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A Theoretical review of cognitive biases and deficits in obsessive–compulsive disorder

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ABSTRACT

During the past 30 years, experimental psychopathologists have conducted many studies aiming to elucidate the cognitive abnormalities that may figure in the etiology and maintenance of OCD. In this paper, we review research on both dysfunctional beliefs and cognitive deficits in OCD, as findings from both traditional self-report and information-processing approaches provide distinct sources of information concerning cognitive abnormalities. First, we discuss dysfunctional beliefs and metacognitive beliefs implicated in the disorder. Research has identified a number of maladaptive appraisals (e.g., heightened responsibility) and metacognitive beliefs (e.g., need to control one's thoughts) that are associated with the disorder, yet these are not invariably present in all cases of OCD. Next, we review the literature on memory and attentional deficits and biases in OCD. This line of research shows inconsistent evidence for deficits in memorial and attentional processes, but does indicate that people with the disorder have memory and attention biases that may be related to metacognitive beliefs about their ability to remember and attend to stimuli. Finally, we discuss recent work that suggests that people with OCD have reduced access to internal states, thus causing them to engage in rituals to resolve persistent uncertainty. Implications and future directions are discussed.

1. Introduction

Individuals who suffer from obsessive–compulsive disorder (OCD) are afflicted by time-consuming repetitive and intrusive thoughts, images, and impulses (obsessions) and repetitive actions (compulsions) that cause significant distress and impairment (American Psychiatric Association, 2013). Though OCD is broadly characterized by obsessions and compulsions, it is a very heterogeneous disorder that manifests in a variety of ways. Researchers have outlined four major symptom dimensions, or subtypes, of OCD, including (1) contamination obsessions and cleaning compulsions, (2) responsibility for harm obsessions and checking compulsions, (3) symmetry/incompleteness obsessions and ordering/arranging/repeating compulsions, and (4) aggressive/sexual/religious obsessions (e.g., "unacceptable thoughts") and mental/checking compulsions (Abramowitz et al., 2010). Research indicates that different subtypes are associated with different treatment outcomes (Mataix-Cols, Rauch, Manzo, Jenike, & Baer, 1999) and thus may be relevant to understanding the mechanisms mediating the disorder.

Salkovskis (1985) developed a cognitive-behavioral model of OCD by elucidating how people can develop the disorder by catastrophically misinterpreting the significance of normal, distressing intrusive thoughts, thereby explaining how obsessions originate. His work indicates that most people without OCD occasionally experience intrusive thoughts that do not differ in content from those experienced by people with OCD. Rather, people who develop the disorder seem to misinterpret the significance and consequences of these thoughts, which leads them to engage in compulsions, thereby perpetuating this cycle of obsessions and compulsions. Notably, Salkovskis emphasizes the importance of inflated responsibility in this model. He asserts that people with OCD interpret normal intrusive thoughts as indicative of harm or danger and feel responsible for preventing harm to themselves or others (Salkovskis, 1985; Shafran, 2005). Thus, this feeling of increased responsibility motivates people to take measures to prevent such harm. According to this model, a man without OCD who has an intrusive thought of pushing a person in front of an oncoming train would be likely to dismiss the thought as meaningless. However, a man with OCD would interpret the same thought as an indication that he is dangerous and a true threat to others' safety. In an attempt to prevent harm to others, he would then engage in compulsions (e.g., keeping his hands occupied, praying repeatedly, counting to a lucky number, etc.) that would temporarily decrease

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his anxiety. According to Salkovskis's model, this decrease in anxiety not only reinforces his compulsive behavior, but also prevents him from learning that the thought is meaningless and that his anxiety would naturally decrease even without performing compulsions (Salkovskis, 1985; Taylor, 2002). Indeed, the attempts to suppress the obsessive thought may itself increase its frequency of occurrence, further reinforcing the man's belief in his dangerousness.

In his cognitive model of OCD, Rachman (1997) later expanded upon Salkovskis's work to include cognitive biases other than inflated responsibility. He theorized that what distinguishes people with OCD from those without the disorder is that the former group makes "catastrophic misinterpretation[s]" (p. 4) of their thoughts, interpreting them as meaningful, significant, and threatening. Rachman (1997) includes inflated responsibility as one of the cognitive misappraisals, but also includes others, which we discuss later in greater detail. Since the introduction of this cognitive model of OCD, experimental psychopathologists have conducted many studies aiming to elucidate the cognitive abnormalities that may figure in the etiology and maintenance of OCD. In this article, we review research on both dysfunctional beliefs and cognitive deficits in OCD, as findings from both traditional self-report and information-processing approaches provide distinct sources of information concerning cognitive abnormalities (McNally, 2001). Specifically, we review work on abnormalities in beliefs, attention, and memory before discussing a recent line of work on doubt and accessing internal states. There is abundant research on the biological aspects of OCD, especially neuropsychological studies on content-independent deficits unrelated to processing of emotional information (For a review, see Abramovitch, Abramowitz, & Mittelman, 2013). However, cognitive neuroscience research concerning how the brain mediates information-processing biases and dysfunctional beliefs has only just begun. We discuss this work when relevant with suggestions for future directions.

2. Dysfunctional beliefs

Since Salkovskis (1985) and Rachman (1997) first proposed that catastrophic misinterpretations, such as inflated responsibility, might contribute to the onset and the maintenance of the OCD, many studies have examined different thoughts that might be associated with the disorder. Building on early cognitive models, the Obsessive Compulsive Cognitions Working Group (OCCWG) was formed to identify and create an assessment of dysfunctional beliefs that are specific to OCD. In a series of papers, they outlined three domains of dysfunctional beliefs that contribute to the development and maintenance of the disorder, including (1) overestimation of threat and inflated responsibility, (2) importance of and need to control thoughts, and (3) perfectionism and intolerance of uncertainty (OCCWG, 1997, 2001, 2003, 2005). Numerous studies have demonstrated the importance of these dysfunctional beliefs in OCD, and research within these domains continues. A description of each of these domains appears below, followed by a general discussion of how dysfunctional beliefs are related to OCD.

2.1. Inflated responsibility & overestimation of threat

Conceptualized as the belief that one is responsible for preventing harm or other negative outcomes, inflated responsibility has been identified as a significant cognitive distortion in OCD. As noted above, Salkovskis (1985) emphasized the importance of inflated responsibility in his cognitive model of OCD, and since then, many studies have shown its association to OCD symptoms in clinical and non-clinical samples (Salkovskis et al., 2000). Indeed, research suggests that manipulating beliefs about personal responsibility affects both thoughts and behavior. For example, Lopatka and Rachman (1995) placed people with OCD in low and high responsibility conditions. The low responsibility situation prompted significant decreases in discomfort, panic, and urges to engage in checking behavior; an opposite trend was observed when the same individuals were placed in a high responsibility condition. Similarly, Ladouceur et al. (1995) asked a non-clinical sample to perform tasks in both low and high responsibility conditions. The authors found that individuals in the high responsibility condition not only experienced an increase in anxiety, but also engaged in more checking behaviors. In a subsequent study, Ladouceur, Leger, Rheaume, and Dube (1996) treated four OCD patients whose primary symptoms included checking. Interestingly, the treatment consisted of cognitive therapy that specifically targeted beliefs about inflated responsibility, but not other dysfunctional thoughts. After 32 sessions of treatment, all four patients showed significant improvements in symptoms and three of them maintained these gains at 6 and 12-month follow-up. Taken together, these studies support the link between heightened responsibility and obsessive–compulsive symptoms, and suggest that directly targeting this cognitive factor may have clinical benefits.

