From the laboratory to the clinic (and back again): How experiments have informed cognitive–behavior therapy for obsessive–compulsive disorder

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Abstract
Behavioral and cognitive models—as well as complementary theories such as the inference-based, mood-as-input, and seeking proxies for internal states approaches—have been put forward to explain the development and maintenance of obsessive–compulsive disorder (OCD). Although theory is important to inform the conceptualization and treatment of OCD, experimental research is essential to provide empirical support for these different theoretical approaches. Experiments allow an increased understanding of the mechanisms (e.g., maladaptive beliefs) associated with the etiology and maintenance of OCD symptoms and, in this way, directly contribute to the expansion and creation of cognitive–behavioral treatment strategies. This selective review demonstrates how foundational and sometimes groundbreaking experiments pertaining to core OCD symptoms (i.e., checking/reassurance seeking, obsessions, contamination, and ordering/arranging) have informed the improvement of cognitive–behavior therapy for this debilitating mental illness. The relevance of experiments with both clinical and analog samples is discussed, and recommendations for future experimental work are provided.

Keywords
Obsessive–compulsive disorder, cognitive–behavior therapy, beliefs, experimental psychopathology, mechanisms, knowledge translation, review

Obsessive–compulsive disorder (OCD) affects approximately 2.3% of the population (Ruscio, Stein, Chiu, & Kessler, 2010) and is known to be particularly debilitating. Indeed, OCD was listed among the leading causes of disability worldwide (World Health Organization, 1999). The main
features of this disorder are unwanted intrusive thoughts and/or repetitive behavior (Rachman & Hodgson, 1980). Often, obsessions relate to contamination fear, immoral thoughts, responsibility, and symmetry/incompleteness (e.g., Schulze, Kathmann, & Reuter, 2018). Frequently reported compulsions include checking, washing/cleaning, reassurance seeking, and ordering (e.g., Ball, Baer, & Otto, 1996; Ruscio et al., 2010). Nonetheless, 20–30% of individuals seeking treatment for OCD indicate that their most important symptom is obsessions (Stein, Forde, Anderson, & Walker, 1997).

In this selective review, explanatory models of OCD will be outlined. Then, foundational experiments that have provided evidence for these models and, accordingly, informed cognitive–behavior therapy (CBT) will be discussed. Emphasis will be placed on experimental research pertaining to compulsive checking and reassurance seeking, obsessions, contamination fear, and “just right” experiences. Experiments that have focused on complementary cognitive–behavioral theories will also be addressed. Of note, experiments conducted with both clinical and analog (i.e., undergraduate students and community participants) samples will be reviewed. It is now well established that OCD symptoms and related phenomena (e.g., maladaptive beliefs) are dimensional (vs. categorical) in severity and frequency and that they are sufficiently prevalent in community samples (Abramowitz et al., 2014; Gibbs, 1996). In addition, observing the emergence of compulsive-like behavior in the laboratory with nonclinical samples (i.e., individuals who usually do not engage in such repetitive behavior) provides compelling information about mechanisms associated with the development and maintenance of symptoms.

**Explanatory models of OCD**

**Behavioral models**

Initial theories attempting to explain the development and maintenance of OCD were behavioral in nature and included the two-stage theory of fear and avoidance (e.g., Mowrer, 1939, 1960; Steketee, 1993). According to this model, neutral thoughts are paired with aversive events and, via classical conditioning, become obsessive (i.e., first stage). Then, a failure to habituate to obsessions was proposed to occur due to compulsive behavior, which readily alleviates the anxiety associated with obsessions (i.e., second stage). Early experimental research provided some empirical support for behavioral models. Rachman, de Silva, and Röper (1976) showed that allowing individuals with OCD to engage in checking (after being exposed to a trigger) led to a rapid decay of anxiety and urges to check; conversely, preventing participants from engaging in checking led to equivalent yet spontaneous reductions in anxiety and urges. Such experiments were not only useful to support the two-stage theory but also to inform the use of exposure and response prevention (ERP) in treating OCD, which consists of exposing individuals to feared stimuli and asking them to refrain from engaging in compulsions.

Although this behavioral model provided a theoretical framework for ERP, a number of issues were raised regarding the lack of empirical evidence for the model, making it no longer tenable (e.g., Rachman, 1977; Rachman & Hodgson, 1980; Salkovskis, 1989). More precisely, research does not support a direct association between aversive experiences and the emergence of obsessions (Steketee, 1993). Further, the two-stage theory cannot adequately explain why a single individual may have a broad range of obsessions and why the content of intrusive thoughts is extremely similar across individuals with OCD (Clark, 2004). Finally, compulsions are sometimes associated with an increase in anxiety, as opposed to a decrease (Marks et al., 2000).

It should be noted, however, that recent evidence suggests that a potential mechanism at play in ERP is inhibitory learning (e.g., Milad et al., 2007, 2009). According to this model, associations between neutral stimuli (e.g., thoughts) and aversive events remain intact throughout treatment, but new “safety” associations are also created (i.e., a neutral stimulus becomes associated with the absence of negative consequences; Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). Although findings related to inhibitory learning do not provide direct evidence supporting the two-stage theory, they nonetheless show that behavioral factors are important treatment targets in OCD.

**Cognitive models**

It is now well documented that unwanted intrusive thoughts, similar in content to obsessions, are experienced by nearly everyone (e.g., Rachman & de Silva, 1978; Radomsky et al., 2014). This finding plays a key role in current cognitive theories, such as the cognitive appraisal model, which proposes that
individuals with OCD misinterpret these normal intrusive thoughts as overly meaningful and significant (e.g., Rachman, 1997, 1998, 2002; Salkovskis, 1985, 1999). This then leads normal intrusive thoughts to become recurrent obsessive thoughts and to the emergence of compulsions to prevent the occurrence of negative outcomes. Importantly, it is posited that maladaptive beliefs underlie misinterpretations of intrusive thoughts, such that beliefs should be a core component of treatment according to this model. These beliefs include inflated responsibility, threat overestimation, intolerance for uncertainty, perfectionism, overimportance of thoughts, and beliefs about the need to control one’s thoughts (e.g., Obsessive Compulsive Cognitions Working Group [OCCWG], 1997, 2005). Other lines of research have proposed that metacognition, such as confidence in one’s attention and perception (e.g., Hermans et al., 2008) and negative beliefs about memory (e.g., Alcolado & Radomsky, 2011), also plays a role in the development and maintenance of symptoms. Recent work further suggests that negative beliefs about losing control over one’s thoughts and behavior should also be considered in cognitive models of OCD (Gagné & Radomsky, 2017). Of note, cognitive theories address previously mentioned limitations of behavioral models and is well supported by experimental research (as outlined in the following). Still, other theorists have expanded cognitive models and/or have proposed complementary explanations for the genesis of symptoms in order to broaden our understanding of OCD.

**Complementary and recent theories**

The inference-based approach is a complementary cognitive theory that emphasizes inferential confusion (e.g., O’Connor & Robillard, 1995, 1999). It is proposed that obsessions stem from doubts and hypothetical possibilities that are mistakenly assumed to reflect the true state of the world. In other words, individuals with OCD infer that these doubts and possibilities are true because they engage in a number of maladaptive reasoning processes (O’Connor, Aardema, & Pélissier, 2005). These include, among others, drawing inferences about a reality based on hypothetical scenarios instead of actual observations (i.e., inverse reasoning; e.g., “a lot of people must have opened this door [hypothetical scenario], therefore the knob is dirty [inference]” instead of “this knob is dirty [actual observation], therefore a lot of people must have opened this door [inference]”). O’Connor and colleagues (2005) proposed that the inference-based approach is compatible with the cognitive appraisal model, such that inferential confusion is the cognitive process through which the content of maladaptive beliefs is expressed. Still, instead of beliefs, this approach claims that maladaptive reasoning processes (found in clients’ obsessional narratives) should be a main treatment target (O’Connor & Aardema, 2012).

