# To Look, or Not to Look? Attention to Threat and Avoidance of Threat While Checking

by

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## Author's declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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**Abstract**

It has been argued that people with obsessive-compulsive disorder (OCD) exhibit facilitated attention to threat (early attentional capture) and difficulty disengaging from it (persistent attentional capture), which in turn produces prolonged compulsive behaviour (e.g., Rachman, 2002). In turn, prolonged or repeated behavior reduces, rather than increases, confidence that things have been properly checked (e.g. van den Hout & Kindt, 2003). A recent study of visual attention to threat while checking a stove found that more attention to stove was associated with reduced certainty that the stove was off in the anxious controls, but not in the group with OCD (Bucarelli and Purdon, 2016). They also observed that people with OCD looked at threat stimuli (flammable items around the stove) less than did anxious controls, leading the authors to hypothesize that those with OCD may strategically avoid looking at threat in order to avoid checking long enough for it to degrade certainty. The current study was designed to further explore the relationship between visual attention to threat, checking behavior, and strategic avoidance. In this study, 29 participants high in checking behavior (HCB) and 30 participants low in checking behaviour (LCB) completed a stove-checking task while wearing an eye tracker, after which they rated their motivation to attend to, and avoid, threat items around the stove. The HCB group checked longer and were less certain after the task. They reported more subjective avoidance of threat items than the LCB group but actual visual attention to threat was not different between groups. Visual attention to threat did predict less certainty that harm was avoided in the HCB but not the LCB group. It is possible that people who have sub-clinical checking concerns do not yet have experience with prolonged checking and have not yet evolved actual strategic avoidance, despite a desire to avoid threat.

*Keywords:* checking compulsions; attentional avoidance; phenomenology; attention.

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## Literature Review

### Obsessive-compulsive disorder

Obsessive-compulsive disorder (OCD) is a psychological disorder, as defined by the Diagnostic and Statistical Manual of Mental Disorders- Fifth Version (DSM-5; American Psychological Association, 2013). Individuals with OCD may have obsessions, compulsions, or, most commonly, both (Abramowitz, Taylor, & McKay, 2009). Obsessions are distressing, intrusive, unwanted thoughts, images, or doubts that increase the anxiety of the experiencer (Jenike, 2004; Stein, 2002). Those with OCD attempt to ignore, suppress, or neutralize their obsessions with some other thought or action, called a compulsion. Compulsions are repetitive, excessive, interfering behaviours that serve to decrease the anxiety of the performer (Stein, 2002). However, compulsions are excessive or not realistically connected to the event they are intended to prevent (i.e. eating food in groups of three to prevent poisoning; Abramowitz, Taylor, & McKay, 2009). Compulsions can be either observable behaviours, such as aligning the items in one's home, or mental acts, such as thinking specific thoughts or counting in one's head.

OCD has a heterogeneous presentation (Mataix-Cols, Rosario-Campos, & Leckman, 2005), making it a challenging disorder to study. The most common OCD symptoms are concerns about contamination paired with excessive hand-washing, or concerns about being responsible for harm paired with repetitive checking (Stein, 2002). Other categories include concerns about symmetry, hoarding, and intrusive aggressive, religious, or sexual thoughts (Abramowitz, Taylor, & McKay, 2009; Mataix-Cols, Rosario-Campos, & Leckman, 2005; Stein, 2002). These symptom dimensions are mostly consistent across cultures (Abed & de Pauw, 1999; Abramowitz, Taylor, & McKay, 2009).

**Severity, prevalence and course**. The symptoms of OCD can lead to extreme impairment and have significant ramifications on one's quality of life (Stein, 2002). Compulsive behaviours can take up a significant proportion of the OCD sufferer's day, interfering with the ability to participate in work, social, or other activities. Those with OCD are less likely to be married and employed than those with other anxiety or mood disorders (Abramowitz, Taylor, & McKay, 2009). The lifetime prevalence of OCD has been estimated to be between 0.8%—3% in adults (Abramowitz, Taylor, & McKay, 2009; Bandelow et al., 2008; Heyman, Mataix-Cols, & Fineberg, 2006; Jenike, 2004; Stein, 2002). OCD can be present at any age throughout the lifespan, and may present as early as 6 years of age (Heyman, Mataix-Cols, & Fineberg, 2006). Males more often present in childhood than females (Abramowitz, Taylor, & McKay, 2009). However, most commonly, the onset of OCD is in adolescence (Abramowitz, Taylor, & McKay, 2009; Heyman, Mataix-Cols, & Fineberg, 2006). OCD can also begin shortly after a pregnancy, miscarriage, or giving birth (Stein, 2002). The course of the disorder is generally chronic (Abramowitz, Taylor, & McKay, 2009; Stein, 2002), but may wax and wane with time (Jenike, 2004).

**Risk factors**. There are a number of risk factors for OCD, including genetic factors, neurobiological dysfunction, early childhood adversity, and stressors, such as traumas (Bandelow et al., 2008; Jenike, 2004). OCD is more common in family members of those with OCD (Jenike, 2004), and genetic factors are estimated to account for 27-47% of the variance in OCD symptoms (Abramowitz, Taylor, & McKay, 2009). OCD may also be linked to an insult to the brain, such as a lesion, head injury, or infection (Abramowitz, Taylor, & McKay, 2009;

Heyman, Mataix-Cols, & Fineberg, 2006; Jenike, 2004). In addition, OCD has been strongly linked to abnormal activity levels in the orbitofrontal cortex, and less strongly linked to abnormalities in the anterior cingulate, striatum, lateral frontal and temporal cortices, amygdala, and insula (Mataix-Cols, Rosario-Campos, & Leckman, 2005). However, as with many other disorders, it is unclear whether these neurobiological irregularities serve as a risk factor for OCD, or are present as a result of OCD.

**Treatment.** Many individuals with OCD are reluctant to seek help. This may be due in part to lack of insight, or shame and stigma (Jenike, 2004). In one sample, there was an average 10-year delay in seeking treatment, and 17-year delay before receiving an appropriate treatment (Hollander et al., 1997). Lack of recognition by healthcare providers, as well as lack of access to care or affordable care, can both be barriers to receiving the appropriate treatment for OCD (Jenike, 2004; Stein, 2002). Fortunately, there are some effective treatments for OCD. NICE guidelines recommend evidence-based treatments, like Cognitive-Behavioural Therapy with Exposure and Response Prevention (CBT-ERP) and/or treatment with medication, like Selective Serotonin Reuptake Inhibitors (SSRI) (National Institute for Health and Clinical Excellence, 2005). Both psychological and pharmacological treatments have been shown to be effective (Bandelow et al., 2008), however CBT has been shown to have larger effect sizes than antidepressants (such as SSRIs; Foa et al., 2005; Ost, Havnen, Hansen, & Kvale, 2015). Some studies have found that CBT can have a longer duration of effectiveness after discontinuation of treatment, although results are mixed (Bandelow et al., 2008). The combination of CBT and medication is not superior to either alone (Foa et al., 2005; Ost, Havnen, Hansen, & Kvale, 2015). Beyond CBT-ERP and medication, later lines of treatment may include transcranial magnetic stimulation, deep brain stimulation, or surgical intervention (Abramowitz, Taylor, & McKay, 2009; Jenike, 2004).

**The cognitive-behavioural model of OCD**

One of the most well-supported and oft-cited models for understanding OCD is the *cognitive-behavioural model*. This model begins with the assumption that everyone experiences unwanted thoughts with similar content to OCD obsessions (Byers, Purdon, & Clark, 1998; Rachman and de Silva, 1978), but those prone to developing obsessional problems react differently to these thoughts than those not prone (Abramowitz, Taylor, & McKay, 2009). It is believed that those with OCD have six main beliefs which make them more susceptible to act on these thoughts than others: they place great importance on their thoughts, as well as their ability to control them; they have an inflated sense of responsibility to protect self and others from harm, are intolerant of uncertainty, have perfectionistic traits, and tend to overestimate threat (Jenike, 2004; Obsessive Compulsive Cognitions Working Group, 2001; Purdon & Chang, 2016; Rachman, 2002; Salkovskis, 1985; Stein, 2002; Steketee, Frost, & Cohen, 1998). An individual who has these beliefs is more likely to appraise an unwanted thought as important, unacceptable, and threatening; thus, they are more likely to be distressed and more likely to engage the thought and make efforts to banish it, or to prevent the harm the thought suggests (Abramowitz, Taylor, & McKay, 2009). In addition, perfectionism and intolerance of uncertainty may be related to the persistence of compulsions, as the individual seeks perfect certainty that harm has been avoided. There is evidence that those with obsessions use more criteria and more subjective criteria to decide when to end their compulsion (Salkovskis, 1998; Salkovskis, Millar, Gregory, & Wahl., 2017). The individual may respond to an intrusion with any number of safety behaviours, including performing compulsions, seeking reassurance, avoiding situations related to the obsessional thought, trying to suppress their intrusion, or by engaging in other safety behaviours. The cognitive-model states that the interpretation, or appraisal, of the obsession mediates the behavioural outcomes, not the obsession itself.

**Self-perpetuating mechanisms in OCD**

The intrusion-compulsion pattern in OCD is maintained through a number of means. These processes can lead intrusions to become obsessions, can contribute to the repetitive nature of compulsions, and may result in worsening of OCD symptoms over time.