In an attempt to understand the etiology of cognitive misappraisals, Salkovskis, Shafran, Rachman, and Freeston (1999) posited that there exist a number of pathways that might lead to the development of heightened responsibility. Pathways outlined by the researchers included recurring experiences, such as growing up with rigid rules of conduct, being shielded from responsibility, and being raised with a sense of responsibility for avoiding harm, as well as isolated experiences, including incidents in which one actually does cause harm or erroneously believes that he or she did. Coles and Schofield (2008) developed a self-report measure (i.e., the Pathways to Inflated Responsibility Beliefs Scale (PIRBS)), based on these proposed pathways, and a recent study using this scale indicated that parental overprotection and experiences in which a person caused or influenced harm were associated with stronger OCD-related beliefs and symptoms in a clinical sample (Coles, Schofield, & Nota, 2014). Findings from additional studies, using measures other than the PIRBS, likewise suggested that overprotective parenting (Smari, Martinsson, & Einarsson, 2010) and feelings of increased responsibility for family members' protection and happiness (Careau, O'Connor, Turgeon, & Freeston, 2012) were associated with OCD-related beliefs. Although the aforementioned studies have found relationships between certain developmental pathways and cognitive biases, ultimately, the results only offered modest support for Salkovskis et al.'s model, as other pathways were not significantly and uniquely associated with OCD symptoms (Coles et al., 2014). Coles et al. (2014) concluded from their study that early developmental experiences are likely insufficient to explain cognitive factors in OCD and that future research should aim to expand the current etiological model.

Researchers have likewise identified overestimation of threat as a significant cognitive distortion in individuals with OCD. This construct includes dysfunctional beliefs about the likelihood of danger occurring in general and about personal vulnerability to aversive events (Moritz & Pohl, 2009; OCCWG, 1997). A series of studies suggest that individuals with the disorder do not actually overestimate the likelihood of aversive OCD (e.g., a contamination item asks about the number of new HIV infections documented in Germany in a given year) and non-OCD events in general, but rather lack an "unrealistic optimism" (Moritz & Pohl, 2009, p. 5) bias, the belief that one is less vulnerable to harm and more likely to experience positive events than are others. Indeed, findings from three studies showed that OCD subjects overestimate the likelihood of harm befalling them and experience less relief than do those without the disorder when presented with actual statistics about the low frequency of harmful events (Moritz & Jelinek, 2009; Moritz & Pohl,

2006). This pattern of thinking may help to explain why people with OCD are especially risk averse (Admon et al., 2012). That is, if these people feel more vulnerable to harm, then it seems reasonable they would make a greater effort to avoid potentially dangerous situations and engage in compulsions to decrease potential threat to themselves, even though such behaviors give them a false sense of security and instead serve to reinforce their maladaptive thoughts and behaviors (Moritz & Pohl, 2009).

Beliefs about excessive responsibility imply fear of experiencing guilt (or shame) from harming others or failing to prevent harm. This theme has motivated studies relevant to moral reasoning in OCD. For example, Franklin, McNally, and Riemann (2009) presented OCD patients and healthy control subjects with moral dilemma scenarios involving two options: a utilitarian option whereby one chooses to sacrifice the life of one person to save the lives of others, and a deontological option whereby the subject refuses to harm another, resulting in the indirect deaths of others. The groups did not differ in terms of the rate of choosing the utilitarian option. However, the higher the scores on the Responsibility Attitude Scale within the OCD group, the less likely were patients to choose to kill one person to save the lives of others.

Using functional magnetic resonance imaging (fMRI) to target brain regions implicated in moral reasoning, Harrison et al. (2012) exposed OCD patients and healthy control subjects to moral scenarios while in the scanner. Replicating Franklin et al., they found that the groups did not differ in their endorsement rate of the utilitarian option. Although both groups exhibited robust activation in frontal and temporoparietal regions of the brain, the OCD group exhibited heightened activation of the ventral frontal cortex, especially the medial orbitofrontal cortex. Moreover, the patients also exhibited heightened activation in the left dorsolateral prefrontal cortex and left middle temporal gyrus. These data suggest that OCD patients respond to moral dilemmas with amplified neural activation even though they do not differ from healthy control subjects in how they say they would resolve the dilemma.

2.2. Over-importance of and need to control thoughts

The importance of thoughts refers to the distorted belief that simply having a thought means that it is significant or that it reflects a person's desires or true nature (OCCWG, 1997). A specific misappraisal that falls within this category and has garnered a lot of attention is thought-action fusion (TAF; e.g., Berle & Starcevic, 2005). This cognitive bias consists of two subtypes: (1) TAF moral, the belief that thinking about doing something bad is the moral equivalent of engaging in the corresponding action (e.g., thinking about stabbing my husband is the moral equivalent of harming him) and (b) TAF-likelihood, the belief that thinking about a negative outcome occurring increases its likelihood (e.g., thinking about my sister dying in a car crash increases the chances of its happening; Rachman, 1993; Shafran, Thordarson, & Rachman, 1996; Rachman & Shafran, 1999). TAF-likelihood can be further categorized as either "likelihood self," the belief that thoughts will result in negative outcomes for oneself, or "likelihood-other," the belief that one's thoughts will cause danger to befall other people.

In their early cognitive models of OCD, Salkovskis (1985) and Rachman (1993) observed that people with OCD often believe that their thoughts and actions are intertwined, and Shafran et al. (1996) later created the Thought-Action Fusion Scale to examine the presence of these thoughts in people with the disorder. Subsequent studies have indicated that OCD is associated with elevated levels of TAF, particularly TAF-likelihood (Berle & Starcevic, 2005; Shafran & Rachman, 2004; Shafran et al., 1996). Interestingly, a study by Amir, Freshman, Ramsey, Neary, and Brigidi (2001) suggests that TAF extends to beliefs about the power of thoughts to prevent harm from befalling others, and may contribute to other cognitive distortions commonly associated with OCD. The authors state that TAF may cause people with OCD to feel a heightened responsibility for preventing harm, to assess negative events as especially costly, and to experience "overvalued ideations" (p. 5), or the belief that obsessions have the ability to cause harm (Kozak & Foa, 1994). Indeed, Rachman (1993) asserted that thought-action fusion may arise when misinterpretations of thoughts interact with an exaggerated sense of responsibility for preventing harm, and a subsequent study (Rachman, Thordarson, Shafran, & Woody, 1995) found that TAF emerged as one of four factors of responsibility. TAF is now considered to be a related, but separate, construct from heightened responsibility, and research suggests that TAF may trigger unrealistic beliefs about preventing harm and vice versa (Shafran & Rachman, 2004).