Alternatively, the mood-as-input hypothesis (e.g., Martin & Davies, 1998; Martin, Ward, Achee, & Wyer, 1993) suggests that individuals with OCD have difficulty stopping themselves from engaging in compulsions because they adhere to a rule of “perform as many compulsions as you can” and that their negative mood (while engaging in compulsions) indicates that they are still not satisfied with the number of compulsions they have performed (Davey, Startup, Zara, MacDonald, & Field, 2003). It is further proposed that this “as many as can” stop rule partially emerges from an inflated sense of responsibility (Davey et al., 2003). Hence, the mood-as-input hypothesis also considers the role of maladaptive beliefs in the maintenance of symptoms and appears to put emphasis on explaining the persistence of compulsions—instead of explaining the genesis of obsessions—making this hypothesis compatible with cognitive theory as well.

Finally, a model termed seeking proxies for internal states claims that individuals with OCD experience pathological doubt, which is manifested in internal states (e.g., doubting one’s attention, perception, memory; Lazarov, Dar, Liberman, & Oded, 2012a, 2012b; Lazarov, Dar, Oded, & Liberman, 2010; Lazarov, Liberman, Hermesh, & Dar, 2014). The model also suggests that doubting one’s internal states leads to difficulty accessing such internal states. As a result, those struggling with OCD rely on proxies (i.e., alternative internal and/or external cues) to put a stop to pathological doubt temporarily. Individuals with OCD may have difficulty knowing when their hands are clean. They thus are proposed to rely on a proxy (e.g., washing ritual) to attenuate the doubt that their hands might still be dirty (Lazarov, Cohen, Liberman, & Dar, 2015). According to this approach, this reliance on internal and/or external proxies should be attenuated throughout treatment to see a reduction in symptoms (Lazarov et al., 2010).

**Experimental research**

Although a number of theories have been put forward in the literature, it is extremely important to ensure
that such models are supported by empirical evidence. Theoretical models are essential to inform clinical practice and to identify novel treatment targets. In this way, empirically supported models are the foundation of and the route toward evidence-based psychotherapies. Experiments are a particularly compelling source of support for theories as they allow for the assessment of causal mechanisms—something that correlational work cannot do. In an experiment, an aspect of a theoretical model thought to influence or exacerbate symptoms is often manipulated (i.e., independent variable) and its impact on OCD symptoms or other variables of interest (i.e., dependent variable) is then measured.

For example, Salkovskis (1985) proposed that an inflated sense of responsibility underlies misinterpretations of unwanted intrusive thoughts in OCD, which then leads to recurrent obsessional thoughts and compulsions. Using an experimental design, Lopatka and Rachman (1995) tested this theory in a sample of participants with OCD. The authors manipulated responsibility beliefs using contracts: in the high responsibility condition, participants signed a contract indicating they were fully responsible for anything bad that might happen during a subsequent behavioral approach test; however, in the low responsibility condition, the experimenter signed a contract indicating that they were fully responsible. Following the manipulation, Lopatka and Rachman found that low perceived responsibility caused significant declines in urges to check and discomfort. This is a demonstration of how an experiment provided evidence for the causal mechanism between responsibility and OCD symptoms, a core aspect of the cognitive appraisal model. Critically, such experiments have informed novel cognitive strategies to target responsibility and alleviate compulsive checking.

Compulsive checking and reassurance seeking

Checking is among the most frequently reported compulsions in those diagnosed with OCD (e.g., Ruscio et al., 2010). As predicted by the cognitive appraisal model, Rachman (2002) theorized that the severity of compulsive checking is influenced by three cognitive multipliers or belief domains: inflated responsibility as well as perceived probability of harm and perceived severity of harm (i.e., threat overestimation). Rachman added that compulsive checking is reinforced through a self-perpetuating mechanism, which involves paradoxical increases in responsibility and harm probability, and paradoxical decreases in memory confidence along with the absence of certainty regarding the end of the threat. This theory builds on Salkovskis’ (1985) cognitive model of OCD, which also designates inflated responsibility as a core component of symptom maintenance. In this way, a number of experimental studies have been dedicated to supporting the role of inflated responsibility as a mechanism involved in the development and maintenance of urges to check and checking behavior.

Inflated responsibility and threat overestimation

As previously described, Lopatka and Rachman (1995) were able to show the effect of low perceived responsibility on urges to check and discomfort with a clinical sample. Ladouceur and colleagues (1995) expanded on these findings by demonstrating that nonclinical participants engaged in significantly more checking behavior and reported significantly more anxiety and preoccupation with errors during a task under conditions of high (vs. low) responsibility. The authors manipulated responsibility by telling participants that their performance on a medication classification task would have implications for the manufacture of that medication (i.e., high responsibility), whereas others were told that the task was a practice run (i.e., low responsibility). Interestingly, participants in the high (vs. low) responsibility condition also believed that the negative consequences of the task would be more severe and reported that the odds of negative consequences happening were higher. These findings mirror Rachman’s (2002) proposed interaction between inflated responsibility and threat overestimation in exacerbating checking behavior. Results supporting a causal relationship between responsibility and checking were later replicated in experiments with both clinical and nonclinical samples (e.g., Arntz, Voncken, & Goosen, 2007; Ladouceur, Rheaume, & Aublet, 1997).

Reassurance seeking or checking “by proxy” (Rachman, 2002) is defined as repetitively seeking safety-related information, despite having already received the information previously (Parrish & Radomsky, 2006). Therefore, Parrish and Radomsky hypothesized that inflated responsibility could be one of the mechanisms driving this behavior. To manipulate responsibility in undergraduate students, the authors used a similar paradigm as in the study by Ladouceur et al. (1995) and found that those in the
high (vs. low) responsibility condition reported greater urges to seek reassurance. These findings were recently expanded to reassurance-seeking behavior, also using an experimental design (Leonhart & Radomsky, in press). Further, it was found that seeking reassurance predicted lower perceived responsibility, such that this behavior may be an interpersonal technique aiming to transfer one’s responsibility. Hence, beliefs about responsibility may be involved in direct and indirect forms of compulsive checking.

Metacognition: Memory, attention, and perception

Radomsky, Rachman, and Hammond (2001) asked compulsive checkers to reflect back on checking-related tasks. Although participants had a positive memory bias toward threat-relevant information, the authors also found that participants were significantly less confident about their memory under conditions of high (vs. low or no) responsibility. Similarly, Tolin and colleagues (2001) found that individuals with OCD, especially those with primary checking, experience a progressive decline in memory confidence over repeated trials of checking objects previously categorized as “unsafe,” as opposed to those categorized as “safe” or “neutral.” These findings reflect another important aspect of Rachman’s (2002) cognitive theory of compulsive checking: the role of poor memory confidence in perpetuating checking. The theory (rooted within the cognitive appraisal model) claims that repetitive checking tarnishes one’s memory of the checking. Accordingly, memory confidence (or one’s beliefs about their memory) deteriorates as checking increases. Compulsive checkers are then caught in a cycle of declining certainty: the more you check, the less confident you become.

