatie om afstand te doen van hun compulsieve rituelen kunnen verhogen en hen kunnen helpen de neiging tot checken te weerstaan.

Ten tweede zijn er mogelijk ook manieren om checkgedrag geleidelijk te veranderen i.p.v. direct volledig te moeten stoppen. Het zelf-monitoren van checkgedrag voorafgaand aan ERP zou mogelijk de mate van het checken en het belang dat eraan gehecht wordt kunnen doen afnemen (zoals gevonden in **hoofdstuk 6**). Daarnaast lijkt het verhoogde checkgedrag dat patiënten met OCS

zelfs in slechts milde onzekere situaties uitvoeren op automatisch gewoontegedrag, wat aansluit bij bevindingen uit eerder onderzoek (o.a. Gillan et al, 2011, 2014). Interventies die specifiek gericht zijn op het veranderen van gewoontes, zoals het gebruik van implementatie intenties, zouden daarom mogelijk ook bevorderlijk kunnen zijn voor de behandeling van compulsief checken.

Conclusies

Samenvattend laat dit proefschrift zien dat patiënten met OCS niet alleen over het algemeen meer checkgedrag uitvoeren, onafhankelijk van ervaren obsessies, maar belangrijker nog, dat dit checkgedrag wordt versterkt door milde onzekerheid. Bovendien lijkt dit checkgedrag specifiek voor patiënten met OCS, terwijl patiënten met andere angststoornissen wel eenzelfde mate van intolerantie van onzekerheid ervaren maar hier dus niet met checkgedrag op reageren. Daarnaast hebben onze bevindingen laten zien dat checkgedrag direct bijdraagt aan de verergering van OCS symptomen: het verhoogt geheugenonzekerheid en specifieke obsessieve gedachten over de ernst van mogelijk gevaar. Door de wederkerige relaties tussen checkgedrag en cognitieve symptomen van OCS te demonstreren werd duidelijk dat checkgedrag meer is dan alleen “output” van obsessieve angsten en dat het mogelijk een rol speelt bij het ontstaan van nieuwe OC problemen. Tot slot, ook al is er meer onderzoek nodig om de functionele relatie tussen obsessies en compulsies verder te onderzoeken, zouden strategieën die bedoeld zijn om checkgedrag direct te veranderen (zoals de checktaak gebruiken als gedragsexperiment, het zelf-monitoren van checkgedrag en het gebruik van implementatie intenties) veelbelovend kunnen zijn om de effectiviteit van bestaande behandelingen te verbeteren.

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I love you. Just cause.

Curriculum Vitae

Curriculum Vitae

Marieke Toffolo was born on June 9, 1986 in Venray, a town in the south of The Netherlands. In 2004 she graduated from secondary school (VWO-Gymnasium) and could not wait to move to a big city to start college. She followed in her parents footsteps and began studying Psychology at Utrecht University. Her interest in research started when she conducted her Bachelor Thesis research on the topic of chocolate temptations. This interest further increased after studying a quarter abroad at the University of California, San Diego (UCSD) in 2007. When she returned home, she did an (extra) internship at the Adolescent Clinic of the Vincent van Gogh Institute in Venray to gain clinical experience. After that she switched back to research and started the Research Masters Program in Social and Health Psychology at Utrecht University in 2008 (graduated Cum Laude in 2010). In 2009 she combined this with a Masters in Clinical and Health Psychology (graduated in 2011) and wrote her Master Thesis about the Proust phenomenon: odors as triggers of aversive memories. After another taste of working in clinical practice at the centre for young adults of Altrecht Mental Health Care, she started her Ph.D. project in experimental psychopathology research on obsessive-compulsive disorder (again at Utrecht University). During this project Marieke also developed a passion for teaching Psychology and was active as member and vice-chair of the Ph.D. Council of the Faculty of Social and Behavioral Sciences and as a Ph.D. representative in the Educational Committee of both the Graduate School of Social and Behavioral Sciences of Utrecht University and the Dutch/Flemish Research School Experimental Psychopathology. Additionally, she spent three months at Concordia University in Montréal Canada to collaborate with Prof. Adam Radomsky. Because she left a piece of her hearth in San Diego she is excited to return in September 2015 and start working as a Lecturer in the Department of Psychology of UCSD.

Publications

Van Uijen, S.L. & **Toffolo, M.B.J.** (2015). Safety Behavior Increases Obsession-Related Cognitions About the Severity of Threat. *Behavior Therapy, 46,* 521-531. doi:10.1016/j.beth.2015.04.001

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Submitted manuscripts

Toffolo, M.B.J., van den Hout, M.A., Engelhard, I.M., Hooge, I.T.C., & Cath, D.C. (2015). Patients with obsessive-compulsive disorder check excessively in response to mild uncertainty. *Manuscript submitted for publication.*

Toffolo, M.B.J., van den Hout, M.A., Radomsky, A.S., & Engelhard, I.M. (2015) Check, check, double check: Investigating memory deterioration within multiple sessions of repeated checking. *Manuscript submitted for publication.*

Conference presentations

Toffolo, M.B.J., van den Hout, M.A., Radomsky, A.S., & Engelhard, I.M. (2015). Check, check, double check: Investigating memory deterioration within multiple sessions of repeated checking. *Poster presentation at the International Convention of Psychological Science (ICPS). Amsterdam, The Netherlands.*

Toffolo, M.B.J., Radomsky, A.S., & van den Hout, M.A. (2015). How do multiple sessions of repeated checking influence memory confidence over time? *Poster presentation at the second annual conference of the Centre for Clinical Research in Health, Concordia University. Montreal, Canada.*

Toffolo, M.B.J., van den Hout, M.A., Engelhard, I.M., Cath, D.C, & Hooge, I.T.C. (2014). Mild uncertainty promotes checking in patients with obsessive-compulsive disorder. *Oral presentation at the fourth meeting of the EABCT S.I.G. on OCD. Assisi, Italy.*

Toffolo, M.B.J., Van den Hout, M.A., Engelhard, I.M., Hooge, I.T.C. & Cath, D.C. (2013). Checking responses to mild uncertainty in patients with OCD. *Oral presentation in Giele, C.L. & Toffolo, M.B.J., New research developments in the psychological understanding of obsessive compulsive disorder. Symposium at the European Association for Behavioural and Cognitive Therapies (EABCT) 43rd Annual Congress. Marrakech, Morocco.*

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Toffolo, M.B.J., van den Hout, M.A., Engelhard, I.M., & Hooge, I.T.C. (2013). Mild Uncertainty Promotes Visual Checking in Subclinical Obsessive-Compulsive Disorder: Data from an Eye-Tracking Paradigm. *Poster presentation at the Anxiety Disorders and Depression Conference 2013. La Jolla (San Diego), USA.*

Toffolo, M.B.J., van den Hout, M.A., Engelhard, I.M., & Hooge, I.T.C. (2012). Stimulus ambiguity promotes visual checking in sub-clinical OCD: Data from an eye-tracking paradigm. *Oral presentation at the European Association for Behavioural and Cognitive Therapies (EABCT) 42nd Annual Congress. Geneva, Switzerland.*

Awards

Battle of the Brains Award 2014 (best presentation), EPP research day of the Dutch-Flemish postgraduate school 'Experimental Psychopathology' (EPP). The Netherlands.

First Place Poster Competition, Second Annual Conference (2015) of the Centre for Clinical Research in Health, Concordia University, Montréal, Canada.