A number of studies suggest that heightened levels of thought-action fusion have also been associated with pathological worry and negative affect, even in the absence of OCD symptoms (Abramowitz, Whiteside, Lynam, & Kalsy, 2003; Hazlett-Stevens, Zucker, & Craske, 2002). Although this distorted belief is not unique to OCD, studies have modeled how the belief may contribute to the maintenance of the disorder. For example, van den Hout, Kindt, Weiland, and Peters (2002) demonstrated that a behavioral TAF task, in which subjects were asked to write out a disturbing sentence (e.g., "I hope my sister is in a car accident") increased people's urge to neutralize their thoughts (Shafran & Rachman, 2004). Attempting to neutralize one's thoughts, in turn, leads to more intrusive thoughts, thereby maintaining the cycle of obsessive thoughts and compulsive behaviors (Rachman & Hodgson, 1980).

If people appraise their thoughts as significant and potentially dangerous, it follows that they will attempt to resist or control such thoughts to prevent harm to themselves or others (Rachman & Hodgson, 1980). Hence, belief in the over-importance of thoughts seems related to the need to control them (OCCWG, 1997). The metacognitive belief that one must control one's thoughts is associated with higher frequency of obsessive thoughts in non-clinical subjects (Clark, Purdon, & Wang, 2003). Additionally, the OCCWG (2001) found that OCD subjects score higher on thought control subscales than do healthy individuals and people with other anxiety disorders (Purdon & Clark, 2002). This cognitive distortion prompts people to attempt to control their thoughts with maladaptive strategies such as compulsions or thought control techniques (e.g., thought suppression, worry) that paradoxically trigger further intrusive thoughts (Purdon & Clark, 2002). Though classified as a dysfunctional belief by some researchers, the importance of and need to control thoughts also lies as the heart of the metacognitive theory of OCD discussed below.

2.3. Perfectionism and intolerance of uncertainty

Intolerance of uncertainty (IU) refers to the distress one experiences in ambiguous or unpredictable situations (Boswell, Thompson-Hollands, Farchione, & Barlow, 2013; OCCWG, 1997; Sarawgi, Oglesby, & Cougle, 2013). Individuals who have a low tolerance for uncertainty tend to "find uncertainty stressful and upsetting, believe that uncertainty is negative and should be avoided. . .experience difficulties functioning in uncertainty-inducing situations. . . and [consequently] engage in futile attempts to control or eliminate uncertainty" (Buhr & Dugas, 2009, p. 216). Moreover, experimentally inducing intolerance of uncertainty increases worry (Buhr & Dugas, 2009; Ladouceur et al., 2000), and the association between IU and worry remains strong even after one controls for other variables, such as responsibility and anxiety sensitivity (Dugas, Gosselin, & Ladouceur, 2001). Unsurprisingly, then, IU has been identified as a transdiagnostic feature common to generalized anxiety disorder, social anxiety disorder, panic disorder, and OCD. Furthermore, reductions in IU correlate

with reductions in anxiety symptoms from pre- to post-treatment (Boswell et al., 2013).

Individuals with OCD have a low tolerance for uncertainty (Holaway, Heimberg, & Coles, 2006), and high scores on self-report measures of IU predict discomfort following a range of OCD-related in vivo tasks (e.g., ordering, checking, contamination in non-clinical subjects; Sarawgi et al., 2013). Indeed, people with OCD may engage in compulsions, especially checking, in an attempt to resolve their uncertainty associated with an obsession (Tolin et al., 2001). For example, a man might doubt whether he locked the door to his house and thus continue checking it in an attempt to feel more certain that it is actually locked. However, this temporary reduction in uncertainty comes at a great cost, as compulsions are negatively reinforced, rendering the person vulnerable to even more frequent obsessions and subsequent compulsions (Abramowitz, Taylor, & McKay, 2009). Moreover, people with OCD often avoid situations that could potentially trigger their obsessions or compulsions, or continually seek reassurance from others to alleviate their uncertainty, thereby perpetuating the cycle of obsessions and compulsions (Kobori & Salkovskis, 2013).

Finally, perfectionism refers to the dysfunctional belief that one must meet exceedingly high standards accompanied by persistent concern over making mistakes, which are viewed as failures (Frost, Novara, & Rheaume, 2002). Long thought to be associated with OCD, perfectionism may be an attempt to avoid negative outcomes, such as uncertainty, and to gain some control over one's environment (Frost et al., 2002). As with the other maladaptive beliefs described above, perfectionism is associated with OCD symptoms in both non-clinical and clinical populations (Frost, Steketee, Cohn, & Griess, 1994; Rheaume, Ladouceur, & Freeston, 2000), and seems especially relevant to checking compulsions and "not just right" experiences (Coles, Frost, Heimberg, & Rheaume, 2003; Moretz & McKay, 2009). Moreover, a study by Bouchard, Rheaume, and Ladouceur (1999) indicated that perfectionism may cause people to feel a heightened responsibility for negative events. Hence, dysfunctional beliefs about perfectionism and responsibility may interact to exacerbate obsessive–compulsive symptoms.

2.4. Dysfunctional beliefs and OCD

Given the prominence of dysfunctional beliefs in cognitive and cognitive-behavioral theories of OCD, a great deal of research has investigated the specific relationship between these biases and the disorder. Steketee, Frost, and Cohen (1998) found that OCD subjects endorsed higher levels of dysfunctional thinking, as measured by self-report measures, than did healthy control subjects or people with other anxiety disorders. Though the anxious control group was also characterized by elevated dysfunctional thinking, the association of beliefs about responsibility, threat estimation, uncertainty, and need to control thoughts were more strongly related to OCD. More recently, Abramowitz, Lackey, and Wheaton (2009) examined the relationship between experiential avoidance, dysfunctional beliefs, and OCD symptoms in non-clinical undergraduate students. Using the Obsessive Compulsive Inventory, the authors categorized subjects into one of two groups: high OC symptoms or low OC symptoms. The high OC group had greater levels of dysfunctional thinking than did the low OC group, and these beliefs predicted obsessive thinking and checking rituals even after the authors controlled for other factors. These beliefs predicted variance in OCD symptoms and severity of compulsions in patients with the disorder (Taylor, McKay, & Abramowitz, 2005).