A number of experiments have provided support for this theory and have focused on both physical checking and mental checking. van den Hout and Kindt (2004) published a series of three experiments demonstrating that memory confidence, vividness, and detail decrease as a result of repetitive checking. In the experimental condition, undergraduate students were subjected to 20 trials of checking a virtual gas stove (i.e., relevant and threatening checking); in the control condition, participants were subjected to 20 trials of checking virtual light bulbs (i.e., irrelevant and nonthreatening checking). As expected, recollections of the last checking episode were significantly less vivid and less detailed, and memory confidence was significantly poorer in the experimental (vs. control) condition. Of note, memory accuracy remained unaffected, indicating that compulsive checking mainly affects thoughts and beliefs about one’s memory. Radomsky, Gilchrist, and Dussault (2006) replicated these findings while asking undergraduate students to check a real stove in the experimental condition (i.e., relevant checking) and to check a real kitchen faucet in the control condition (i.e., irrelevant checking). The paradoxical effect of physical checking on memory confidence has been replicated in both clinical and nonclinical samples (e.g., Coles, Radomsky, & Horng, 2006; Radomsky, Dugas, Alcolado, & Lavoie, 2014; Toffolo, van den Hout, Radomsky, & Engelhard, 2016) and appears to be exacerbated under conditions of high responsibility (e.g., Boschen & Vukusic, 2007; Moritz et al., 2007).

Radomsky and Alcolado (2010) also extended this line of research to mental checking. Depending on condition assignment, undergraduate students were asked to either physically or mentally check a kitchen stove. After 10 trials of checking in either modality, all participants were instructed to physically and mentally check the stove again. The authors found that repeated mental checking led to decreased memory confidence, vividness, and detail for the last mental (but not physical) check and vice versa. This indicates that a match in checking modality may be an essential component of this phenomenon. The impact of repetitive checking on other metacognitive processes has been examined as well. For instance, Hermans and colleagues (2008) found that five checking trials of individually selected compulsive actions were enough to cause increased attention distrust in individuals with OCD. Moreover, van den Hout, Engelhard, de Boer, du Bois, and Dek (2008) demonstrated that prolonged staring at gas rings or light bulbs caused uncertainty about one’s perception. Later, van den Hout and colleagues (2009) conducted a similar version of this study and found that even relatively short intervals of staring can lead to uncertainty about perception. Together these results indicate that paradoxical effects pertaining to repetitive checking (and staring) affect a number of metacognitive processes.

Although these results suggest that the symptom itself (i.e., checking) may be self-perpetuating via increasing uncertainty and metacognitive decay, cognitive theory stipulates that dysfunctional beliefs are involved in the development of symptoms (e.g., Rachman, 1997, 1998, 2002; Salkovskis, 1985, 1999).
Alcolado and Radomsky (2011) thus predicted that holding negative beliefs about memory would play a role in the emergence of checking. The authors experimentally manipulated undergraduate participants’ beliefs about their memory by providing them with false feedback about their performance on a standardized memory test. They found that participants who had been told that they scored poorly on the standardized test (i.e., low memory confidence condition) reported significantly greater urges to check during a subsequent memory task, as compared to participants who had been told that they scored highly on the test (i.e., high memory confidence condition). This led the authors to propose the integration of beliefs about memory as an important etiological mechanism in cognitive models of OCD.

Beliefs about losing control

Recently, Gagné and Radomsky (2017) explored other belief domains that could influence the occurrence of checking in OCD and focused their work on control cognitions. Clark (2004) posited that failed attempts at controlling one’s unwanted intrusive thoughts are misinterpreted as catastrophic by individuals with OCD (e.g., “Losing control over my thoughts means I can lose control over my behavior and act on the thought”). Based on the cognitive appraisal model, he added that such misinterpretations likely lead to escalations in distress and frequency/salience of intrusive thoughts. Gagné and Radomsky thus hypothesized that believing that one can lose control over their thoughts and behavior would result in elevated checking behavior. Indeed, checking and other compulsions are often conceptualized as maladaptive techniques to increase one’s sense of control (e.g., Reuven-Magril, Dar, & Lberman, 2008). In a sample of undergraduate students, Gagné and Radomsky manipulated beliefs about losing control by providing false feedback to participants about their performance on a task asking them to inhibit their intrusive thoughts. Participants were led to believe that they were either more or less likely to lose control over their thoughts and behavior as compared to a normative sample. As predicted, it was found that participants with high (vs. low) negative beliefs about losing control engaged in significantly more checking behavior during a subsequent task asking them to control pictures. It was recommended to broaden beliefs about control in cognitive models of OCD by integrating aspects of losing control.

Mood-as-input hypothesis

Experimental support has also been provided for the mood-as-input hypothesis in relation to the perpetuation of checking. Using an experimental design, Davey, Startup, Zara, MacDonald, and Field (2003) manipulated both mood and “stop rules” in an analog sample. First, to manipulate mood, participants listened to a piece of music that had been shown to induce either positive or negative mood. Second, to manipulate “stop rules,” some participants were asked to generate as many items as they could during a subsequent task, whereas others were asked to generate items as long as they felt like continuing. Specifically, participants were asked to generate items that would need to be checked for safety-related reasons before leaving on holiday. The authors found that participants who were in the negative mood condition and were adhering to the “as many as can” rule generated significantly more checking items and spent significantly more time performing the task, as compared to those in the positive mood condition who were adhering to the same rule and to those in the negative mood condition who were adhering to the “feel like continuing” rule. This finding supports the mood-as-input hypothesis, given that the compulsive checkers are thought to be in a negative mood while engaging in compulsions and to adhere to such “as many as can” rules, likely because of an inflated sense of responsibility (Davey et al., 2003).

Clinical implications

Although ERP is still widely used to treat compulsive checking and is currently listed as a first-line treatment for OCD (National Institute for Health & Clinical Excellence, 2005), the abovementioned experimental findings transformed the way that checking is targeted in CBT, primarily through the development of novel cognitive strategies (e.g., Rachman, 2003), that might even be more acceptable (e.g., Levy, Senn, & Radomsky, 2014; Shafran, Radomsky, Coughtrey, & Rachman, 2013; but see Ong, Clyde, Bluett, Levin, & Twohig, 2016). For instance, therapists can target inflated responsibility using behavioral experiments that stem from such experimental designs. As in Lopatka and Rachman’s (1995) study, contracts can be used to temporarily transfer responsibility to the therapist and eventually to family members. Clients can then assess how their urges to check, actual checking, and anxiety vary under conditions of transferred versus baseline/inflated responsibility.
Such behavioral experiments allow clients to gather new, credible, and personally relevant information and are thus a core component of cognitive change (Radomsky et al., 2010). Based on the work presented above (Leonhart & Radomsky, in press; Parrish & Radomsky, 2006), we suggest that behavioral experiments involving contracts and a transfer of responsibility could also be used to treat excessive reassurance seeking, but intervention studies are necessary to assess this hypothesis.

Further, maladaptive beliefs about checking can be challenged with psychoeducation about the relationship between repetitive checking and memory confidence/attention distrust. Specifically, findings from the experiments described above (e.g., Radomsky et al., 2006; van den Hout & Kindt, 2004) can be presented to clients. Therapists can emphasize that this decrease in memory confidence was observed in undergraduate students, such that most individuals are susceptible to the paradoxical effects of repetitive checking. Elements stemming from those experiments can be used to create behavioral experiments and test the theory in the clinic (e.g., Radomsky et al., 2010; Toffolo et al., 2016). Clients can be asked to track and compare their memory confidence, vividness, and detail when checking once versus for a lengthy period of time. Based on their own experimental work (Alcolado & Radomsky, 2011), Alcolado and Radomsky (2016) proposed and assessed a new cognitive intervention to target negative beliefs about one’s memory. They demonstrated that these beliefs could be shifted by asking clients to gather objective evidence about the true state of their memory ability between therapy sessions.