**No natural terminus to the compulsive behaviour.** Rachman (2002) observed that the concern expressed in the obsession is vague and future-oriented, which means that it is not possible to establish with certainty that harm has been avoided. Thus, compulsive behaviours have no natural terminus. Indeed, Szechtman & Woody (2004) posited that people with OCD uniquely are unable to achieve the internal, felt sense we normally rely on to signal that danger has passed and safety behaviours can be terminated. Consistent with this, Salkovskis, Millar, Gregory, & Wahl (2017) found that in those with OCD the decision to terminate washing behaviour was more effortful and required more evidence than in both anxious and non-clinical comparison groups.

**Learning mechanisms.** Safety behaviours, like compulsions, are reinforced because they reduce distress in the short term, which increases the probability of engaging in the safety behaviour in future instances of the intrusion (Hodgson and Rachman, 1972). Salkovskis, Thorpe, Wahl, Wroe, & Forrester (2003) found that when people with OCD responded to an intrusion with a neutralizing thought they had more discomfort and more urges to neutralize later on than those who did not neutralize. In addition to the negative reinforcement of distress reduction, engaging in safety behaviours eliminates the opportunity to learn that the thought is innocuous, even when not acted upon (Abramowitz, Taylor, & McKay, 2009). Thus, the sufferer is likely to continue avoiding situations that elicit obsessions or compulsions, without learning that the intrusion is harmless on its own.

**Mood-appraisal spiral.** Negative interpretations of intrusions are thought to lead to a decline in one's mood, whether that be sadness, anxiety, or distress of some other kind. Adverse mood is theorized to result in further ritualization (Beech & Liddell, 1974), which can lead to a "mood-appraisal spiral", whereby negative interpretation leads to worsened mood, which leads to compulsions, which have been associated with an increase in intrusions (Salkovskis, 1999). Compulsions can serve as reminders of obsessions, perpetuating the symptoms even further (Abramowitz, Taylor, & Mckay, 2009).

**Impact of compulsions on beliefs.** The more one performs compulsions, the greater sense of responsibility one feels, and an increase in perceived harm probability is observed (Bucarelli & Purdon, 2016; Rachman, 2002; Radomsky, Dugas, Alcolado, & Lavioe, 2014). In addition, compulsions decrease one's confidence in their memory for the performance of the compulsion (Bucarelli & Purdon, 2016; Boschen & Vuksanovic, 2007; Radomsky & Alcolado, 2010; Radomsky, Dugas, Alcolado, & Lavoie, 2014; Radomsky, Gilchrist, & Dussault, 2006; van den Hout & Kindt, 2003). In other words, the behaviour that one performs in order to feel more certain has the effect of increasing one's sense of doubt about their own behaviour: this has been deemed the "ironic effect" of repetition in OCD. This effect has been seen for perseverative checking (Boschen & Vuksanovic, 2007; Radomsky, Gilchrist, & Dussault, 2006; van den Hout & Kindt, 2003) and perseverative attending (van den Hout, Engelhard, de Boer, du Bois, & Dek, 2008); thus, van den Hout et al., 2008 summarize the ironic effect as a general perseveration-uncertainty association.

However, the ironic effect literature has some important limitations. Most often, the effect of checking on certainty has often been explored using a virtual stove (e.g. Boschen & Vuksanovic, 2007), which may be less threatening than a real one that can cause actual harm if left on. In addition, most often, the checking is artificially induced; that is, experimenters tell participants to repeatedly look at a stove (e.g. van den Hout & Kindt, 2003), turn a stove on and off (e.g. Radomsky, Gilchrist, & Dussault, 2006), or imagine checking the stove (e.g. Radomsky & Alcolado, 2010) a set number of times. The relationship of natural checking to certainty is rarely explored. Furthermore, ironic effect has been explored for physical checking and mental checking, but less often for visual checking; less is known about the impact of paying attention to threatening stimuli on certainty for a check. Lastly, it is not clear why, despite repetition in OCD, certainty is achieved in over half of all compulsive episodes (Bucarelli & Purdon, 2015). This suggests that the repetition-doubt cycle must be broken in some cases, but the circumstances under which this occurs is not clear.

**Impact of compulsions on memory.** Rachman (2002) wrote that impaired memory consolidation during a check may occur due to high levels of affective arousal during the performed compulsion. Van den Hout and Kindt (2003) posited that increased familiarity with a particular set of behaviours (i.e. the compulsion) leads to conceptual processing of the act, while perceptual processing is suppressed, which diminishes the vividness of the memory for perceptual details of the behaviour, which is the very information relied upon to establish that a task was done correctly. Thus, the effect of checking on memory can help explain the ironic effect of repetition: those who check more actually have poorer memory for the sensory details of the action, leading to less certainty it has been done properly. This can evoke concerns about mental deterioration and produce general doubts about one's cognitive abilities (Rachman, 2002). This, in turn, can exacerbate concern about ability to avoid harm and lead to increasingly strict criteria that have to be met in order to establish certainty. In this way, washing one's hands one time may no longer be enough in order to feel certain that one has eliminated contamination, and unusual criteria may be relied upon in an attempt to gain that certainty (Richards, 1995, 1997; Wahl, Salkovskis, & Cotter, 2008).

**Attention deployment.** People with OCD may be hypervigilant to both internal and external threat stimuli. Internally, those with OCD are thought to be more cognitively self-conscious, making them more likely to detect intrusions (Cohen & Calamari, 2004; Salkovskis, 1985). This can contribute to greater distress over the lack of mental control that the sufferer perceives themselves to have. It may also lead to increasing attempts to suppress one's intrusions, which has been shown to lead to an increase in thought occurrence (Abramowitz, Tolin, & Street, 2001). Thought recurrences, in turn, are associated with increasingly negative appraisals of the thought's meaning and importance (Purdon, Rowa, & Antony, 2007).

Those with OCD may also find stimuli related to their obsessions to be threatening, and may pay more attention to these (Rachman, 2002; Salkovskis, 1999). Paying more attention to intrusion-related cues could lead to an increase in obsessive thoughts (Muller & Roberts, 2005).

## Attention in OCD

As previously noted, patterns of attentional deployment may play a role in the maintenance of OCD. However, the literature on attention in OCD is inconsistent.

**Attention theory.** Poser and Peterson's (1990) seminal paper on visual attention identified three patterns of attentional deployment: disengaging attention from a stimulus, shifting attention, and engaging attention with a new stimulus. Posner and Peterson viewed these patterns as being the product of one of two types of processing, automatic and effortful. Automatic processing is stimulus-driven and quick, and is often described as "bottom-up" attention. Luria (1973) called it "involuntary orienting". It is akin to when a stimulus simply catches our eye and automatically draws our attention. Effortful processing, on the other hand, is motivation or goal-driven, and involves purposefully directing our attention to a specific stimulus (Armstrong & Olatunji, 2012). Because executive function is implicated, is often referred to as "top-down" attention.

**Attention in anxiety.** Studies of the role of attention in anxiety have typically compared the tendency for anxious individuals to pay more attention to threatening stimuli than neutral stimuli, or compared people high in anxiety to a control group in the extent to which they attend to threatening stimuli. Various theories have been posited to predict how anxiety influences attentional deployment. The vigilance theory of attentional biases purports that for people high in trait anxiety, threat cues have early and ready capture of attention. That is, the bottom-up, involuntary attentional system has a low threshold for threat detection and capture. This is called "facilitated attention" (Cisler & Koster, 2010). The maintenance model suggests that people high in trait anxiety are more likely to maintain attention on a threat stimulus once it has been detected (Armstrong & Olatunji, 2012), which Cisler and Koster (2010) refer to as "difficulty disengaging", but at some point during exposure to the threat stimulus they also may deliberately start to avoid attending to it, which Cisler and Koster (2010) refer to as "attentional avoidance" (Cisler & Koster, 2010).

Attentional avoidance is much less well understood than facilitated attention and difficulty disengaging. Cisler & Koster (2010) noted that attentional avoidance may be driven by one's emotion regulation goals in that moment. There is evidence that attentional deployment can be influenced by the goal of the participant; for example, Vogt, Lozo, Koster, and De Houwer (2011) found that those who touched an object they found disgusting were more likely to look at stimuli relevant to cleanliness than those who did not touch a disgust object, implying that their desire to become clean influenced their attentional deployment. See Table 1 for a summary of the components of attention and their relationship with attention biases.

*Table 1. Attentional biases in anxiety and their related attentional components*

| Attentional bias | Definition | Attentional system(s) implicated | Attentional process(es) implicated |
|---|---|---|---|
| **Hypervigilance** | Being drawn to threat stimuli quickly | Bottom-up, stimulus-driven system | Shifting attention and engagement with a new stimulus |
| **Maintenance** | Paying more attention to threat stimuli over time | May be a combination of bottom-up and top-down processing | Difficulty disengaging with a stimulus |
| **Avoidance** | Greater avoidance of threat stimuli over time | Top-down, goal-driven system | Lack of re-engagement with a stimulus |

**Attention in OCD.** If those with OCD are assumed to exhibit similar features as those with anxiety disorders, we would expect that people with OCD show similar attentional biases to threat. However, we cannot assume that what we know about attention biases in anxiety is an exact parallel to what is experienced by those with OCD because there are many phenomenological and neurological differences between the two (Heyman, Mataix-Cols, & Fineberg, 2006; Stein et al., 2010). Rachman (2002) proposed that those with OCD are likely to pay more attention to threat cues than those without OCD. Studies investigating attention in

OCD use one of a set of paradigms: a dichotic listening paradigm, an emotional Stroop task, a dot probe task, an inhibition of return paradigm, or a free-viewing paradigm.