To elucidate the relationship between dysfunctional thoughts and specific obsessive–compulsive symptoms, Taylor et al. (2010) conducted a study on a large non-clinical sample of students from five different universities across the United States. In agreement with previous research, distorted beliefs predicted OC symptoms. Moreover, structural equation modeling indicated that certain beliefs were predictive of different symptoms. The authors found that dysfunctional thoughts about threat estimation and heightened responsibility predicted the presence of six different OCD symptoms (i.e., ordering, checking, neutralizing, obsessing, hoarding, and washing), whereas beliefs about perfectionism and intolerance of uncertainty were associated only with ordering rituals, and beliefs about the importance of and need to control thoughts were predictive only of obsessive thoughts and washing and neutralizing behavior. Corroborating other studies, this study suggests that cognitive biases are more pronounced in some subtypes of OCD than in others, thus underscoring the heterogeneity of the disorder (Abramowitz, Lackey et al., 2009; Taylor et al., 2010; Tolin, Woods, & Abramowitz, 2003). Indeed, in some studies, subgroups of OCD subjects were no more dysfunctional in their thinking than were control subjects (Calamari et al., 2006; Taylor et al., 2006). Hence, dysfunctional thoughts may play a role in only certain individuals with the disorder.

Though most research examining the role of cognitive distortions is based on cross-sectional studies, several researchers have conducted prospective studies to determine if the presence of such beliefs predicts the development of OCD symptoms. Abramowitz, Khandker, Nelson, Deacon, and Rygwall (2006) assessed 100 parents three months prior to and three months following the birth of their first child, as first-time parents are particularly vulnerable to developing obsessive–compulsive symptoms, especially intrusive thoughts about their newborns. The study revealed that the severity of dysfunctional beliefs prior to the birth predicted the severity of post-partum OC symptoms, especially obsessing, checking, and washing, even after Abramowitz et al. controlled for baseline measures of anxiety, depression, and OC symptoms. In another prospective study, baseline levels of cognitive distortions predicted OC symptom severity six weeks later in a non-clinical sample (Coles & Horng, 2006). Consistent with prior research, the study also showed that certain maladaptive beliefs (e.g., heightened responsibility) had more predictive power of OC symptoms than did others. However, a later study failed to replicate these findings in a six-month prospective study of a non-clinical sample (Coles, Pietrefesa, Schoefield, & Cook, 2008). Although dysfunctional beliefs predicted distress associated with OC symptoms, they did not predict the frequency of these symptoms. Hence, more research on the causal relationship between thoughts and symptoms is warranted.

2.5. Summary

Early cognitive models and clinical observations of OCD postulated that dysfunctional thoughts figure prominently in the development and maintenance of the disorder. Since then, a great deal of research has confirmed that these thoughts are frequently associated with obsessive–compulsive symptoms in both non-clinical and clinical populations, and that the relationship among specific thoughts and symptoms might vary (e.g., perfectionism is more strongly associated with checking symptoms than with contamination symptoms). Though the etiology of thoughts is still unclear, studies show that targeting these beliefs can, in turn, affect subsequent thoughts and behavior. Indeed, cognitive therapy is an effective treatment for OCD (Wilhelm et al., 2009), and reductions in dysfunctional beliefs mediate reduction in OCD symptoms in cognitive therapy (Wilhelm, Berman, Keshaviah, Schwartz, & Steketee, 2015). However, other studies have questioned the causal direction of reduced beliefs and symptom improvement (Woody, Whittal, & McLean, 2011), and have found cognitive therapy to be less effective than behavioral therapy at reducing OCD symptoms (Olatunji et al., 2013). Hence, a better understanding of these thoughts, their development, and how they relate to specific OCD

subtypes may result in even more effective and targeted treatments for the disorder.

Finally, in a thoughtful, provocative critique of the Salkovskis–Rachman cognitive model, Cougle and Lee (2014) mention further concerns additional to those we raise in our review (e.g., determining whether presumed cognitive causes are epiphenomenal correlates of the disorder). For example, they observe that the standard cognitive model presupposes that intrusive thoughts are benign occurrences that only become problematic in virtue of individuals appraising them catastrophically. Yet they provide evidence suggesting that many repugnant intrusive thoughts do not require catastrophizing to render them pathological; some are inherently so. Yet they, and we, agree that the cognitive model has been richly heuristic even though its limitations are becoming apparent.

3. Metacognitive model

Like the cognitive model, the metacognitive model of OCD emphasizes the etiological importance of dysfunctional thoughts. However, the metacognitive model, first proposed by Wells and Matthews (1994), distinguishes between beliefs about the world, such as perfectionism and heightened responsibility, and metacognitive beliefs about one's thoughts, such as the importance of and need to control thoughts. Specifically, the model asserts that "metacognitive beliefs are central to the development and maintenance of OCD. . . [whereas] cognitive beliefs [are] by-products of the effects metacognitive beliefs have on processing" (Myers, Fisher, & Wells, 2009, p. 133; for a complete review of the metacognitive model, see Fisher, 2009). The theory states that not only do these thoughts trigger dysfunctional appraisals and anxiety, but also motivate individuals to devise a coping strategy, which consists of rumination, thought monitoring, hypervigilance to threat, and compulsive behaviors that are often terminated according to other metacognitive beliefs (e.g., when he or she "feels" or "knows" it is okay to do so; Fisher, 2009).

Like cognitive theorists, proponents of the metacognitive theory have identified the importance of and need to control thoughts as an especially important etiological fact; unlike cognitive theorists, however, they underscore the importance of the metacognitive nature of the belief. Researchers have developed a measure, the Thought Fusion Instrument (Wells, Gwilliam, & Cartwright-Hatton, 2001), that assesses three components of this belief: thought event fusion, thought action fusion, and thought object fusion (Fisher, 2009). Thought event fusion is the belief that thinking about an event makes it more likely to happen or signifies that it did happen (e.g., having a thought about a hit and run car accident indicates that the person is responsible for such an accident). Thought action fusion refers to the belief that having a thought of doing something will cause the person to act on the thought even if he or she has no desire to do so (e.g., thinking of stabbing a friend will make a person more likely to do so). Finally, thought object fusion is the belief that thoughts can be transferred to inanimate objects (e.g., negative thoughts can contaminate an object, which can then contaminate other people).

Several cross-sectional studies have shown that metacognitive beliefs predict OCD symptoms. Moreover, thought fusion prospectively and independently predicted OCD symptoms in college students even after controlling for worry and other dysfunctional thoughts, whereas non-metacognitive beliefs did not independently predict OCD symptoms (Myers et al., 2009). More recently, Myers and Wells (2013) found that inducing metacognitive beliefs in a non-clinical sample caused individuals to develop obsessive–compulsive symptoms. The researchers recruited college students who scored in the upper quartile or lower quartile on a measure of obsessive symptoms. Subjects were told that an EEG machine could indicate when they were thinking about water. After viewing some videos about water, subjects in the experimental condition were told that they would hear an unpleasant noise when the EEG machine detected thoughts about water, whereas the other half was told they would hear this noise randomly, unrelated to any specific thoughts. Findings indicated that subjects in the experimental condition who had greater OC symptoms were more likely to experience intrusive thoughts about water, felt more discomfort when these thoughts arose, and spent more time thinking about these intrusive thoughts. This study suggests that it is possible not only to induce metacognitive thoughts, but also that doing so can cause people who have high levels of obsessional thinking to experience OCD-like symptoms.