**Future directions**

Creating a pie chart is another cognitive strategy that is often used to target beliefs about responsibility in the clinic (e.g., Radomsky et al., 2010; Salkovskis, 1999; van Oppen & Arntz, 1994). Pie charts consist of asking clients to estimate other people’s percentage of responsibility in preventing potential mishaps (e.g., ensuring the house does not get robbed), to place these numbers in a pie chart, and to then (re)assess their own percentage of responsibility (i.e., what is left in the pie chart). It would therefore be relevant for researchers to design an experiment in which responsibility beliefs are manipulated using pie charts and to assess whether checking behavior is directly influenced by this procedure. This is a clear example of how clinical work can affect and interact with laboratory research.

Behavioral experiments are also a useful tool to challenge threat overestimation and reduce checking behavior. Clients are often encouraged to track whether their estimate of the probability of a negative event happening and their perceived seriousness of that same negative event decrease as checking increases (e.g., Clark, 2004; Radomsky et al., 2010). Again, this clinical tool could be brought to the laboratory. Participants could be asked to provide pre- and post-estimates of perceived likelihood/severity (e.g., kitchen catching on fire) after checking (a laboratory stove) once versus for a lengthy period of time, depending on condition assignment.

Experiments and intervention studies are warranted to determine which cognitive strategies would be useful to challenge negative beliefs about losing control, although behavioral experiments are a likely avenue (Gagné & Radomsky, 2017). Moreover, concrete interventions emerging from the mood-as-input hypothesis should be formulated and assessed to better inform CBT for checking. For example, it is unclear whether challenging responsibility simultaneously targets “as many as can” stop rules. This possibility could be tested in the laboratory using similar experimental manipulations as the ones described above.

**Obsessions**

As explained previously, both behavioral (e.g., Mowrer, 1939, 1960) and cognitive (e.g., Rachman, 1997, 1998) models have been put forward to explain the genesis and maintenance of obsessions. Still, specific factors thought to exacerbate unwanted intrusive thoughts have been incorporated into models of OCD and have been studied experimentally to better understand and treat obsessions.

**Thought–action fusion**

Rachman (1997, 1998) initially proposed that two types of thought–action fusion (TAF), namely likelihood (i.e., belief that having a thought about an outcome increases the likelihood of that outcome happening) and moral (i.e., belief that having a thought about an immoral action is as immoral as doing the action), are core cognitive factors underlying active resistance to intrusive thoughts in
individuals with OCD. Current cognitive conceptualizations of OCD—such as the cognitive appraisal model—categorize TAF as a cognitive bias that exacerbates dysfunctional beliefs about the importance of thoughts, which then leads to faulty appraisals of unwanted intrusive thoughts and to recurrent obsessions (e.g., Frost & Steketee, 2002; OCCWG, 1997; Shafran & Rachman, 2004).

Early experiments focusing on TAF provided support for the use of ERP in treating OCD. Rachman, Shafran, Mitchell, Trant, and Teachman (1996) elicited TAF in the laboratory by asking students (who scored high on a TAF scale) to think about a friend or relative who is close to them and to then insert the person’s name in statements such as “I hope ____ is in a car accident.” After copying the sentence, participants were instructed to think about the situation for a few seconds. Participants reported experiencing anxiety and guilt, and some even refused to write down the statements. It was found that immediately engaging in neutralizing behavior (e.g., destroying the paper) had the same function as a compulsion and alleviated anxiety and guilt. The authors also found that negative emotions naturally decreased when participants in a different condition waited 20 min before engaging in neutralizing behavior (strengthening the rationale for ERP). van den Hout, van Pol, and Peters (2001) replicated these findings in a sample of undergraduate students who were not initially screened for high levels of TAF.

Later, Rassin, Merckelbach, Muris, and Spaan (1999) provided preliminary experimental support for the role of TAF in exacerbating obsessions. Using a bogus electroencephalographic (EEG) recording session, they manipulated TAF in high school students: participants in the TAF condition were told that the EEG device was able to pick up the word “apple” and that an electrical shock would be delivered to another person every time the word would be detected; participants in the control condition were told that the EEG device was able to pick up the word “apple.” It was found that participants in the TAF condition experienced significantly more target thoughts (i.e., “apple”) and greater discomfort and thought resistance.

Moreover, Berman, Wheaton, and Abramowitz (2012) provided experimental support for Rachman’s (1998) assertion that intrusive thoughts about vulnerable individuals are more likely to elicit TAF than those about able-bodied individuals. Depending on condition assignment, undergraduate students were instructed to either think about a vulnerable (e.g., elderly male) or able-bodied (e.g., strong and young male) individual getting into a car accident. Findings showed that those in the “vulnerable” (vs. “able-bodied”) condition reported significantly higher likelihood estimates of the accident happening (i.e., TAF-likelihood) and significantly greater urges to engage in neutralization, along with higher anxiety, guilt, and moral wrongness. The authors referred to this phenomenon as the “Arnold Schwarzenegger effect,” such that the content of intrusive thoughts seems to interact with beliefs about the importance of thoughts.

Thought suppression
A social cognition experiment by Wegner, Schneider, Carter, and White (1987) directly influenced cognitive theories explaining the development and maintenance of obsessions and opened a new research domain in OCD on thought suppression. Based on condition assignment, undergraduate students were first instructed to either suppress or express their thoughts about a white bear. Then, they were instructed to do the opposite. Researchers found that participants who first experienced the “suppression” phase expressed significantly more white bear thoughts during the “expression” phase, as opposed to participants who started with the “expression” phase. It was concluded that thought suppression causes a rebound effect. Thus, some authors suggested that persistent thought suppression is responsible for the maintenance of recurrent obsessive thoughts in OCD (e.g., Wenzlaff & Wegner, 2000). However, replication studies and extended versions have provided mixed findings in both clinical and nonclinical samples.

For instance, Salkovskis and Campbell (1994) had undergraduate students with frequent obsessional thoughts engage in a modified thought suppression paradigm and demonstrated that suppression of a personally relevant negative thought led to an immediate enhancement effect, but no rebound effect was found. However, Purdon and Clark (2001) found no immediate enhancement and no rebound effects when undergraduate students were instructed to either suppress or simply monitor (depending on condition assignment) obsessional thoughts, pleasant thoughts, and neutral (white bear) thoughts. In the same vein, Janeck and Calamari (1999) did not find any
suppression effects in a similar experiment conducted with individuals with OCD and clinical controls. Given these inconsistencies, Abramowitz, Tolin, and Street (2001) conducted a meta-analysis of thought suppression experiments and identified a small-to-moderate post-suppression rebound effect but no immediate enhancement effect. These polarizing findings were clearly an issue for aspects of cognitive models emphasizing the role of thought suppression in obsessions. Nonetheless, by relying on the cognitive appraisal model, Purdon and Clark (e.g., Purdon, 2001, 2004; Purdon & Clark, 2000, 2001) explained that the role of thought suppression in OCD is more complex than a paradoxical rebound effect, such that misappraisals of mental control effort may be a central piece to consider.