The dichotic listening paradigm involves presenting participants with a threat cue and a neutral or other cue in the other ear, simultaneously. Participants are instructed to focus on the non-threat words, and then asked to try to recall as many threat words as they can. An attentional bias is said to be present when fear-related words are remembered more readily in one group than another, as this indicates that those words are particularly salient for the listener (Muller & Roberts, 2005).

The emotional Stroop task involves presenting participants with emotionally salient words in different colours and asking that participants say the colour of the word, rather than the word itself. Longer reaction times to state the colour of the word is interpreted to mean that the word is especially distracting, indicating an attention bias (Muller & Roberts, 2005).

In the dot probe task, participants are presented with a threat word or image on one side of a screen, and a neutral word or image on the opposing side. These stimuli are removed, and a target is presented on either the same side as the threat (congruent trial) or the same side as the neutral cue (incongruent trial). Participants are asked to press a key to indicate on which side the target was presented. An attentional bias is thought to be present if the participant responds to congruent trials faster than incongruent trials (Waechter, Nelson, Wright, Hyatt & Oakman, 2014).

In the emotional inhibition of return paradigm, a neutral or threatening image or word is presented on one side of the screen. Then, a target is presented either on that same side (valid trial) or the opposing side (invalid trial). Participants are asked to press a key to indicate on which side the target was presented. Attentional bias is said to be present if there is a quicker response to valid trials (indicating facilitated attention) or if there is a slower response on invalid trials (indicating difficulty disengaging) when a threat stimulus is presented before the target than when a neutral stimulus is presented before the target (Moritz et al., 2009).

Studies comparing people with OCD to those without OCD on these paradigms has yielded quite mixed findings. See Table 2 for a summary of this research.

*Table 2. Studies of attention in OCD*

| **Article** | **Method** | **Result** |
|---|---|---|
| Foa & McNally, 1986 | Dichotic listening (word detection in non-dominant ear) | Fear-relevant words detected more before treatment than after treatment |
| Foa et al., 1993 | Emotional stroop task (RT) | Those with OCD (washing type) took longer to name contamination words than neutral words |
| Lavy, Van Oppen, & Van Den Hout, 1994 | Emotional stroop task (RT) | Those with OCD took longer to name OCD-related words than neutral words |
| Direnfeld, Pato & Roberts, 2001 | Emotional stroop task (RT) | Response delay to OCD words correlated with total number of OCD symptoms; delay decreased from pre- to post-treatment |
| Kampman, Keijsers, Verbraak, Naring, & Hoogduin, 2002 | Emotional stroop task (RT) | No group differences (OCD, Panic Disorder, controls) on delay in naming OCD or general threat words |
| Kyrios & Iob, 1998 | Emotional stroop task (RT) | No difference between OCD and controls on naming OCD and neutral words |
| Tata, Leibowitz, Prunty, Cameron, & Pickering, 1996 | Dot-probe task (RT) | OCD contamination group quicker to respond to a dot in the place of contamination words than a social phobia group |
| Harkness, Harris, Jones & Vaccaro, 2009 | Dot-probe task (RT) | No difference between OCD checking participants and matched controls on reaction time to checking or washing stimuli |

*Table 2 (Continued). Studies of attention in OCD*

| | | |
|---|---|---|
| Amir, Najmi, & Morrison, 2009 | Dot-probe task (RT) | More attention to OCD stimuli in first block, attenuation over trials |
| Moritz et al., 2009 | Inhibition of Return (IOR) | Those with OCD took longer to respond to targets preceded by an OCD stimulus |
| Armstrong, Olatunji, Sarawgi, and Simmons, 2010 | Free viewing of images (ET) | High contamination fears group paid more attention to disgusted and fearful expressions; were quicker to orient to fearful faces only |
| Bradley, Hanna, Wilson, Scott, Quinn, & Dyer, 2016 | Free viewing of images (ET) | No group difference on speed of orienting to stimuli; OCD severity predicted frequency and duration of fixations over time |
| Armstrong et al., 2012 | Free viewing of scenes (ET) | High contamination fears group were quicker to orient to threat; no difference on time spent looking at threat |
| Bucarelli & Purdon, 2016 | In-vivo stove checking task (ET) | Those with OCD paid less attention to threatening stimuli than an anxious control group |

*Note.* RT= reaction time data used; ET= eye tracking data used

These studies suggest that those with OCD may have an attentional bias towards threat cues that are relevant to their central obsessional concern. However, there are also a number of null findings in the literature that challenge the idea that attentional biases to threat play an important role in the persistence of obsessional problems (e.g. Armstrong et al., 2012; Harkness, Harris, Jones & Vaccaro, 2009; Kyrios & Iob, 1998). Due to the conflicting findings, attention processes in OCD warrant more attention.

**Limitations of attention paradigms.** Reaction time measures, such as dot-probe tasks, stroop tasks, and inhibition of return paradigms, are limited, both in design, and in the conclusions that can be drawn from them. Tasks like the dot-probe and spatial cueing paradigms require a response, such as a key press, from the observer, thus pulling the attention of the participant away from the stimuli they are meant to be attending to. Participant attention to the keyboard is not ideal when one is purely aiming to study attention to threat.

In addition, the data yielded from these tasks do not allow us to distinguish between the different attentional processes that may be implicated (Armstrong & Olatunji, 2012). Most authors using these techniques use inferential reasoning to try to discern the attentional processes at play; however, most often, no conclusive statements can be made about this. For example, a longer reaction time on a Stroop task may indicate that the participant is more distracted by a word (i.e. difficulty disengaging is at play), or that they are avoidant of the word (i.e. attentional avoidance is at play). Evidence for this can be seen in a study by Lavy & van den Hout (1994), who asked participants to avoid reading certain types of information, and stroop reaction times increased, indicating that avoidance can have the same effect as difficulty disengaging. Additionally, during these tasks, more than one attentional process may be at play, depending on the duration of stimulus appearance—in short, interpretations of reaction time data are difficult.

Furthermore, these paradigms rely on a pre-determined set of stimuli (most often OCD-related words or images) that are thought to be relevant to the participant. However, evidence from some studies (e.g. Tata, Lebowitz, Prunty, Cameron, & Pickering, 1996) suggest that attention biases may only be found within the realm of what is idiosyncratically threatening to each participant; that is, stimuli must reflect the particular concerns of the participant.

Lastly, the dot probe task has been found to be wholly unreliable, with reliability estimates centering around 0 (Schmukle, 2005; Staugaard, 2009; Waechter, Nelson, Wright, Hyatt & Oakman, 2014).

**Measuring attention using eye tracking.** Due in part to these limitations, as well as advancing technology and available methodologies, researchers have begun to use eye tracking technology to study attentional processes. Eye trackers may be used while participants are engaging in a reaction time task, or during free-viewing paradigms. Eye trackers assess overt attention, in the form of eye movements, to gather information about the participants' visual attention; in this way, eye tracking data goes beyond reaction times, telling us about dynamic changes in attention over time. Using this data, researchers can make conclusions about the three attentional processes: quicker time to orient to threat stimuli indicates facilitated attention, more time attending to threat indicates difficulty disengaging, and eye fixations away from a stimulus can indicate attentional avoidance (Cisler & Koster, 2010). In contrast to the dot probe task, the use of eye movement indices over a longer time course (5000 ms) has been shown to have excellent reliability (Waechter, Nelson, Wright, Hyatt & Oakman, 2014).

This method, too, has its limitations. Some authors argue that overt attention is only half of the picture, and that covert attention is important to study in these populations as well (Armstrong & Olatunji, 2012). In addition, the argument that stimuli must be idiosyncratic to the individual still applies when using eye tracking technology.

**Bucarelli & Purdon, 2016**

Bucarelli & Purdon (2016) addressed many of the limitations in the ironic effect of repetitive checking and attentional deployment to threat by tracking eye movements during a task involving an actual stove. Participants with OCD whose primary concern was checking, and a clinical control group of participants with another anxiety disorder (but no OCD), used a stove while wearing a portable eye tracker, allowing participants to engage in both physical and visual checking as they normally would. Participants were asked to boil a kettle of water, then turn off the burner and place a pot of dry rice on the same burner used to boil the kettle, and then leave the kitchen to join the researcher several rooms away. Around the stove were an equal number of non-flammable items (coffee mugs, a glass salt shaker, and metal cooking utensils) and “threat” items (flammable items such as matches, paper towels, paper coupons).

The researchers examined attention to the stove, attention to flammable items, and attention to non-flammable items during a “pre-check” phase (the time between when the stove was turned on and the kettle boiled) and “check” phases (the time between when the kettle was removed and the participant left the kitchen). Pre- and post-task ratings of harm and responsibility were taken, as were post-task ratings of confidence in memory for having turned off the stove, and certainty that the stove was, in fact, off. This paradigm allowed Bucarelli and Purdon to examine the extent to which looking at the stove (that is, visually checking the stove) was associated with subsequent memory confidence.

A key finding was that the anxious control group did exhibit an ironic effect of checking the stove knob, lights, and burners, such that greater fixations on these cues was associated with less confidence and certainty that the stove was off. Contrary to hypotheses, the OCD group did not show this effect, but it was considered noteworthy that those with OCD had a significantly less fixation time on threat items than did the anxious controls. The authors hypothesized that those with OCD have experience getting caught in an attention-uncertainty cycle, and strategically avoid paying attention to threatening items in order to avoid getting caught in this cycle. However, motivation to attend to threat and to avoid attending to threat was not directly explored within this paradigm.