Finally, reducing negative metacognitive thinking mediates symptom improvement in individuals suffering from OCD. Solem, Haland, Vogel, Hansen, and Wells (2009) found that changes in metacognitive thoughts, as measured by the Metacognitions Questionnaire (Wells & Cartwright-Hatton, 2004), predicted symptom improvement in patients treated with exposure with response prevention. This factor remained significant after controlling for other factors such as baseline OCD severity, mood, and overlap with non-metacognitive thoughts.

3.1. Summary

The metacognitive model of OCD acknowledges that dysfunctional thoughts have an important role in the development and maintenance of the disorder, but underscores the central role of metacognitive beliefs such as thought fusion. Studies have indicated that metacognitive beliefs may engender OCD symptoms, and that this association remains after researchers control for non-metacognitive beliefs and other variables. However, metacognitive thoughts are more strongly associated with OCD in groups of patients with high levels of dysfunctional (non-metacognitive) thinking than with OCD patients with low levels of dysfunctional thinking (Chik, Calamari, Rector, & Riemann, 2010). Therefore, as with the cognitive theory of OCD, the metacognitive theory may only apply to a subgroup of people with the disorder. Finally, in an important extension of the metacognitive model, Exner, Martin, & Rief (2009) have shown that monitoring one's thoughts are an important cause of memory deficits common in OCD, as we discuss below.

4. Cognitive deficits and information-processing biases

Unlike much of the research on dysfunctional beliefs and metacognition, research on cognitive deficits and information-processing biases do not rely on self-report, but rather on behavioral measures such as reaction time and neuropsychological assessment (McNally, 2001). Consequently, this line of research may reveal important etiological information about the disorder that is not readily accessible to patients' awareness. Early experimental research examined the possibility that individuals with OCD have deficits in various cognitive processes such as memory, reality monitoring, and attention (Muller & Roberts, 2005). Considering the repetitive nature of obsessions and compulsions, it is possible that people with OCD have impairments in how they attend to threatening versus non-threatening information (attention), in remembering if they completed an action (memory), and in knowing if they performed an action or simply imagined it (reality monitoring; Muller & Roberts, 2005). These deficits may be especially relevant in certain subtypes of OCD, such as those that involve checking rituals. Indeed, if a person has difficulty remembering if she checked the door to ensure it is locked, then she may continue to

check it repeatedly until she can be certain it is properly secured. In addition to reviewing deficits on memory, reality monitoring, and attention, we also include a review of a more recent line of research on deficits in accessing one's internal states.

4.1. Memory

Research on memory deficits in OCD has garnered mixed support. Some studies involving neuropsychological measures, such as the Wechsler Memory Scale (WMS) and the California Verbal Learning Task found that individuals with the disorder performed worse than did people without OCD on verbal recall, but not recognition, tasks (Muller & Roberts, 2005). Deckersbach, Otto, Savage, Baer, and Jenike (2000) found that deficits in verbal and non-verbal memory performance apparently arise from suboptimal organizational strategies that OCD patients often use when they attempt to memorize material. Hence, the memory deficits appear to arise from an encoding deficit. Yet other studies failed to detect deficits in verbal memory performance (Christensen, Kim, Dysken, & Hoover, 1992; Dirson, Bouvard, Cottraux, & Martin, 1995; Muller & Roberts, 2005), whereas another that matched non-depressed OCD and healthy subjects on age, gender, and education found no significant differences on verbal memory, as measured by the Wechsler Adult Intelligence Scale (WAIS) and the WMS, but did detect a relative deficit in the OCD group in nonverbal memory (Christensen et al., 1992). Indeed, OCD subjects have exhibited deficits on nonverbal memory tasks more consistently than on verbal ones (Christensen et al., 1992; Deckersbach et al., 2000). Deckersbach et al. (2000) and Christensen et al. (1992) found that people with OCD performed below the general population norm and worse than healthy control subjects, respectively, on nonverbal memory tasks as measured by neuropsychological batteries. Moreover, Savage et al. (1999) found that individuals with OCD demonstrated worse performance on measures of nonverbal memory, including the WAIS and the Rey-Osterrieth Complex Figure Task. In the latter task, subjects are shown a complex figure and then asked to draw it from memory immediately after seeing it and then again after a 30-min delay. Consistent with Deckersbach et al. (2000) study, Savage et al. (1999) found that disorganized encoding strategies mediated OCD subjects' poor performance on these non-verbal memory tasks (Savage et al., 1999). They concluded that people with OCD are more likely to focus on "irrelevant details of to-be remembered items," (Savage et al., 1999, p. 914) which in turn impairs their recall of that information later.

Cross-sectional data indicate that cognitive self-consciousness (CSC), a propensity to monitor one's thinking, characterizes people with OCD and distinguishes them from those with other anxiety disorders and those free of mental disorders (Janeck, Calamari, Riemann, & Heffelfinger, 2003). Presumably motivating this tendency are maladaptive metacognitive beliefs about the dangerousness of intrusive thoughts. As Exner et al. (2009) noted, chronically monitoring the content of one's thoughts consumes cognitive capacity, and thereby may impede the encoding and subsequent retrieval of information from memory. Moving beyond correlational studies, Exner et al. have conducted experiments whereby they induce CSC in people via instructing them to monitor their thoughts during subsequent tasks (e.g., encoding words for later recall). In one study, they found that inducing CSC during word encoding impaired subsequent verbal memory performance as much as a dual-task condition whereby subjects monitored auditory digit strings for the number 9 (Kikul, Van Allen, & Exner, 2012). Importantly, they found that inducing CSC consumes capacity as traditional dual-task paradigms do; instructional induction of CSC produces verbal memory deficits in healthy subjects that mimic the deficits often occurring in people with OCD.

Another experiment produced broadly similar effects; OCD patients exhibited a decline in visual memory performance after having encoded complex designs during induced CSC or during the auditory secondary task versus no concurrent task (Kikul, Vetter, Lincoln, & Exner, 2011). Interestingly, the healthy control group exhibited memory deficits only after encoding the complex figures during the auditory secondary task, whereas CSC induction did not decrement their performance relative to the no concurrent task condition.

CSC again produced verbal memory deficits in people with OCD in an experiment showing that similar deficits occurred in people with major depressive disorder (Weber et al., 2014). Taken together, these studies suggest that deficits in memory performance in people with OCD (and depression) are attributable to a metacognitive habit of monitoring one's thoughts, thereby consuming cognitive resources essential for robust encoding of material that one must recall later.