Misappraisals of thought recurrence

With a focus on cognitive control as it pertains to obsessions, Clark (2004) suggested that faulty appraisals of excessive mental control play a key role in the escalation of intrusive thoughts. Purdon and Clark (2000, 2001) also indicated that beliefs about responsibility and the importance of thoughts underlie misappraisals of thought control failure. In support of this idea, Purdon (2001) conducted an experiment in which she first asked undergraduate students to either suppress or not suppress (depending on condition assignment) an idiosyncratic obsessive thought during a 4-min interval, followed by another 4-min interval of “not suppressing” for all participants. Then, participants were asked about their appraisals of thought recurrence in relation to the first interval. Similar to other thought suppression experiments, no immediate enhancement and rebound effects were found. But most importantly, the author found that appraisals related to TAF and responsibility (e.g., “the more I had the thought the more responsible I felt for making sure it didn’t happen in real life”; Purdon, 2004, p. 128) predicted discomfort over thought recurrence during the first interval. Beliefs about the need to control one’s thoughts also predicted active resistance to the obsessional thought. A replication of this experiment with a clinical sample revealed similar results (Purdon, Rowa, & Antony, 2005), providing evidence for the importance of misappraisals of mental control, beyond paradoxical suppression effects, in cognitive models of obsessions.

Clinical implications

Because a third of clients with OCD report that obsessions are their main and sometimes only concern (Stein et al., 1997), cognitive strategies are particularly important in the treatment of this phenomenon (e.g., Rachman, 2003). Indeed, ERP primarily targets the reduction of compulsions. Based on experimental work, it appears that targeting cognitive domains beyond inflated responsibility, such as beliefs related to the importance of and need to control one’s thoughts (including TAF), is important in CBT for obsessions.

Along this line, behavioral experiments are an optimal technique to challenge TAF-likelihood (e.g., Clark, 2004; Rachman, 2003; Whittal & McLean, 2002). As in Rachman et al. (1996) and van den Hout et al. (2001), TAF can be elicited in the clinic by asking clients to write down anxiety-inducing statements. Clients can then compare their urges to neutralize and ratings of negative emotions immediately after writing the statement versus after a lengthy period of time. More elaborated but related versions of this behavioral experiment have been proposed, such that clients can be asked to first record a baseline occurrence of a positive event happening (e.g., winning the lottery). During the following week, clients can then think about the event happening every morning and record occurrences of the event happening. Recorded occurrences during the baseline versus TAF weeks are then compared. The same behavioral experiment can be repeated with an obsessional thought to further challenge TAF-likelihood.

We also suggest that findings from Berman and colleagues’ (2012) experiment could be utilized in the clinic to highlight the irrational nature of TAF. Specifically, clients can be asked to compare their likelihood estimates of negative events happening and their ratings of negative emotions when experiencing intrusive thoughts involving vulnerable versus strong individuals. Following the behavioral experiment, Socratic questioning can be used to discuss the relationship between the content of a thought and the perceived likelihood of a thought becoming reality.

Beliefs about the need to control one’s thoughts can also be challenged via behavioral experiments (e.g., Clark, 2004; Rachman, 2003; Salkovskis, 1999). These cognitive strategies are directly related to manipulations from thought suppression experiments (e.g., Purdon & Clark, 2001; Salkovskis & Campbell, 1994; Wegner, Schneider, Carter, &
White, 1987). Clients can be asked to exert excessive control over their obsessions during 1 week and to respond to their obsessions as they usually do during the subsequent week. Clients then compare levels of thought recurrence, anxiety, control effort, and compulsive behavior between both weeks. The costs and benefits of consistently monitoring/controlling one’s thoughts can also be discussed. As in Wegner et al. (1987), white bears thoughts can be used at first to demonstrate the basic phenomenon.

Future directions

Future experiments should emphasize manipulations of beliefs about the negative consequences of failed thought control, given that such beliefs are likely primary mechanisms underlying obsessions (e.g., Clark, 2004). Because clients often report that having poor control over their thoughts will lead to them losing control over their behavior (e.g., Clark, 2004), Gagné and Radomsky (2017) started to explore this avenue by manipulating negative beliefs about losing control. Still dependent variables did not include intrusive thoughts. As noted by Purdon (2004), thought suppression research is still fundamental to better understand obsessions, but the focus should go beyond paradoxical rebound effects and emphasize appraisals. Nonetheless, the cognitive appraisal model predicts that all belief domains identified by the OCCWG (2005) lead to the escalation of intrusive thoughts. Experiments are thus warranted to explore the causal role of all these beliefs in the emergence and maintenance of obsessions.

Interestingly, Aardema and O’Connor (2003) suggested that inconsistencies in thought suppression experiments are in part due to a poor conceptualization of the actual thoughts that are suppressed in these studies. They indicated that participants in such experiments likely confuse recurrent thoughts about the instructions of the study (e.g., “I shouldn’t be thinking about white bears now”) with actual thoughts about white bears (e.g., “White bears are big animals”) and consequently infer that they are experiencing recurrent target thoughts. For Aardema and O’Connor, greater thought recurrence in these experiments is actually an indication of greater thought confusion, a core component of the inference-based approach to OCD. Although a small-scale randomized clinical trial provided support for the use of inference-based therapy for obsessions (O’Connor et al., 2005), experimental work showing a direct causal effect of thought confusion on recurrent obsessive thoughts is warranted to better inform treatment.

Contamination fear

Concerns about contamination are a hallmark feature of OCD and are characterized by persistent feelings of dirtiness despite engaging in washing behavior (Hodgson & Rachman, 1972). Classically characterized as a fear of physical contamination, research previously focused on the effects of direct contact with contaminants (e.g., Dorfan & Woody, 2006). Consequently, treatments have focused on reducing symptoms of physical contamination using repeated exposure to sources of contamination (e.g., Foa et al., 2005). However, efficacy trials of ERP show that symptoms persist in 40–50% of patients (e.g., Fisher & Wells, 2005). One reason that has been proposed is that contamination fear consists of concerns arising in domains other than physical contamination. Indeed, survivors of sexual assault with OCD have reported that feelings of contamination and urges to wash are triggered simply by recalling their assault or thinking of their attacker (e.g., Fairbrother & Rachman, 2004). Rachman (1994, 2006) suggested that washing and cleaning compulsions could be more effectively treated if mental contamination was acknowledged as an additional treatment target in CBT.

Mental contamination

Mental contamination refers to feelings of dirtiness in the absence of direct contact with a physical source of contamination or to a feeling of moral corruption (Rachman, 1994, 2006). Based on the cognitive appraisal model, Rachman, Coughtrey, Shafran, and Radomsky (2015) posited that mental contamination emerges from serious misinterpretations of a perceived violation. This cognitive theory stems from research by Fairbrother and Rachman (2004) who studied urges to wash in 50 female survivors of sexual assault and found that 70% of victims reported an urge to wash following the assault. Further, recalling the assault in the laboratory was sufficient to induce washing behavior in 20% of participants. In this way, Rachman and colleagues added that triggers (e.g., intrusive thoughts and images pertaining to dirtiness, immorality, and violation) lead to feelings of “pollution,” which are misinterpreted as evidence that one is bad, dangerous, dirty, and so on. In other words, individuals with mental contamination engage in the
ex-consequentia bias: they infer that their feelings of guilt, shame, and disgust mean something about them (e.g., “If I feel guilty, it means I did something wrong, and therefore I am contaminated”). Individuals then engage in compulsive behavior, such as washing, to counteract feelings of mental contamination. Recent qualitative work provided further support for this theory: Zysk, Shafran, and Williams (in press) interviewed individuals with mental contamination and found that 76.5% of them recalled a direct learning experience leading to their symptoms. These experiences were often violations and immoral acts, such as being bullied, cheated on by their partner, or wrongly accused of rape.

To study this phenomenon experimentally, Fairbrother, Newth, and Rachman (2005) developed the “dirty kiss” paradigm to induce mental contamination as described by victims of sexual assault. In this paradigm, participants are asked to listen to a recording and imagine themselves in the described scenario as vividly as possible. The scenarios consist of a kiss at a party described as romantic and mutually enjoyable in the consensual condition or as unwanted and forced in the nonconsensual condition (i.e., a violation).