There is certainly evidence for behavioural and cognitive avoidance in OCD. Those with OCD tend to avoid coming into contact with cues that may induce obsessions (American Psychiatric Association, 2013); behavioural avoidance may be effective in the short term to reduce anxiety, but is associated with increased anxiety over time (Purdon, 2007). Cognitive avoidance, in the form of thought suppression, is also common in OCD (Rachman & Hodgson, 1980), and is often commonly used to get rid of the obsession in order to avoid having to do the compulsion (Purdon, Rowa, & Antony, 2005). Attentional avoidance, however, is only beginning to be investigated in anxiety disorders, and has not yet been investigated explicitly in OCD. Interestingly, Moritz et al. (2009) found that those with OCD took longer to respond to targets preceded by an OCD-related stimulus. The authors interpreted this to suggest that people with OCD were "more distracted" by these images; however, an alternative explanation may be that people with OCD were deliberately trying to avoid the images. Thus, attentional avoidance may occur in OCD, but further investigation is indeed necessary.

**The present study**

The theory on attention in OCD states that those with OCD are more likely to pay attention to threat than those without OCD (Rachman, 2002). However, Bucarelli and Purdon (2016) found that those with OCD paid *less* attention to threat than anxious controls. Meanwhile, there are robust findings which suggest that when people with and without anxiety disorders repeat an action, such as visually checking a stove to determine whether or not it is off, they have less, rather than more, confidence that the stove is off (e.g., van den Hout & Kindt, 2003). In contrast, Bucarelli and Purdon (2016) found that the more anxious controls looked at a stove, the less certain they felt that it was turned off properly, whereas in those with OCD, this was not the case. These intriguing findings lead the authors to hypothesize that those with OCD did not show an ironic effect of prolonged checking on certainty because, knowing that threat cues can increase their doubt, they strategically avoided attending to the threatening items, which may have reduced the need for perfect certainty the stove is off, thereby dodging a pattern of prolonged checking. Participants high in anxiety but without a history of prolonged checking may not have had the experience to recognize that attention to threat may lead to prolonged checking.

One possibility is that avoidance of threat may improve post-task certainty. In attending to threat cues, people may begin to envision numerous possibilities by which harm could occur (e.g., the matches could spill onto the burner, one could inadvertently knock one into the vicinity of the burner, the paper towels may get blown over onto the burner as one leaves the kitchen, etc.) which further increases perceived harm and concomitant importance of perfect certainty that everything is safe before leaving. Afterwards, if they cannot conjure a perfect image of the threatening items as being safely away from the burner the may begin to doubt whether the stove is safe. When people have had this experience, and have become stuck in a check-doubt-repetition cycle, they may implicitly recognize that attending to threat heightens their appraisal of harm, increases the number of stimuli they need to check perfectly, and results in repeated checking that fosters doubt, rather than certainty. They may thus choose to simply avoid attending to threat, particularly when they are not fully responsible for the environment, as is the case in a lab setting. Although they may still check longer than people without checking concerns due to over-estimations of harm and responsibility, avoiding threat may result in greater confidence that the check was done properly. If this is the case, this may provide an explanation for why many compulsions end in certainty, despite the ironic effect.

The purpose of the current study was to elaborate and extend Bucarelli and Purdon by: 1) examining the relationship between check duration and OCD-relevant trait and state appraisals; 2) investigating whether people high in checking concerns avoid threat cues, as assessed by both self-report and actual visual attention; 3) and exploring whether avoidance is associated with increased post-check certainty. In addition, we aimed to collect information on how people knew it was okay to end the check (their "termination criteria"). Only one study has investigated termination criteria for checking, finding that more criteria were used by obsessional checkers than controls (Salkovskis, Millar, & Gregory, 2017). However, this study was done retrospectively, not in-lab, and we are interested in exploring the type of criteria that is reported shortly after a check.

To address these questions, we used Bucarelli and Purdon's in-vivo stove-checking paradigm to examine checking in people high and low in checking behaviour. Participants were asked to rate how much they attended to and avoided attending to threat stimuli, and were interviewed about the extent to which they strategically avoid threat and if so, the purpose of this avoidance.

**Hypotheses**

1. In line with the cognitive-behavioural model of OCD, those high in checking concerns will have higher levels of trait responsibility, lower levels of trait memory, sensory, and cognitive confidence, higher levels of state responsibility and state harm estimation.
2. Due to hypothesized overestimations of harm and responsibility, those high in checking behaviour will have longer check duration than those low in checking behaviour. Accordingly, check duration will be influenced by trait and state appraisal ratings.

3. Those high in checking behaviour will report greater motivation to avoid threat and the proportion duration of eye fixations on threat will be fewer than those of participants low in checking behaviour.
4. Greater subjective and actual avoidance of threat will be associated with higher post-task certainty in those high, but not low, in checking behaviour.
5. Those in the HCB group will use more criteria to end their check than those in the LCB group and this will be associated with longer check duration.

## Methods

### Design overview

A between-subjects design was used with those high and low in checking concerns. The study involved 4 steps: a) pre-task scale completion, b) checking induction with eye-tracker, which included a pre-check phase (time between when the stove was turned on and when the kettle boiled) and a check phase (time between when the stove was turned off and the participant left the kitchen), c) post-task scale completion, and d) an interview. See Procedures section for details.

### Participants

Participants were recruited from University of Waterloo's participant pool and took part in this hour-long study in exchange for partial course credit. The study was advertised as an exploration of checking using eye-tracking technology. An analogue sample was used, with participants high and low in checking concerns. Analogue samples are thought to be both appropriate and valuable in the study of OCD, since checking symptoms are present in non-clinical populations, and OCD symptoms are thought by many to be dimensional, rather than categorical. Previous analogue studies have found phenomenological similarities between those with OCD and non-clinical samples of those who endorse OCD concerns (Gibbs et al., 1996; Abramowitz et al., 2014).

Participants were pre-screened using the *Concerns about being responsible for harm, injury, or bad luck* subscale ("Responsibility subscale" hereafter) of the Dimensional Obsessive-Compulsive Scale, scores on which are associated with checking behaviour (DOCS; see measures section). To ensure equal sampling in the extreme ranges of responsibility concerns, those who scored 0.5 standard deviations below the student mean for this subscale and 0.5 standard deviations above the OCD mean for this subscale were able to participate. A total of 103 participants (age range= 18-26 years, mean age= 20.52 years, SD= 1.79 years) completed the study. See Table 3 for demographic information about this sample.

Participants were re-administered the DOCS in-lab. The score on their Responsibility subscale in-lab determined their group membership for analyses. Scores of 0-2 on this subscale marked the bottom quartile of participants (those Low in Checking Behaviour; LCB; n=30), and scores of 8 or higher marked the top quartile (those High in Checking Behaviour; HCB; n=29). Because participants' in-lab scores did not match their pre-screen scores, the sample size used for analysis was smaller than the sample of participants who completed the study.

*Table 3. Demographic information, whole sample (n=103)*

| Characteristic | Category | n | % of sample |
|---|---|---|---|
| Gender Identity | Male | 27 | 24.8 |
| | Female | 72 | 66.1 |
| | Other | 4 | 9.1 |
| Sex Assigned at Birth | Male | 27 | 24.8 |
| | Female | 76 | 69.7 |
| Primary Ethnicity | Aboriginal | 1 | 0.9 |
| | Black/African American | 3 | 2.8 |
| | East Asian | 28 | 25.7 |
| | Middle Eastern | 4 | 3.7 |
| | South Asian | 15 | 13.8 |
| | Southeast Asian | 8 | 7.3 |
| | West Indian/Caribbean | 1 | 0.9 |
| | White/Caucasian | 38 | 34.9 |
| | Other | 3 | 2.8 |
| | Decline to answer | 2 | 1.8 |

## Materials

**Dimensional Obsessive-Compulsive Scale** (DOCS; Abramowitz et al., 2010). The DOCS is a 20-item, self-report measure used to assess OCD symptom and severity. It is scored using 4 subscales: Concerns about Germs and Contamination; Concerns about being Responsible for Harm, Injury, or Bad Luck; Unacceptable Thoughts; and Concerns about Symmetry, Completeness, and the Need for Things to be "Just Right". These subscales have been confirmed through the use of factor analysis across diagnostic groups. Each subscale consists of 5 items, asking about time spent on these concerns, avoidance of triggers, distress, impairment, and mental control over these concerns. Items are scored on a range from 0, indicating an absence of that symptom, to 4, indicating an extreme presence of that symptom. Internal consistency is excellent, with Cronbach's alphas ranging from 0.86-0.94 for the Responsibility subscale, and 0.90-0.93 for the total score. The DOCS demonstrates good convergent validity, correlating well with other scales that measure OCD symptoms, such as the Obsessive-Compulsive Inventory-Revised (OCI-R) and Yale-Brown Obsessive Compulsive Scale (Y-BOCS). Of particular importance in our study, the DOCS Responsibility subscale significantly correlates with the OCI-R Checking subscale. The DOCS was also able to discriminate those with OCD from those with other anxiety disorders and from a non-clinical population of students. In our sample, the reliability of this scale was excellent (Cronbach's alpha= 0.93, Spearman-Brown Coefficient for split half reliability= 0.85).

**Memory and Cognitive Confidence Scale** (MACCS; Nedeljkovic & Kyrios, 2007). The MACCS is a 28-item, self-report scale designed to assess beliefs about memory and other cognitive processes. It has four scales: General Memory, Decision-Making, Attention/Concentration, and High Standards. Responses range from 1 (strongly disagree) to 7 (agree very much). Even when controlling for mood, those with OCD score higher on the MACCS, indicating lower levels of cognitive confidence; in this way, the MACCS is able to discriminate between those with OCD and community controls. Adequate internal consistency has been found using this scale. The MACCS correlates significantly with OCD-related beliefs as measured by the OBQ. In our sample, the reliability of this scale was excellent (Cronbach's alpha= 0.92, Spearman-Brown Coefficient for split half reliability= 0.93). This scale was included to assess trait memory and cognitive confidence.