Reality monitoring denotes the process whereby people discriminate mental content arising from perception from that arising from imagination. A reality monitoring deficit might cause the uncertainty that drives people with OCD to repeatedly check whether they performed a certain action correctly. Some studies show that people with sub-clinical (Rubenstein, Peynircioglu, Chambless, & Pigott, 1993) and clinical (Merckelbach & Wessel, 2000) OCD have difficulty recalling if they had performed certain actions or simply imagined performing them (Muller & Roberts, 2005). Yet other studies suggest that the problem lies elsewhere. For example, McNally and Kohlbeck (1993) found no differences in reality monitoring abilities between OCD patients, including checkers, and healthy comparison subjects, but they did find that OCD patients reported less confidence in their abilities to distinguish actions they performed from those they had imagined performing relative to comparison subjects. Other studies have confirmed that people with OCD, especially those with checking rituals, lack confidence in their memories rather than having deficits in reality monitoring (Nedeljkovic & Kyrios, 2007) relative to people without the disorder (Hermans, Martens, De Cort, Pieters, & Eelen, 2003; Muller & Roberts, 2005; Olley, Malhi, & Sachdev, 2007; Tolin et al., 2001). Indeed, decreased confidence could explain apparent memory impairments in OCD (Radomsky & Rachman, 2004). That is, people with OCD may believe they have memory problems when they merely lack confidence in their memory.

In fact, repeated checking can actually decrease one's memory confidence. Tolin et al. (2001) found that with repeated checking, OCD subjects who were asked to repeatedly observe and recall different objects demonstrated a decline in memory confidence for ideographically selected threatening items. This decrement did not occur in anxious and non-anxious control groups. Similarly, using virtual gas burners and light bulbs, van den Hout and Kindt (2003b) measured subjects' ability to recall turning off gas burners before and after instructing them to repeatedly manipulate and check relevant (gas burners) or irrelevant (light bulbs) stimuli. Although memory accuracy was not affected by repeated checking, individuals who were asked to repeatedly check a relevant stimulus reported lower memory confidence in and decreased vividness and detail of their memories of turning off the gas burners. The authors replicated their findings in two additional independent studies and concluded that repeated checking increases familiarity with an object, which subsequently interferes with bottom-up processing of the object's details such as color and shape, thereby reducing the detail and vividness of memories of the object (van den Hout & Kindt, 2003b). Importantly, this study was conducted with a non-clinical sample, and thus indicates that repeated checking can cause memory distrust in individuals without OCD symptoms. A recent study identified a similar pattern of findings in a clinical

sample that was asked to repeatedly check real, functioning stoves and faucets (Radomsky, Dugas, Alcolado, & Lavoie, 2014).

In subsequent replications, van den Hout and Kindt (2003a, 2004) found that repeated checking shifted the basis of their memory from remembering that they performed an action to knowing that they must have performed it. As Tulving (1985) observed, people may believe that an event occurred either because they remember specific details about the event (e.g., "I remember turning the gas knob with my right hand and watching the flame go out") or know it happened based on a previously established pattern of behavior (e.g., "I always turn off the stove when I'm done using it"). Indeed, after repeated checking, study subjects were more likely to endorse statements about knowing the gas burner was off but having a fuzzy or unclear memory of turning it off (van den Hout & Kindt, 2003a).

Some studies suggest that individuals with OCD may have improved memory (i.e., a memory bias) for threat-related words and actions (Brown, Kosslyn, Breiter, Baer, & Jenike, 1994; Constans, Foa, Franklin, & Mathews, 1995; Merckelbach & Wessel, 2000). Constans et al. (1995) found that individuals with checking compulsions had better recall for anxiety-inducing items they had manipulated than did people without OCD, whereas Brown et al. (1994) and Merkelbach and Wessel (2000) observed that OCD subjects outperformed healthy controls on reality monitoring tasks. Though other researchers have failed to find a memory bias in OCD, Radomsky and Rachman (1999) point out that the majority of these studies failed to use stimuli that are both threatening and relevant to the OCD subjects tested. Accordingly, they examined whether individuals with contamination obsessions and washing compulsions have a memory bias for "contaminated" objects. Findings indicated that the OCD group had better recall for contaminated items than they did for uncontaminated items; this memory bias was not observed in either the anxious or healthy control group. In a subsequent study, Radomsky, Rachman, and Hammond (2001) detected a memory bias for threatening information in people with checking rituals, but only under conditions of high responsibility (i.e., when the subjects felt that they, and not the experimenter, were responsible for checking). These studies underscore the importance of using stimuli that are significant and threatening in order to detect memory biases in OCD. The authors' findings are consistent with research on information processing "which predict that increased attentional and memorial resources are allocated to process information relevant to a person's current emotional state" (p. 820).

4.2. Attention

Just as people with OCD have memory biases for relevant, threatening stimuli, so too do they demonstrate attentional biases for threatening information (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van, 2007; MacLeod, Mathews, & Tata, 1986). Indeed, information-processing models of anxiety hold that people with anxiety disorders are hypervigilant to emotionally salient information, which in turn, prevents them from attending to other important stimuli in their environment (Muller & Roberts, 2005; Radomsky & Rachman, 2004). Though OCD is no longer classified as an anxiety disorder in the most recent revision of the DSM (American Psychiatric Association, 2013), people with the disorder typically experience high levels of anxiety, and attentional biases have been associated with the disorder (Muller & Roberts, 2005). One of the first investigations of attentional biases in OCD (Foa & McNally, 1986) used a dichotic listening task, during which subjects were presented with two simultaneous recordings (one in each ear) and were asked to repeat one of the passages while also indicating when they heard certain target words that were neutral (e.g., "pick") or threatening (e.g., "feces"). Nine individuals with OCD completed the task both before and after undergoing treatment, which consisted of 15 sessions of exposure and response prevention. Patients detected threat words more than neutral, and exhibited increased skin conductance responses upon detecting threat targets relative to neutral targets. This bias favoring threat words vanished after treatment. Yet subsequent studies on attentional bias for threat in OCD have yielded mixed findings

In studies using the emotional Stroop task, subjects are presented with neutral or threat-related words that are typed in various colors and are asked to name the color of the words while ignoring their meanings. Yet when the meaning of the word captures the subject's attention despite the subject's effort to attend to its color, subjects exhibited delayed color-naming of the word (MacLeod et al., 1986; Muller & Roberts, 2005). Two early studies using the modified Stroop task found that subjects with OCD demonstrated an attentional bias to OCD-related words (Foa, Ilai, McCarthy, Shoyer, & Murdock, 1993; Lavy, van Oppen, & van den Hout, 1994). Interestingly, a more recent study asked individuals with and without OCD to read neutral and ideographically threatening passages prior to completing the standard, non-emotional Stroop task in order to investigate the effect of anxiety on attention (Cohen, Lachenmeyer, & Springer, 2003). Findings indicated that people with OCD responded more slowly than did non-OCD subjects on the Stroop task in both the neutral and anxiety conditions, but that their performance declined substantially in the latter condition. The authors concluded that situational anxiety can impair people's attention on subsequent tasks, even when the task involves non-OCD stimuli as measured by a neutral, non-threatening Stroop task (Cohen et al., 2003).