When this paradigm was used in a sample of undergraduate females, exposure to the nonconsensual recording did induce feelings of dirtiness and discomfort in participants (Fairbrother, Newth, & Rachman, 2005). Precisely, those in the nonconsensual (vs. consensual) condition were significantly more likely to report urges to wash and to engage in neutralizing behavior (e.g., distraction and thought stopping). Eight participants even engaged in washing and rinsing behavior to neutralize feelings of mental contamination. Although this experiment and other replications (e.g., Herba & Rachman, 2007) show that mental contamination is an important aspect of washing compulsions and anxiety in OCD, questions remained about the effect of different descriptions of the perpetrator in inducing mental contamination.

Elliott and Radomsky (2009) modified the “dirty kiss” paradigm such that both the desirability of the kiss and the morality of the perpetrator varied across conditions. Indeed, female undergraduate participants were provided with information about the morality of the man before learning about the kiss. They found that listening to a recording describing a nonconsensual (vs. consensual) kiss led to significantly greater feelings of dirtiness and urges to wash, regardless of the morality of the perpetrator. Still, receiving a consensual kiss from an immoral (vs. moral) man produced feelings of dirtiness and urges to wash. Later, Elliott and Radomsky (2012) manipulated the physical dirtiness of the man across conditions and found that listening to a scenario describing a nonconsensual kiss from a dirty man led to significantly greater feelings of dirtiness, urges to wash, and negative emotions, as compared to a nonconsensual kiss from a clean man and a consensual kiss from a clean or dirty man. Interestingly, feelings of mental contamination were comparable between the nonconsensual kiss + clean man condition and the consensual kiss + dirty man condition.

In other versions of the paradigm, the roles were reversed and male undergraduate participants were asked to imagine themselves as the perpetrator (Rachman, Radomsky, Elliott, & Zysk, 2012). Similar results emerged such that participants in the nonconsensual (vs. consensual) kiss condition reported greater feelings of dirtiness, urges to wash, as well as shame, disgust, and guilt. It was thus shown that imagined unacceptable acts (whether experienced by the perpetrator or the victim) can induce mental contamination. This effect was replicated in females imagining themselves as perpetrators (Waller & Boschen, 2015).

Social psychological research has also helped shed light on the phenomenon of mental contamination. Zhong and Liljenquist (2006) explored the “Macbeth effect” (i.e., when a threat to one’s sense of morality evokes a need to physically clean oneself). The authors asked participants to remember and describe an immoral deed from their past and found that washing one’s hands using sanitation wipes (vs. not washing) led to significantly lower levels of emotions related to morality (e.g., disgust, shame, guilt) and to a significantly lower desire to engage in volunteering. Later, clinical research demonstrated that these findings were stronger in samples of individuals with OCD (vs. matched control participants; Reuven, Lieberman, & Dar, 2014). Hence, in OCD, washing might lead to a temporary reduction of negative emotions and of mental feelings of dirtiness, thereby reinforcing compulsive behavior.

In line with this hypothesis, Coughtrey, Shafran, and Rachman (2014) demonstrated that a number of tasks can evoke significant increases in reported mental contamination, urges to wash, washing behavior, and anxiety in undergraduate students. These included recalling autobiographical memories in which participants had violated a moral standard (i.e., perpetrator memory) or in which they had felt
betrayed by someone (i.e., victim memory) and inducing unwanted thoughts and images associated with undesirable individuals (e.g., imagining wearing a sweater belonging to an immoral person). The authors had participants either (1) repeat the task that induced the most mental contamination 20 times without engaging in neutralizing behavior (i.e., reevoke condition); (2) repeat the task 20 times but engage in washing behavior between each induction (i.e., washing condition); or (3) repeat the task once and do nothing for 20 min (i.e., control condition). Participants in the control (vs. reevoke and washing) condition experienced a significant, natural decay in mental contamination, such that their reported feelings of dirtiness, urges to wash, and anxiety had returned to baseline after 3 min of waiting. The authors concluded that, when left alone, mental contamination spontaneously faded, whereas reevoke intrusive thoughts/images and engaging in compulsive behavior prevented its natural decay, as indicated above.

**Clinical implications**

Over a quarter of individuals with OCD report a fear of contamination, driving them to engage in washing and cleaning compulsions (Ruscio et al., 2010). Although both ERP and cognitive therapy can be used to treat fears of physical contamination (e.g., Clark, 2004), the abovementioned experiments demonstrate that mental contamination should be given special attention in CBT for OCD.

On the one hand, experimental work involving the “dirty kiss” paradigm (e.g., Elliott & Radomsky, 2009, 2012; Fairbrother et al., 2005; Herba & Rachman, 2007) has provided direct support for cognitive theories of mental contamination, which links this phenomenon to misinterpretations of a perceived violation (Rachman, 1994, 2006; Rachman et al., 2015). We believe that this line of experimental research can be presented to clients during the psychoeducational phase of treatment. These experiments (mostly conducted with undergraduate students) can normalize clients’ experience of internal feelings of dirtiness, help them better understand the cognitive model, and demonstrate the importance of targeting their beliefs about the perceived violation via cognitive restructuring. On the other hand, we propose that experiments examining the “Macbeth effect” (e.g., Reuven et al., 2014; Zhong & Liljenquist, 2006) are also important to share with clients. These studies suggest how mental contamination is maintained when engaging in washing behavior: It temporarily reduces feelings of dirtiness and immoral emotions but does not alter underlying beliefs.

Behavioral experiments are optimal to challenge beliefs pertaining to mental contamination and one’s perceived need to engage in washing behavior (Coughtrey, Shafran, Lee, and Rachman, 2013; Rachman et al., 2015). The abovementioned experiment by Coughtrey and colleagues (2014) highlights the spontaneous decay of internal feelings of dirtiness, urges to wash, and related negative emotions when washing behavior is prevented. To help clients understand the mechanism maintaining their contamination fear, the authors proposed to use behavioral experiments during which clients track whether washing increases or decreases their internal feelings of dirtiness, urges to wash, anxiety, and guilt. Therefore, we believe that clients could be encouraged to rate and compare these symptoms on days during which they wash because they feel dirty versus because they are actually physically dirty.

Rachman and colleagues (2015) also posited that inflated responsibility plays a role in mental contamination, such that clients sometimes feel responsible for a perceived violation. Support for this aspect of the theory mainly comes from experiments in which participants imagined themselves as the perpetrator (e.g., Rachman et al., 2015; Waller & Boschen, 2015). In this way, cognitive strategies targeting inflated responsibility (as described above) are also used in the treatment of mental contamination (e.g., Rachman et al., 2015).

**Future directions**

As indicated previously, the theory claims that individuals with mental contamination are affected by an *ex-consequentia* bias (Rachman et al., 2015). Experiments are needed to confirm that this bias is a relevant mechanism in the development and maintenance of internal feelings of dirtiness and urges to wash. Such experimental work could also lead to recommendations on how to address the *ex-consequentia* bias in CBT. Of note, this cognitive bias is extremely similar to inverse reasoning, one of the core maladaptive processes in the inference-based approach to OCD. It was recently demonstrated that manipulating inverse reasoning in an analog sample directly influenced contamination symptoms (Wong & Grisham, 2017). In this experiment, participants who underwent inverse reasoning training—as opposed to healthy
reasoning training or no training—showed significantly greater disgust and contamination fear during a subsequent behavioral approach task. To the best of our knowledge, this is the first study providing experimental data supporting the causal role of inferential confusion on OCD symptoms. Future research should not only explore appraisals and beliefs to better understand mental contamination, but perhaps also consider the impact of faulty reasoning processes.