**Obsessive Belief Questionnaire – Brief Version** (OBQ-44; Obsessive Compulsive Cognitions Working Group, 2005). The OBQ-44 is a 44-item, self-report measure for assessing beliefs that are thought to be implicated in OCD. Factor analysis revealed three scales: Perfectionism and Intolerance of Uncertainty; Importance of Control of Thoughts; and Responsibility and Overestimation of Threat. Participants score how much each item reflects the way they see the world, from 1 (disagree very much) to 7 (agree very much). Internal consistency for the scale was very good, with a Cronbach's alpha of 0.95. The OBQ-44 shows convergent validity with the Padua Inventory-Revised (PI-R), another widely used instrument to measure OCD severity. The OBQ-44 is able to discriminate between those with OCD, those with other anxiety disorders, student controls, and community controls. In our sample, the reliability of this scale was excellent (Cronbach's alpha= 0.96, Spearman-Brown Coefficient for split half reliability= 0.92). This scale was included to examine trait beliefs about cognitions.

**Visual-Analogue Scales** (VAS; Bucarelli & Purdon, 2016). Visual analogue scales of 125 mm were used to assess responsibility for harm, estimation of harm, and certainty that the task had been done correctly. The scales were anchored on the left by a phrase indicating an absence of that property (e.g. “not at all” or “no harm at all”) and on the right indicating an extreme presence of that property (e.g. “extremely” or “100% certain”). Pre-task scales included the questions: “imagine what could happen if the stove was left on…” (a) how much harm could occur?, (b) how responsible would you feel if harm occurred?, (c) how guilty would you feel if harm occurred, and (d) how likely is it that harm will occur? Questions (a) and (d) were aggregated to make up the “estimation of harm” scale; questions (b) and (c) were combined to estimate “responsibility for harm”. Post-task scales began with the prompt “imagine the status of the stove right now…” and asked the same four questions as above, plus two questions about certainty: (a) how certain are you that the check has been done properly? And (b) how certain are you that harm has been prevented?. These were combined to make up the “certainty” scale.

**iViewX™ HED Portable Eye Tracker.** The eye tracker used in this study was a head-mounted, mobile eye tracker from SensoMotoric Instruments (SMI). It is comprised of an outward-facing camera, producing person-perspective video, and an inward-facing eye monitor that is calibrated to track the participants’ right pupil. These two inputs are combined to generate video footage with a superimposed crosshair that indicates participants’ attention. Then, this video can be coded to generate eye tracking indices. This eye tracker was calibrated using 5-point calibration. Eye tracking data was coded with SMI BeGaze™ Version 2.5 software and then exported to SPSS Version 24.0 for further analysis.

**Threat and non-threat items.** From left to right, the following items were placed around the stove: a metal canister with spaghetti noodles in it, a paper towel roll, a metal tin with metal cooking utensils in it, a container of matches, a salt shaker, a paper basket with blank recipe cards, stacked mugs, and a jar with wooden spoons. These items were selected to ensure that a range of flammable (paper towels, matches, basket, spoons) and non-flammable (canister, tin, salt, mugs) items with approximately equal physical qualities were sampled. These items were the same used by Bucarelli & Purdon (2016), but for the present study, they were arranged around the stove in approximately symmetrical fashion, to avoid item size and colour from pulling participants' attention to one area for any extraneous reason. See Appendix A for a picture of the stove and surrounding items.

## Procedure

**Introduction and consent-gathering.** Participants were brought into the lab and the stove task was explained. Participants were given the opportunity to ask questions and were provided with consent forms. All participants provided consent to participate; one participant declined to have their interview audio recorded (notes were taken in-lab in lieu of this recording).

**Pre-task scales and task set-up.** Participants were asked whether they wear corrective eyewear (glasses or contacts), and whether they were wearing colour contacts or eye makeup. Researchers ensured that participants wore eyewear if they normally would for a kitchen task to ensure ecological validity. Glasses, colour contacts, and heavy eye makeup are also known to impair calibration (Xu & Merritt, personal correspondence), so these variables were collected for researcher awareness purposes. Participants were then given the MACCS, OBQ-44, and DOCS to complete in paper format, while the researcher waited in another room. Once completed, the participants were explained the stove task in full detail (see Checking Induction for more details). Participants then completed the pre-task VAS. Next, eye tracker fitting and calibration was completed. If calibration was unsuccessful, participants completed the rest of the study as they normally would, wearing the eye tracking for consistency.

**Checking induction.** Before leaving the room, the researcher turned on all burners to demonstrate stove functioning, leaving participants to turn off the three unnecessary burners. The participants were asked to boil a pre-measured amount of water in the kettle (on the fourth burner), then take the kettle off the stove when it whistled. Participants were told to ensure the stove was off, and then put a prepared pot of dry rice onto the burner they just finished using. If participants asked when it was okay to put the rice on, or if they should put the rice on right away, researchers answered that they should put the rice on when they feel comfortable doing so. Participants were instructed to take off the eye tracker and leave the room after this task, meeting the researcher in another room.

**Post-task scales and interview.** When the task was complete, participants completed the post-task VAS. After this, the researcher asked participants for their subjective ratings, from 1-10, of their attention to, and avoidance of, the items around the stove, for both the pre-check and post-check phases. The pre-check phase was explained to participants as the time between when the researcher left the room and when the kettle boiled. The post-task phase, then, constituted all the time between when the kettle boiled and when the participant left the room. Specifically, participants were asked "to what extent did you feel the need to pay attention to [item]" and "to what extent did you feel the need to avoid paying attention to [item]?". If attention or avoidance was endorsed (rating > 1), the researcher queried about participant motivation to attend to or avoid items (e.g. "why do you think you felt the need to pay more attention to that?" or "why do you think you wanted to avoid looking at that?"). It was assumed that subjective attention to stove would yield ratings at or close to ceiling, so this data was not collected. Similarly, looking at the stove was necessary to complete the task, so data on subjective avoidance of the stove was not collected. For clarity, these questions were administered back in the kitchen, while looking at the items around the stove; however, previous to this, participants did not know that they would be re-entering the kitchen. This ensured that participants truly felt responsible for turning the stove off correctly before leaving.

**Termination criteria.** The person-perspective eye tracker video was reviewed with participants. At the point in the video when the participant put the rice on the stove, they were asked how they knew it was okay to put the rice on the stove at that time. At the end of the video, participants were asked how they knew it was okay to leave the kitchen when they did. These two questions elicited participants' termination criteria for the check.

## Results

Data was inspected for outliers. Outliers were defined as data points three standard deviations or further from the group mean and discontinuous from the rest of the data. Outliers were replaced with the second most extreme data point in that group (Kwak & Kim, 2017). The number of outliers adjusted for each variable is as follows (if the variable is not listed, there were no identified outliers): pre-task responsibility (*n*= 3), check duration (*n*= 2), subjective avoidance of threat (*n*= 1), subjective attention to threat (*n*= 2), post-task certainty (*n*= 2).

### Demographics

There were no differences between the High Checking Behaviour (HCB; *M*= 20.37, *SD*= 1.950) and Low Checking Behaviour (LCB; *M*= 20.35, *SD*= 1.623) groups on age, $t(43) = -.042$, $p = .967$), gender identity ($\chi^2(2) = 2.146$, $p = .342$), sex assigned at birth ($\chi^2(1) = .005$, $p = .942$), or self-identified ethnicity ($\chi^2(7) = 6.860$, $p = .444$). Both the HCB and LCB group were majority female and culturally diverse, with less than 32% self-identifying as white in each group. See Table 4 for demographic information by group.

*Table 4. Demographic information by group*

| Characteristic | Category | LCB n | LCB % | HCB n | HCB % | $\chi^2$ value (df) | *p* value |
|---|---|---|---|---|---|---|---|
| Gender identity | Female | 22 | 73.3 | 20 | 69.0 | 2.146 (2) | .342 |
| | Male | 8 | 26.7 | 7 | 24.1 | | |
| | Other | 0 | 0 | 2 | 6.9 | | |
| Sex assigned at birth | Female | 23 | 76.7 | 22 | 75.9 | .005 (1) | .942 |
| | Male | 7 | 23.3 | 7 | 24.1 | | |
| Ethnicity[a] | Black/African American | 0 | 0 | 2 | 6.9 | 6.860 (7) | .444 |
| | East Asian | 8 | 26.7 | 9 | 31.0 | | |
| | Middle Eastern | 1 | 3.3 | 1 | 3.4 | | |
| | South Asian | 5 | 16.7 | 6 | 20.7 | | |
| | Southeast Asian | 4 | 13.3 | 2 | 6.9 | | |
| | White/Caucasian | 8 | 26.7 | 9 | 31.0 | | |
| | Other | 3 | 10 | 0 | 0 | | |
| | Decline to answer | 1 | 3.3 | 0 | 0 | | |

*Note*. [a]No respondents self-identified as Aboriginal or West Indian/Caribbean.