Other studies using the Stroop task have failed to find evidence of attentional bias in OCD subjects. For example, Kyrios and Iob (1998) found no significant differences between OCD and non-OCD subjects' performance on both a masked and unmasked Stroop task. Indeed, both healthy and OCD subjects had faster color-naming times to threatening and positive stimuli in the unmasked condition than in the masked condition. However, the authors point out that the control group had high levels of trait anxiety, which may help to explain the lack of differences between the groups. Moreover, the OCD sample was characterized by high levels of depression, which may have further complicated the results (Kyrios & Iob, 1998; Muller & Roberts, 2005). Similarly, Moritz et al. (2008) found no evidence of bias on an emotional Stroop in OCD washers and checkers relative to a healthy control group; rather, OCD washers showed faster color-naming responses to OCD washing-related stimuli than did healthy control subjects. Though these findings do not provide support f or attentional bias in people with OCD, the authors note that the threatening words were not idiographic to individual OCD subjects and that words alone may be insufficient to elicit a bias (Moritz et al., 2008). Other studies have likewise found no evidence of bias on the emotional Stroop task (Kampman, Keijsers, Verbraak, Naring, & Hoogduin, 2002; Moritz et al., 2004). However, in a neuroimaging study, van den Heuvel et al. (2005) found that subjects with OCD made more errors on a standard, non-emotional Stroop task than did healthy individuals or subjects with panic disorder or hypochondriasis. Interestingly, OCD subjects did not demonstrate an attentional bias to OCD-threat words on the emotional Stroop task, but did show a unique pattern of neural activity, including increased activation of the anterior cingulate cortex and limbic regions, on fMRI. These results suggest that although biases may not always be observable with behavioral measures of attention, individuals who suffer from OCD tend to process relevant, threatening stimuli differently than do people without the disorder (van den Heuvel et al., 2005). Nevertheless, the frequent absence of an emotional Stroop interference effect in OCD contrasts with its presence in other anxiety-related disorders (Bar-Haim et al., 2007).

Despite these very mixed findings for the emotional Stroop in OCD, Thomas, Gonsalvez, and Johnstone (2013) administered this task with disorder-relevant threat words to patients with OCD, patients with panic disorder, and healthy control subjects while measuring the subjects' event related potentials (ERPs) to these stimuli. Although only the panic disorder group exhibited significantly longer color-naming latencies to their threat words, the OCD group did exhibit larger P1 amplitudes and long N1 latencies to threat versus neutral words, suggestive of preferential early attentional capture by threat cues.

The dot-probe task is another common measure of attentional bias for threat (MacLeod et al., 1986), in which individuals respond to a probe that replaces either a neutral or threat-related word on a screen (MacLeod et al., 1986). Researchers assert that if people are hypervigilant to threat, they will respond more quickly to the probe when it replaces threatening words than when it replaces neutral words. Tata, Leibowitz, Prunty, Cameron, and Pickering (1996) administered the dot-probe task to people with high-trait anxiety, low-trait anxiety, and contamination-related obsessions and compulsions. Their results showed that OCD subjects were faster to detect probes preceded by contamination-related words, but not to social anxiety-related words, whereas individuals with high-trait anxiety exhibited the opposite pattern; the low-trait anxiety group showed no bias to either group of words. A more recent study failed to find a similar bias in OCD subjects with checking symptoms (Harkness, Harris, Jones, & Vaccaro, 2009), thus suggesting that attentional biases for threat may occur only for certain subtypes of OCD. In another dot-probe study, Amir, Najmi, and Morrison (2009) found that attentional biases for idiographic (personally-relevant) threat words in subclinical OCD subjects waned over the course of the experiment as subjects apparently habituated to threat cues. By experiment's end, they exhibited no more bias for threat than did subjects with minimal OCD symptoms. Amir et al. suggested this waning effect may explain inconsistent findings across studies in OCD subjects; it also raises serious questions about the stability of attentional bias for threat, at least as measured by dot-probe performance.

4.3. Pervasive doubt and diminished access to internal states

Pervasive doubt is a hallmark of OCD, ranging from uncertainty about whether one performed certain actions to uncertainty about one's general knowledge (Dar, Rish, Hermesh, Taub, & Fux, 2000). This cognitive abnormality seemingly drives checking, reassurance seeking, and other tactics designed to diminish distressing doubt. Lazarov, Dar, Liberman, and Oded (2012a) have suggested that such doubt may originate in difficulty accessing internal states including cognitive (e.g., memory, comprehension), affective (e.g., specific emotions, attraction), and bodily (e.g., muscle tension) ones. To compensate for attenuated access, people with OCD seek proxies for internal states that can resolve their uncertainty. Not only may checkers ask others whether doors are locked or stoves turned off, but individuals with OCD may rely on external stimuli, behaviors, or rules as proxies for other internal states unrelated to threat. For example, a man who is uncertain whether he loves his wife may tally the number of times he sends her text messages as an "operational" measure of love. A person uncertain of whether she believes in God may use her frequency of praying as evidence of belief. These objective measures are reminiscent of the economist's use of behavior as "revealed preference" for the inaccessible desires of consumers in a market economy.

The seeking-proxies-for-internal-states (SPIS) hypothesis holds that difficulty accessing internal states is not confined to disorder-relevant themes such as uncertainty about contamination, harm to others, responsibility, or morality. Rather, it is a content-independent deficit relevant to any internal state. Moreover, it extends beyond mere uncertainty or an exaggerated need for certainty. Finally, it conceptualizes compulsive rituals as compensatory substitutes for signals of internal states that are readily accessible to those without OCD. Hence, rituals do not merely reflect a futile attempt to obtain certainty, safety, or a sense of completeness, per se.

These researchers have devised ingenious laboratory methods for measuring attenuated access to internal states (Lazarov et al., 2012a). In their latest study, they had OCD patients, patients with anxiety disorders, and healthy control subjects perform a two-part electromyographic (EMG) study testing for diminished access to muscle tension in the forearm (Lazarov, Liberman, Hermesh, & Dar, 2014). The researchers first attached EMG electrodes to the subject's forearm and then trained them to produce four levels of target muscle tension defined by microvolt levels. In Phase I, they asked subjects to produce each of these levels repeatedly in random order, and they measured the absolute magnitude of the discrepancy between the target level and the level produced by the subject. In Phase II, subjects received visual biofeedback informing them of how close their muscle tension was to the target level. In Phase III, they eliminated the biofeedback, and again asked them to produce target levels of tension as in Phase I. Phase IV was identical to Phases I and III except that the experimenter told subjects that on certain trials they would have the option to view the biofeedback monitor, but that doing so might produce a distracting noise that could impair their attempt to produce the correct level of muscle tension.