Lastly, the role of responsibility in mental contamination experiments has mainly been examined by asking participants to imagine themselves as the perpetrator (Rachman et al., 2015; Waller & Boschen, 2015). However, it would be relevant for experimental work to focus on instances where the victim puts the blame on them. This could be examined in the laboratory: a responsibility manipulation could be added to the original “victim dirty kiss” paradigm and its (possibly enhanced) impact on dirtiness feelings and washing urges/behavior could be assessed.

“Just right” experiences

Individuals with OCD often report an urge to engage in ordering because something about their surroundings does not “feel right.” Unfortunately, these “just right” experiences have not received as much attention compared to other symptoms of OCD, such as checking and washing. This relative paucity of research is surprising, given the high prevalence of compulsive ordering/arranging and symmetry concerns in OCD (Ruscio et al., 2010).

Quasi-experimental designs

An experiment examining the impact of orderliness on anxiety and discomfort was conducted by Radomsky and Rachman (2004). In their study, undergraduate students were randomly assigned to prepare a short speech (to be presented to a faculty panel) in either an orderly or a disorderly environment. They found that participants were significantly more distressed in the disorderly (vs. orderly) space, but only if they already had a high (vs. low) desire for orderliness. Some participants even engaged in spontaneous ordering and arranging behavior in the space, reportedly to reduce “feelings of impending doom”. Others with a high desire for orderliness explained that their surroundings did not “feel right” until they were done ordering the space and some reported that they were “waiting for an internal click” before stopping the behavior. Participants mentioned thinking that arranging the room would be the only way to effectively reduce their anxiety. Thus, the function of ordering and arranging appears to match the function of other forms of compulsions, such as cleaning and checking.

Anxiety as a result of “just right” experiences seems to extend beyond stressful situations (such as preparing a speech) and appears to also occur in everyday contexts. Coles, Heimberg, Frost, and Steketee (2005) had participants who were either highly sensitive or relatively insensitive to “just right” experiences enter a small office with a number of stimuli that were likely to elicit urges to order and arrange (e.g., a chair missing one armrest). The authors demonstrated that those who were highly sensitive (vs. insensitive) to “just right” experiences were significantly more likely to report feelings of discomfort and urges to “fix” one of the stimuli by engaging in ordering and arranging. However, participants did not report a fear of something threatening occurring. Together these quasi-experimental results increased our understanding of the phenomenology and function of “just right” experiences but provided little information regarding cognitive mechanisms underlying such experiences.

Clinical implications

The dearth of experimental research related to these symptoms likely stems from a lack of proposed cognitive mechanisms in the literature. In this way, it is currently suggested to either use ERP or focus on the idiosyncratic cognitions of clients presenting with “just right” experiences and tailor the treatment to their specific beliefs (e.g., Clark, 2004). For example, if case conceptualization indicates that “just right” experiences are driven by positive beliefs about perfectionism, clients can be asked to weigh the costs and benefits (e.g., effort, distress, and time) of completing everyday household chores with the aim of achieving “perfection” (Clark, 2004).

Future directions

The experiments described above (e.g., Coles, Heimberg, Frost, & Steketee, 2005) indicate that individuals with “just right” experiences do not engage in ordering and arranging as a way to prevent threatening outcomes but instead to put an end to discomfort or “feelings of impending doom” (Radomsky & Rachman, 2004). Based on the cognitive appraisal model, one may thus hypothesize that individuals
with “just right” experiences hold dysfunctional beliefs about feelings, sensations, and discomfort, leading them to misinterpret such experiences as catastrophic. Perhaps some individuals with OCD erroneously believe that the feelings and discomfort will never go away, will be intolerable, and will drive them crazy—unless the “right” feeling or “internal click” is attained via ordering and arranging. These observations (stemming from the clinic and those experiments) could be carried to the laboratory, such that experiments could investigate these beliefs in relation to “just right” symptoms. Causal evidence supporting this hypothesis would likely lead to recommendations for CBT (e.g., behavioral experiments during which clients test whether they can tolerate discomfort for one vs. 10 min without going crazy).

Another potential cognitive mechanism involved in “just right” experiences is perfectionism. Indeed, correlational research has shown that elevated perfectionism beliefs uniquely predict “just right” experiences and symmetry concerns above and beyond other belief domains (e.g., Wheaton, Abramowitz, Berman, Riemann, & Hale, 2010). However, it is still unclear whether perfectionism leads to compulsive ordering and arranging. In fact, beliefs about perfectionism likely interact with misinterpretations of feelings and discomfort (e.g., “I should organize this room perfectly as I won’t be able to tolerate this feeling for another minute”), making them both “perfect” candidates for experiments related to this symptom subtype.

**Seeking proxies for internal states**

The seeking proxies for internal states approach suggests that metacognitive doubt experienced by individuals with OCD (e.g., doubt about memory, attention, perception, decision-making, and emotions) drives individuals to find external metrics (i.e., proxies) by which they can judge the doubted cognition (e.g., Lazarov et al., 2010). Experiments have attempted to examine the impact of this doubt on and whether it interferes with access to one’s “true” internal states.

Because experiments examining this approach have not focused on typical subtypes of OCD symptoms, a separate section is dedicated to this theory. Experiments related to other complementary models, such as the inference-based approach and mood-as-input hypothesis, were described throughout the previous sections, as the emphasis was often on compulsive checking (e.g., Davey et al., 2003) and contamination (e.g., Wong & Grisham, 2017).

**Biofeedback as a proxy**

In a series of experiments, Lazarov and colleagues (2010) attempted to identify whether participants with high (vs. low) OCD symptoms differ in their ability to control and estimate their arousal level (as measured by their galvanic skin response) either with or without the help of a biofeedback monitor. The authors found that the presence of biofeedback as an external proxy significantly improved participants’ ability to control their arousal, but only for those with high (vs. low) OCD symptoms. Further, when given the opportunity, individuals with high (vs. low) OCD symptoms requested to check the biofeedback monitor significantly more often. When provided with false biofeedback indicating a reduction in arousal, individuals with high (vs. low) OCD symptoms reported significantly lower anxiety, despite no differences in actual arousal levels between the two groups. These results support the notion that those with high OCD symptoms place less confidence in their subjective experience. These findings were replicated with participants receiving bogus biofeedback about their muscle tension (Lazarov et al., 2012b), suggesting that such group differences are not only related to one’s internal states of relaxation and anxiety. However, the quasi-experimental nature of these studies prevented firm conclusions about the role of doubt in this overreliance on external proxies.

To address this methodological limitation, Lazarov, Dar, Liberman, and Oded (2012a) manipulated confidence in internal states in an analog sample. Participants were either told that feelings of relaxation can be misleading and that they should doubt such feelings (i.e., undermined confidence condition) or were given no specific information (i.e., control condition). All participants then rated their relaxation and anxiety levels after receiving false biofeedback. When shown increasing arousal feedback, no condition differences were found. However, when the feedback matched their efforts to relax (i.e., false declining arousal), participants in the undermined confidence (vs. control) condition rated their anxiety as significantly lower. Similar results were found when participants were told not to trust their perceptions of control over their muscles (Lazarov et al., 2015). Clearly, when doubt about reliability of internal states is introduced, individuals can be primed to
rely on proxies to rate their subjective experience, as is hypothesized to happen in OCD (e.g., Lazarov et al., 2010).