**Hypothesis 1: Appraisals**

We hypothesized that those in the HCB group would have higher levels of trait responsibility, lower levels of trait cognitive confidence, higher levels of state responsibility and state harm estimation than those LCB. A multivariate analysis of variance, with group as the dependent variable and appraisals as the dependent predictors, was significant, Wilk's $\lambda$ (4, 47)= .568, $p < .001$. Between-subjects effects revealed significant differences between groups on all appraisal measures: the MACCS, OBQ-44, and pre-task harm and responsibility ratings, with medium to large effect sizes (Cohen, 1988). See Table 5 for univariate statistics.

*Table 5. Questionnaire ratings by group*

| Measure | LCB<br>M<br>(SD) | HCB<br>M<br>(SD) | F[a] | *p* value | Cohen's *d* |
|---|---|---|---|---|---|
| MACCS Total | 67.483<br>(14.166) | 86.036<br>(17.646) | 17.659 | <.001 | 1.182 |
| OBQ-44 Total | 127.407<br>(36.441) | 187.880<br>(37.125) | 35.108 | <.001 | 1.673 |
| Pre-task harm | 133.100<br>(69.437) | 167.897<br>(52.590) | 4.465 | .040 | 0.575 |
| Pre-task responsibility | 207.600<br>(44.556) | 228.379<br>(25.653) | 4.826 | .033 | 0.579 |

*Note.* LCB= low checking behaviour group; HCB= high checking behaviour group. MACCS= Memory and Cognitive Confidence Scale; OBQ-44= Obsessive Beliefs Scale-Brief Version. [a]Univariate F.

**Hypothesis 2: Check duration and appraisals**

We hypothesized that those in the HCB group would spend more time in the kitchen after the kettle had boiled than those in the LCB ("check duration"), and the amount of time would be influenced by trait and state appraisal ratings.

**Useable data.** Out of the 29 participants in the HCB group, 3 videos were corrupted and check time could not be extracted. Of the 30 participants in the LCB group, one participant's video was not recorded because calibration failed.

**Group differences.** An independent samples *t*-test revealed that the HCB group checked significantly longer than the LCB group, $t(31.332) = 2.308$, $p = .028$, $d = 0.662$. See Table 6 for these data.

*Table 6. Check time by group*

| Group | M (SD) | *t*-value (df) | *p*-value | Cohen's *d* |
|---|---|---|---|---|
| LCB | 42.241 (39.035) | 2.308 (31.332)[a] | .028 | 0.662 |
| HCB | 91.970 (103.471) | | | |

*Note*. LCB= low checking behaviour group; HCB= high checking behaviour group. [a]Levene's test was significant, so equal variances was not assumed.

**Influence of appraisals.** To analyze the influence of appraisals on check duration, a linear regression was performed, with group on step one, appraisal on step two, and the interaction of group and appraisal on step three (in an effort to test a fully specified model and ensure that no effects were missed due to an untested interaction). This linear regression was performed separately with each trait appraisal measure (MACCS, OBQ-44) and state appraisal measure (pre-task harm and responsibility). For each regression, the entry of group on the first step resulted in a significant $R^2$ change. Regression results are presented in Table 7.

***MACCS.*** The addition of the MACCS on the second step did not result in a significant F change, $p$= .531; nor did the interaction of group and MACCS on step three, $p$=.944.

***OBQ-44.*** Similar to the influence of the MACCS, adding the OBQ-44 to step two did not result in a significant F change, $p$= .100; nor did the OBQ-44 by group interaction on step three, $p$=.297.

***Pre-task harm.*** Pre-task harm entry into step two did not result in a significant F change, $p$= .096; however, step three did result in a significant change in F, $p$=.025, such that harm and check time were closely related in the HCB group ($r$= .405, $p$= .040), but their correlation was close to zero in the LCB group ($r$= .040, $p$= .838).

***Pre-task responsibility.*** Pre-task responsibility entry on step two did not result in a significant F change, $p$= .086; nor the interaction of this with group on step three, $p$=.120.

*Table 7. Hierarchical multiple linear regression analyses of check duration*

| Step | Predictors | $R^2$ | $R^2$ change | ß | *F* change |
|---|---|---|---|---|---|
| 1 | Group | .107 | .107 | .328 | 6.129* |
| 2 | MACCS | .114 | .007 | .099 | 0.399 |
| 3 | Group x MACCS | .114 | .000 | -.056 | 0.005 |
| 1 | Group | .115 | .115 | .339 | 6.114* |
| 2 | OBQ-44 | .166 | .051 | .296 | 2.824 |
| 3 | Group x OBQ-44 | .186 | .020 | .763 | 1.114 |
| 1 | Group | .098 | .098 | .314 | 5.790* |
| 2 | Pre-task harm | .113 | .047 | .223 | 2.882 |
| 3 | Group x Pre-task harm | .181 | .080 | .894 | 5.301* |
| 1 | Group | .098 | .098 | .314 | 5.790* |
| 2 | Pre-task responsibility | .148 | .050 | .232 | 3.054 |
| 3 | Group x Pre-task responsibility | .188 | .040 | 1.468 | 2.501 |

*Note.* MACCS= Memory and Cognitive Confidence Scale; OBQ-44= Obsessive Belief Questionnaire; * significant *F* change at $p < .025$.

**Hypothesis 3: Avoidance of threat between groups**

We predicted that those in the HCB group would report more subjective avoidance of threat, and would have lower objective attention to threat (as measured by eye tracking statistics) than those in the LCB group.

**Subjective avoidance.** Attention and avoidance was rated on a 0-10 scale for each item around the stove and at two time points: during the pre-boil and post-boil phases.

***Data preparation.*** For these analyses, ratings across phases were combined, as moderate and significant correlations between the phases indicated redundancy (*r*s from .457 and .707). Outcomes of analyses were identical when performed with variables combined or separate. Subjective attention to threat was the sum of all ratings for flammable items (paper towels, matches, paper basket, and wooden spoons) combined over the pre-boil and post-boil phases.

Subjective attention to neutral items was the sum of all ratings for non-flammable items (metal canister, utensils, salt shaker, and mugs) combined over the pre-boil and post-boil phases.

***Group differences.*** Independent samples *t*-tests showed no group differences on self-rated attention to flammable or non-flammable items, *p*s > .133. However, there was a significant difference between the HCB group ($M$= 17.190, $SD$= 17.075) and LCB group ($M$= 8.900, $SD$=4.180) on avoidance of threat, $t(31.237)$= -2.542, $p$= .016, $d$= 0.684. The difference between groups on avoidance of non-flammable items approached significance, $t(31.798)$= -1.970, $p$= .058, $d$= 0.530. See Figure 1 for these data.

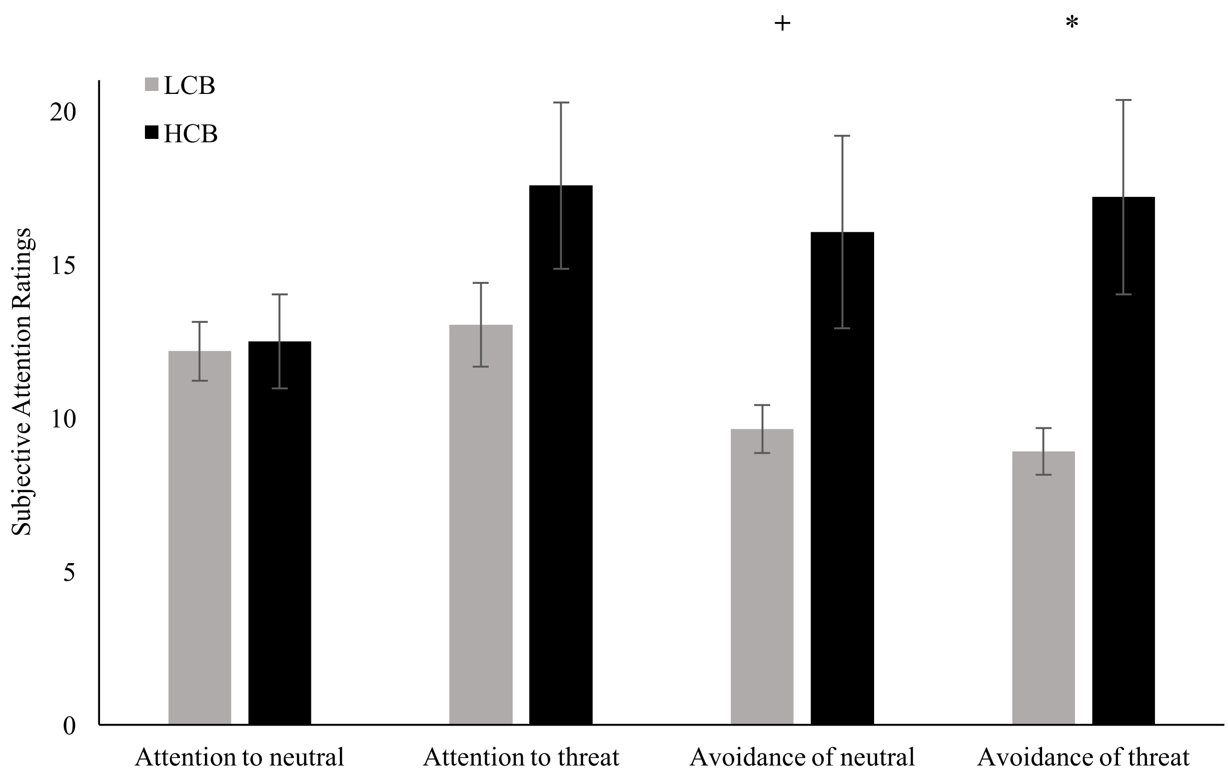


*Figure 1. Mean attention and avoidance ratings in each group.* Error bars (±) represent standard error of the mean. * indicates significance at $p$= .016. + indicates significance at $p$= .055.