Consistent with SPIS, OCD subjects produced markedly more discrepant levels of muscle tension in Phases I and III relative to target levels and relative to both the anxiety disorder and healthy control subjects. Yet when all three groups received the proxy of biofeedback in Phase II, the OCD subjects produced tension levels that were just as accurate as those of the other two groups. In Phase IV, OCD subjects requested to see the biofeedback monitor more than the other groups did, despite the possibility that it might interfere with their performance. Taken together, these data indicate that impaired access to the internal state of muscle tension in OCD and that reliance on the external proxy of biofeedback entirely compensates for this deficit. Notably, analyses indicated that comorbid anxiety disorders and depression could not account for these findings. Finally, the second part of the study indicated that OCD subjects were fooled by false feedback of muscle tension far more than the other groups were, again confirming that OCD patients rely on external proxies to judge their internal states. These studies replicated previous findings showing that college students scoring high on questionnaire measures of OCD exhibit performance deficits in the muscle tensing task except when receiving biofeedback (Lazarov, Dar, Liberman, & Oded, 2012b). However, the magnitude of performance impairment is markedly greater in the OCD patients than in the high-OC-symptom college students (Lazarov et al., 2014).

4.4. Summary

Research fails to provide consistent support for memory deficits in individuals with OCD, though there is compelling evidence that metacognitive beliefs may motivate people to constantly monitor their own thoughts, thereby negatively impacting memory performance. Moreover, people with the disorder seem to have decreased confidence in their memory and have memorial and attentional biases for relevant, threatening stimuli. The evidence for memory bias in OCD is more robust than for attentional biases, but researchers provide a number of explanations for inconsistent findings, as outlined above. Specifically, they highlight the importance of using relevant, idiographic stimuli to elicit group differences, and raise the possibility that habituation to threat may attenuate

biases over time. Moreover, there is evidence that though biases may not be readily observable on behavioral tasks of attention, patterns of neural activation suggest differences in how people with OCD process threatening stimuli.

Stronger evidence for cognitive deficits in OCD comes from recent research on doubt and difficulty accessing internal states. As a result of this apparent deficit, people with the disorder tend to rely on external proxies, thereby explaining why they engage in ritualistic behavior. Though still in its early stages, this unique line of research provides a promising avenue for understanding the cognitive abnormalities that may contribute to the onset and maintenance of OCD.

5. Future directions

In this article, we reviewed cognitive processes implicated as aberrant in OCD, including dysfunctional thoughts, metacognitive beliefs, and cognitive deficits. Though we discussed these processes separately, they are likely interrelated. For example, metacognitive theorists assert that certain beliefs, such as thought fusion, can lead to other non-metacognitive beliefs such as heightened responsibility and intolerance of uncertainty. They also posit that these metacognitive beliefs cause people to ruminate about threat, which in turn, could foster attentional biases or memory biases for threat (Fisher, 2009). It is likewise feasible that such thoughts, which lead to cognitive self-consciousness, account for the aforementioned memory and internal conviction deficits as noted above. Beliefs about the importance of having a perfect memory or having complete access to one's internal states combined with a lack of confidence in one's ability to do so could interfere with performance on these types of tasks, thus leading individuals to ritualize to achieve certainty. Therefore, there may exist a hierarchy of cognitive processes whereby certain thoughts can explain other cognitive abnormalities in individuals with OCD. Indeed, Hirsch, Clark, and Mathews (2006) proposed a "combined cognitive biases" hypothesis for social anxiety disorder. The theory, which has since been applied to depression as well (Everaert, Koster, & Derakshan, 2012; Everaert, Tierens, Uzieblo, & Koster, 2013), asserts that different cognitive biases affect and interact with one another to maintain a given disorder. To our knowledge, no studies have explicitly tested this theory in OCD. Doing so may further elucidate the relationship among the various cognitive abnormalities associated with the disorder, thereby resulting in a better understanding of its etiology.

Moreover, an understanding of the context in which cognitive biases arise may help to inform treatment. For example, do people with OCD have difficulty tolerating uncertainty only when they are anticipating a negative outcome, or when they are awaiting positive information, too? Do people evaluate others' thoughts as more significant and potentially dangerous as their own thoughts? Determining the specificity or generalizability of the thought-action fusion bias may be useful, as this distinction may reveal if subjects' bias reflects underlying distorted beliefs about themselves (e.g., "I am unique, only my thoughts are dangerous") or thoughts in general (e.g., "everyone's thoughts have the potential to do harm"). Likewise, clarifying aspects of other dysfunctional thoughts might lead to more focused, and thus effective, treatments of the disorder.

Though much research has been conducted on different cognitive processes in OCD, it is still unclear which process or processes best explain symptoms that characterize the disorder, and a full understanding of the etiology of the disorder is lacking. Moreover, as the studies above indicate, not every individual with OCD possesses the same cognitive abnormalities (e.g., there is a subset of patients who do not show increased levels of dysfunctional thinking at all). Subsequently, researchers understand even less about the neurobiological correlates of the cognitive abnormalities associated with OCD. We reviewed several studies above that attempt to elucidate more about the neurobiology of attentional biases in people with the disorder by using fMRI and EEG, but there is a general dearth of research on the topic. That OCD is such a heterogeneous disorder likely contributes to the challenges of studying the neural correlates of cognitive biases in this population. It would thus be worthwhile to identify groups of patients with shared biases (e.g., attentional biases, thought-action fusion, etc.), rather than by OCD diagnosis alone, in order to more directly test how these specific abnormalities are manifested in the brain. Moreover, research on depression has revealed that hyperactivation in certain brain regions is associated with cognitive biases in depressed individuals with a specific gene variant (Beck, 2008). Though no single gene has been found to confer risk for developing OCD, combining research from genetics and neuroimaging studies may result in a better understanding of cognitive processes and their neural correlates.

Finally, as researchers embark upon studies of the biological correlates of cognitive abnormalities they should heed the cautions articulated by Miller (2010) in his brilliant critique of the conceptual confusions that abound in the cognitive neuroscience of psychopathology today. To be sure, cognition is implemented in the brain, but that does mean that cognitive biases and deficits are the epiphenomenal consequences of biological processes that many researchers mistakenly characterize as more "basic" phenomena that "underlie" or cause the cognitive features of OCD. Although researchers may discover regular patterns in neurobiology that accompany obsessions and compulsions, imputation of dysfunction to these patterns presupposes that we have anchored these observations in the clinical phenomenology of OCD. One cannot identify a neuroimaging finding as "dysfunctional" on its own; a neurobiological difference can qualify as a potential neurobiological dysfunction only in virtue of its regular covariation with clinical abnormalities identified psychologically (McNally, 2001). And even then, we cannot assume that the neurobiological difference is the cause of the psychological difference that produces suffering in people with OCD. All we can say for sure is that they occur together.

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