**Clinical implications**

This reliance on external cues observed in OCD could be the result of real deficits in accessibility of internal cues. However, given that individuals without OCD symptoms showed similar overreliance on proxies when doubt was experimentally manipulated, it is more likely that metacognitive doubt is the driving mechanism underlying this phenomenon. Therefore, integration of these doubts as additional targets in cognitive therapy may be beneficial.

In particular, Lazarov et al. (2010) proposed that clients should be presented with the model as a way to educate them about how doubt and compulsions are interconnected. They also suggest that clients should know that relying on external proxies comes with the cost of further undermining their conviction about their internal states. They also speculate that inclusion of biofeedback as an interim proxy while training patients to improve their trust in their cognitions may facilitate treatment. Nonetheless, we believe that biofeedback could likely be replaced with behavioral experiments aimed at directly challenging metacognitive doubt (as described earlier), without the need for complex equipment (e.g., Alcolado & Radomsky, 2016).

**Future directions**

Future research should focus on outcomes associated with manipulating confidence in one’s internal states beyond biofeedback. In particular, it would be relevant to assess whether doubt in one’s internal states causes increases in OCD symptoms, such as checking, washing, and ordering/arranging, as is proposed by the seeking proxies for internal states approach.

**Concluding remarks**

Although correlational research provides some insight into potential factors involved in OCD, experiments are essential to increase our understanding of the causal mechanisms associated with the development and maintenance of symptoms. As demonstrated above, experimental work has strengthened cognitive and complementary models of OCD and has accordingly informed novel CBT strategies. For instance, experimental manipulations have consistently shown the direct impact of responsibility on checking (e.g., Armtz et al., 2007; Ladouceur et al., 1995; Lopatka & Rachman, 1995), making responsibility beliefs a fundamental component of the theory and a core target in CBT for OCD (e.g., Clark, 2004; Rachman, 2003). Recent experimental work has also provided support for the expansion of cognitive theory (e.g., Alcolado & Radomsky, 2011; Gagné & Radomsky, 2017) and for contemporary formulations of obsessions and compulsions (e.g., Lazarov et al., 2010), indicating that CBT for OCD is steadily expanding.

Additional lines of research have used experiments to better understand other aspects of OCD and to refine CBT interventions. For instance, several authors agree that safety behavior, like compulsions, is detrimental in CBT because they prevent disconfirmation of maladaptive beliefs (Clark, 1999). In support of this hypothesis, Deacon and Maack (2008) had undergraduate students with high and low contamination fear engage in contamination-related safety behavior for a week. They found that, compared to baseline, both groups experienced significant increases in threat overestimation, contamination fear, and avoidance during a subsequent behavioral approach test. However, Rachman, Shafran, Radomsky, and Zysk (2011) had undergraduate participants engage either in sessions of contamination-related ERP or exposure with safety behavior (i.e., using an hygienic wipe) and found that participants in both conditions experienced significant decreases in contamination-related symptoms. This experiment was replicated and expanded (e.g., van den Hout, Engelhard, Toffolo, & van Uijen, 2011), and recent results support the claim that exposure with safety behavior may be more acceptable for clients (Levy & Radomsky, 2014). Still, more work is necessary, especially over longer time frames, before making clear recommendations for CBT.

Moreover, cognitive bias modification (CBM) is a contemporary paradigm designed to alter individuals’ interpretations and biases. This experimental paradigm has recently been used in various studies to provide evidence in favor of the cognitive appraisal model. For example, in a sample of undergraduate students with elevated OCD symptoms, Clerkin and Teachman (2011) manipulated participants’ obsessive beliefs using CBM. Half of the sample underwent a positive CBM training: participants were presented with a scenario tapping into a specific belief domain (e.g., responsibility) and had to complete a word
fragment at the end of the scenario that was always inconsistent with the obsessive belief (e.g., “You do not pick up a piece of broken glass in the street because you are in a hurry; if someone gets hurts, you are blam_less”). The other half underwent a neutral CBM training: word fragments at the end of the scenarios were half of the time consistent and half of the time inconsistent with obsessive beliefs (e.g., “you are blam_less” or “you are respons_ble”). The authors found that, after the CBM training, those in the positive (vs. neutral) condition reported significantly lower levels of obsessive beliefs and interpretations as measured by questionnaires and reported (at trend level) lower negative affect and fewer urges to engage in neutralizing behavior during a TAF task similar to the one in Rachman et al. (1996). These results were replicated and expanded in a number of experiments (e.g., Clerkin, Magee, & Parsons, 2014; Grisham, Becker, Williams, Whifton, & Makkar, 2014; Williams & Grisham, 2013). Although these preliminary results suggest that CBM could be used in CBT to further alter clients’ misappraisals and obsessive beliefs, the long-term effects of this paradigm on OCD symptomatology are unknown.

Recent research has also proposed novel cognitive factors that might be directly involved in increased washing/cleaning behavior. For instance, Gelfand and Radomsky (2013) showed that having a high sense of predicted controllability led to increased cleaning behavior. Specifically, the authors manipulated undergraduate students’ sense of predicted controllability by having them read bogus newspaper articles claiming that people could control up to 97.5% (i.e., high predicted controllability condition) versus 33.3% (i.e., low predicted controllability condition) of germs. They found that those in the high (vs. low) predicted controllability condition spent significantly more time cleaning a dirty keyboard afterward. Based on these findings, individuals with OCD perhaps believe that germs are highly controllable, which then justifies compulsive behavior. Likewise, Menzies and Dar-Nimrod (2017) demonstrated that death anxiety may play a role in compulsive washing. In their study, individuals with OCD were assigned to either reflect on death (i.e., death anxiety condition) or on dental interventions (i.e., dental pain condition). They found that participants in the death anxiety (vs. dental pain) condition engaged in significantly more washing efforts when asked to wash conductive gel off their hands (i.e., longer washing time and more soap/paper towel used), but only for those who had been identified as compulsive washers. Taken together, these experiments highlight a need for research pertaining to control- and death-related cognitions when investigating contamination fear. Indeed, cognitive interventions targeting beliefs about control over specific stimuli and negative beliefs about death may reveal to be helpful for compulsive washers.

According to the experiments presented throughout the different sections, beliefs appear to be core mechanisms involved in the etiology and maintenance of OCD. In this way, there is a need for researchers to move beyond beliefs previously identified by the OCCWG (2005)—as they are not endorsed by all individuals with OCD (Taylor et al., 2006)—and to identify novel belief domains (e.g., beliefs about feelings and discomfort) and/or focus on clients’ idiosyncratic beliefs (e.g., belief that one is a monster deep down). As with research on beliefs about memory (Alcolado & Radomsky, 2011), this avenue has been shown to lead to a better understanding of mechanisms in OCD and to the improvement of CBT (Alcolado & Radomsky, 2016).

Although novel CBT strategies often stem directly from experimental work, it is clear from the research presented above that the laboratory and clinic continually influence each other. Clinical observations are fundamental to identify promising mechanisms and belief domains contributing to the emergence and maintenance of symptoms. For instance, case reports of clients with responsibility concerns (e.g., Salkovskis, 1985) inspired early experiments investigating the role of this belief domain in OCD (e.g., Lopatka & Rachman, 1995). More recently, experimental work examining the impact of beliefs about losing control on checking behavior (Gagné & Radomsky, 2017) emerged from clients reporting a fear of a potential loss of control over their thoughts and behavior (“If I can’t control unwanted sexual intrusions, then I might lose control over my sexual behavior,” Clark, 2004, p. 145). It is therefore critical for researchers to keep a foot in the clinic in order to create accurate and ecologically valid experimental designs that reflect clients’ beliefs, thoughts, and symptoms.

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