**Objective avoidance.** Using the eye tracker, data on attention to flammable items ("threat") was collected. Available statistics were the amount of time spent looking at threat (fixation duration) and the number of times one looked at a threat item (fixation count).

***Data preparation*.** Using these statistics, proportion variables were created. Proportion fixation duration was generated by summing the duration of fixations on each flammable item, and dividing this sum by the total fixation time collected for each participant. In the same way, proportion fixation count was generated by summing the total fixation count for each participant on flammable items, and dividing this sum by the total number of fixations identified for that participant.

***Useable data.*** Out of the 29 participants in the HCB group, 2 were not able to be calibrated, 2 had eye tracking ratios below 50% (so were excluded), and 3 videos were corrupted and not able to be coded, leaving 22 participants with valid eye tracking data. Out of the 30 participants in the LCB group, 2 were not able to be calibrated, and 8 had low tracking ratios ($\leq$ 50%), leaving 20 participants with valid eye tracking data.

***Correlation with subjective avoidance.*** Across groups, self-rated attention to threat correlated with proportion fixation duration ($r$=.610, $p$= .003; and $r$=.684, $p$= .001 for the HCB group and LCB group, respectively) and proportion fixation count ($r$=.708, $p$< .001; and $r$=.585, $p$= .007 for the HCB group and LCB group, respectively); thus, participants were relatively accurate when reporting how much they paid attention to threat. However, self-rated avoidance of threat was not correlated with self-rated attention or objective fixation duration or count in either group ($p$s > .135). Thus, participants' desire to avoid may not have matched their actual attention patterns. Lastly, across groups, proportion fixation duration and proportion fixation count were highly correlated ($r$=.884, $p$< .001; and $r$= .936, $p$< .001 for the HCB group and LCB group, respectively). See Table 8 for correlational data.

*Table 8. Correlations of subjective and objective measures of attention to threat*

| | Self-rated attention to threat | Self-rated avoidance of threat | Fixation duration on threat | Fixation count on threat |
|---|---|---|---|---|
| Self-rated attention to threat | - | .284 | .610* | .708** |
| Self-rated avoidance of threat | .111 | - | .314 | .321 |
| Fixation duration on threat | .684* | .299 | - | .884** |
| Fixation count on threat | .585* | .298 | .936** | - |

Note: HCB group correlations above the diagonal and LCB group below the diagonal; fixation duration= proportion fixation duration, fixation count= proportion fixation count. ** indicates $p$ < .001, * indicates p < .01.

***Group differences.*** Independent samples t-tests showed no significant differences between the HCB group and LCB group on proportion fixation duration on threat items, $t(32)$= -1.512, $p$= .140; but a trend towards a higher proportion fixation count in the HCB group was observed, $t(32)$= -1.827, $p$= .077. See Table 9 for fixation values by group. See Appendix B for fixation values for the stove and neutral items. Whereas the HCB group looked at threat more often than the LCB group, they did not spend significantly more time overall looking at threat.

*Table 9. Fixation durations and counts by group*

| Area of attention | LCB M (SD) | HCB M (SD) | *t*-value (df) | *p*-value |
|---|---|---|---|---|
| Proportion fixation duration on threat | .045 (.037) | .067 (.043) | -1.512 (32) | .140 |
| Proportion fixation count on threat | .058 (.044) | .085 (.040) | -1.827 (32) | .077 |

*Note*. LCB= low checking behaviour group; HCB= high checking behaviour group.

**Hypothesis 4: Avoidance of threat and certainty**

We hypothesized that subjective and objective avoidance of threat would be associated with higher post-task certainty in the HCB group, but not the LCB group.

**Group differences on certainty.** An independent samples *t*-test revealed that the HCB group had significantly lower post-task certainty than the LCB group, $t(47.212)= 3.155$, $p= .003$, $d= 0.842$. See Table 10 for these data.

*Table 10. Post-task certainty by group*

| Group | M (SD) | *t*-value (df) | *p*-value | Cohen's *d* |
|---|---|---|---|---|
| LCB | 235.267 (19.656) | 3.155 (47.212)[a] | .003 | 0.842 |
| HCB | 213.914 (30.901) | | | |

*Note*. LCB= low checking behaviour group; HCB= high checking behaviour group. [a]Levene's test was significant, so equal variances were not assumed.

**Data preparation.** In looking at the impact of objective avoidance on certainty, we chose to use proportion fixation durations on threat (rather than proportion fixation count) because we were interested in the amount of time spent looking at threat, knowing that less time may indicate attentional avoidance. In addition, fixation duration and fixation count were highly correlated, indicating redundancy (*r*s of .884 and .936, for the HCB group and LCB group, respectively; see Table 8 for this data).

**Predicting certainty.** To explore the effect of attention to threat on post-task certainty, a linear regression was performed with group on step one, proportion fixation duration on threat on step two, and the interaction of group and attention to threat on step three. See Table 11 for regression data. Step one was not significant, $p$=.069; but step two did result in a significant $F$ change, $p$= .018, such that more fixation time on threat predicted less certainty; and step three also resulted in a significant $F$ change, $p$=.023. This significant interaction indicated that proportion fixation duration on threat and certainty were closely negatively correlated in the HCB group ($r$= -.608, $p$= .003), but their correlation was close to zero in the LCB group ($r$= -.027, $p$= .910). Thus, in the HCB group, those who paid less attention to threat had higher post task certainty, whereas this was not the case for those in the LCB group.

A similar linear regression was performed with group on step one, subjective avoidance of threat on step two, and the interaction of group and avoidance on step three. Step one was significant, $p$= .002; but step two did not result in a significant $F$ change, $p$= .675, and neither did step three, $p$= .497. Thus, attentional avoidance, when measured objectively, predicted certainty in the HCB group; however, this was not the case for subjective avoidance.

*Table 11. Hierarchical multiple linear regression analyses of post-task certainty*

| Step | Predictors | $R^2$ | $R^2$ change | ß | F change |
|---|---|---|---|---|---|
| 1 | Group | .080 | .080 | -.283 | 3.495 |
| 2 | Proportion fixation duration on threat | .205 | .125 | -.355 | 6.116* |
| 3 | Group x Proportion duration on threat | .307 | .102 | -.643 | 5.610* |
| 1 | Group | .151 | .151 | -.388 | 10.101* |
| 2 | Subjective avoidance of threat | .153 | .003 | .422 | .178 |
| 3 | Group x Avoidance of threat | .160 | .007 | .684 | .467 |

*Note.* * significant $F$ change at $p < .024$.

**Reasons to avoid: thematic analysis.** Through our post-task interview, we collected qualitative information about why participants were attending to, and avoiding paying attention to threat. After reviewing participants' responses, conceptual categories were generated. When analyzing reasons to attend to items, three groups of reasons arose: curiosity (e.g. thinking about the function, properties of the item), location (e.g. item was close to kettle, directly in line of sight), and danger (e.g. the desire to monitor a potentially dangerous item). When analyzing reasons to avoid attending to items, two general reasons were reported: distraction (e.g. item was pulling their attention away from the task), and worry (e.g. the desire to look away because the item was anxiety-provoking). See Table 12 for a breakdown of the frequency with which each of these reasons were endorsed.

*Table 12. Frequency of endorsement of reasons to attend to and avoid threat by group*

| | Rationale | LCB (n) | HCB (n) |
|---|---|---|---|
| Attend to threat | Curiosity | 8 | 5 |
| | Location | 1 | 0 |
| | Danger | 6 | 8 |
| | Both location and danger | 1 | 2 |
| Avoid looking at threat | Distraction | 6 | 7 |
| | Worry | 1 | 5 |
| | Both distraction and worry | 0 | 2 |

*Note*. LCB= low checking behaviour group; HCB= high checking behaviour group.

A chi-squared test revealed no group difference on reasons to attend to flammable items ($\chi^2(4)= 2.295$, $p = .682$) nor on reasons to avoid flammable items ($\chi^2(3)= 6.413$, $p = .093$). Within the category of worry, specific reasons for avoidance included: avoiding paying attention to flammable items in order to avoid the urge to use them (*n*= 1), avoid the urge to move them (*n*= 2), avoid thinking about the danger they pose (*n*= 8), and avoid getting more anxious (*n*= 1).

Note that these *n*s represent our whole sample, including participants who do not belong to either the LCB or HCB group.

### Hypothesis 5: Termination criteria

**Thematic analysis**. After completing the stove checking tasks, participants' eye tracking videos were reviewed with them. At the point in the video when they placed the dry rice on the stove, participants were asked how they knew it was okay to do so. Their answers constituted their reported termination criteria for putting the rice on. At the point in the video when they took the eye tracker off and left the kitchen, participants were asked how they knew it was okay to do so. Their responses represented their termination criteria for leaving the kitchen. Both sets of termination criteria (when to put rice on the stove and when to leave the kitchen) were categorized using thematic analysis, with guidance from the four categories used by Wahl et al., 2008 and Salkovskis et al., 2017. Six categories arose in our sample. See Table 13 for each category and corresponding examples. The three external/objective categories and the three internal/subjective categories were summed to create the variables "external criteria" and "internal criteria" for each decision (rice on, leave kitchen). Additionally, the total number of criteria used to know when to put the rice on and to leave the kitchen was totaled from the sums of the above categories within each set of criteria.

*Table 13. Termination criteria categories and examples*

| Category | Criteria Type | Examples |
|---|---|---|
| External criteria | External responsibility* | Decision based on instructions given by researcher or with the belief that the researcher is ultimately responsible if harm occurs |
| | External perceptual | Decision based on a perceptual experience, such as seeing the knobs in the off position, feeling that the burners are cool, or hearing the click of the knob |
| | External intellectualizing* | Decision based on reasoning processes, such as a belief that the stove wasn't dangerous enough to start a fire |
| Internal criteria | Internal feeling/mood | Decision based on an internal feeling, certainty, or sense of satisfaction |
| | Internal rules/memory | Decision based on internal rules or memory-related cues, such as remembering that the stove was off |
| | Internal effort | Decision based on feeling as if one tried hard enough or checked long enough |

*Note*. * indicates that this group was not used by previous researchers but was generated through thematic analysis of our sample.

**Group differences.** There were no group differences on total number of criteria used for either decision, $p$s > .080, nor on number of internal or external criteria used, $p$s > .210, nor were there differences in use of any single category of criteria, $p$s > .107. Thus, in contrast to our hypothesis, the HCB group did not use significantly more criteria to determine when to put the rice on, nor to decide when to leave the kitchen. See Table 14 for data on termination criteria.

*Table 14. Mean number of termination criteria types by group*

| | | M (SD) | |
|---|---|---|---|
| **Decision** | **Criteria Type** | **LCB** (n=17) | **HCB** (n=24) |
| Put rice on | External criteria | 1.471 (1.125) | 1.292 (0.690) |
| | Internal criteria | 0.177 (0.393) | 0.333 (0.482) |
| Leave kitchen | External criteria | 1.778 (1.086) | 2.143 (1.044) |
| | Internal criteria | 0.222 (0.506) | 0.357 (0.559) |

*Note*. LCB= low checking behaviour group; HCB= high checking behaviour group.

**Criteria and check length.** Exploratory post-hoc analyses of criteria type were performed to explore whether certain criteria were associated with longer checks or less certainty. Check length was significantly negatively correlated with the number of external responsibility criteria used to decide when to put the rice on ($r$ = -.338, $p$= .004) and significantly positively correlated with the number of external intellectualizing criteria used to decide when to leave the kitchen ($r$ = .328, $p$= .002). Post-task certainty was negatively correlated with the number of external intellectualizing criteria used to decide when to leave the kitchen ($r$ = -.213, $p$= .002).

## Discussion

The aim of this study was to further explore attention to, and avoidance of, threat items during a stove checking task with those high and low in checking concerns.

Our first aim was to analyze the relationship between trait and state appraisals and check duration. We found that the high checking behaviour group had higher trait appraisals of responsibility, and lower confidence in memory and cognitive abilities, with large effect sizes. Their state appraisals of harm and responsibility were higher than the low checking behaviour group, with medium effect sizes. In addition, those with checking concerns had significantly longer checks than those without significant checking concerns. However, in contrast to our prediction, trait appraisals and state responsibility did not explain variance in check duration beyond that explained by group. This finding is in line with emerging findings that once a compulsion begins, situational factors (such as mood, context, and state appraisals) may be more important than trait beliefs (Purdon, 2018). In line with this hypothesis, state harm appraisals did interact with group to predict check duration in our sample. Those in the checking concern group with higher harm appraisals had longer checks, whereas those in the low concern group had similar check lengths no matter their pre-task appraisals. The high checking behaviour group had appraisals that have been shown to be elevated in those with OCD (Rachman, 2002), and higher appraisals of harm seemed to be especially important in predicting longer check durations. It may be the case that the greater the perceived harm, the more important it seemed to participants to ensure the stove was off, and therefore the more careful they were (e.g., waiting until the burner was cold rather than simply checking the position of the stove knob and whether or not the light was on).

A major goal of this study was to explore whether those with checking concerns engage in attentional avoidance, and if so, their reasons for doing so. We found that those high in checking concerns endorsed more motivation to avoid threat items than those low in checking concerns. The HCB group had a nonsignificant tendency to avoid neutral items more than those in the LCB group. This general avoidance (of both threat and neutral items) may be a by-product of the stove set-up in our study; flammable and non-flammable items were spaced closely together, so selective avoidance of flammable items may have been difficult. It may also suggest that participants high in checking concerns are motivated to stay very focused on the information they need to determine whether the stove is off, rather than attending to other information in the environment. Especially given their lower levels of trait cognitive confidence (as measured by the MACCS), it is possible that those HCB felt more vulnerable to distraction. Another possibility is that those HCB envision ways that harm can occur, even with non-flammable objects. Future research might examine how external stimuli evoke catastrophic thinking.

There was no significant difference between groups on time spent looking at threat; however, fixation count approached significance, with the high checking behaviour group appearing to look at threat more often than those in the low checking behaviour group. This may be an indication that those with checking concerns were drawn to look at threat (facilitated attention), but did not let their attention linger on threat. After seeing threat, those HCB may quickly look away, such that the overall time spent looking at threat is no different from those in the LCB group. This may be an indication that those HCB avoided paying prolonged attention to threat. However, we did not analyze the course of attentional deployment over time; future studies may benefit from using a more fine-grained look at attention patterns in order to better discern whether attentional avoidance is present or not.

In terms of the function of avoidance, self-reported avoidance was not predictive of increased certainty after the task, so feeling motivated to avoid looking at threat does not seem to help participants feel more certain that safety was achieved. Perhaps this is because self-rated avoidance did not seem to be related to actual attentional deployment. Actual attentional deployment, as measured by fixation durations, was predictive of post-task certainty in the high checking behaviour group, such that those who looked more at threat were less certain after the check. Whereas Bucarelli & Purdon (2016) found that those with OCD did not exhibit an ironic effect of attention, we did find that the high checking behaviour group's certainty was negatively impacted by their attention to threat.

This difference may be explained in part by the difference in samples, as our study did not use a clinical sample. Although the HCB group had significantly different questionnaire scores than those in the LCB group, the average HCB scores on the MACCS and OBQ scales were somewhat lower than those in the OCD sample from Bucarelli & Purdon, 2016. In our sample, 75% of the HCB met the recommended cutoff score of 21 on the DOCS questionnaire, the score shown to best differentiate those with OCD from those with other anxiety disorders; thus, it is unlikely that all of our HCB participants would meet the severity and impairment requirements to be considered for a diagnosis of OCD. Consequently, our sample may be among those who are the most susceptible to the ironic effect of attention, since they have OCD-like concerns and doubts, but are not familiar enough with the insidious effects of attention to successfully avoid them.

We found moderate correlations between self-reported attention to threat and fixation number and duration on threat, indicating that self-reported attention may be an accurate indicator of actual attention (even if self-reported avoidance is not). Meanwhile, consistent with the hypotheses of Cisler and Koster (2010), we did find that some participants avoided paying attention to threat in order regulate their emotions. However, numbers for those endorsing avoidance were low, and those providing reasons for doing so were even lower. Although behavioural avoidance has been shown to provide relief in the short term (Harding, 2013), the issue as to whether attentional avoidance functions in the same way is a possible direction of future study.

Lastly, we collected information about how participants knew when to end their check. In contrast to previous findings, the HCB group did not use more criteria than the LCB group; however, the number of criteria used to decide when to leave the kitchen approached significance, and may have reached significance with a larger sample. Interestingly, the use of intellectualizing to decide when to end a check appeared to have a negative impact on check duration and certainty, whereas externalizing responsibility was associated with a shorter check duration. This is a novel finding, as the relationship between criteria and check length has not previously been investigated; however, it is in line with theory that check intensity is related to responsibility concerns (Rachman, 2002). It also corresponds to previous research that experimenter presence reduces discomfort in those with OCD (Roper & Rachman, 1976), and that when responsibility is manipulated, memory confidence is affected (Boschen & Vuksanovic, 2007).

As with every study, this study is limited by several factors: we did not ask, nor assess, whether participants had a previous diagnosis of OCD or an anxiety disorder; thus, this information is not available for analyses. In addition, our group sample sizes were relatively small; as previously noted, the more exploratory pieces of our study, such as termination criteria and reasons for avoidance of threat, were underpowered, and warrant more exploration with larger samples. Lastly, we measured check length as a proxy for the extent of participants' checking. However, check length may not have been directly related to check behaviour: a longer check length may mean that participants are checking the stove and surrounding areas, or it may mean that participants are just standing in the kitchen, with their mind on other matters. We could not examine physical checking (e.g. putting hand over burners, turning knobs) for all participants, as our only video of the check was from participants' perspective, and often did not provide a full view of the participants' hands. Future studies could examine physical checking by taping participants from a different angle. In addition, the phenomenology of stove checking may be such that participants check, leave the area, doubt ensues, and then they later to check. Thus, a future measure of checking could be providing participants with the option of returning to the kitchen.

Despite these limitations, our study contributes to the literature on attention in OCD by being the first to explore attention avoidance from the perspective of the individual performing the check. Those with checking concerns do endorse avoiding threatening items for a variety of reasons, including concerns about the danger of the item and balancing the competing demands of the task. Given this initial finding, the impact of avoidance on check phenomenology is an area that warrants more attention.

All in all, while Bucarelli & Purdon (2016) provided information about those with OCD, our study may provide insight into how OCD could develop: when responsibility and harm beliefs are present, one may look more at threat, but at the same time feel anxious about looking at threat and want to avoid it. This may result in longer checking time, and less certainty that harm was avoided. Given time, these preliminary concerns may lead to longer checking, more intense concerns, and the impairment and distress that so often comes with clinical levels of OCD.

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# Appendices

## Appendix A: Configuration of stove and surrounding items at beginning of experiment

## Appendix B: Fixation durations and counts by group

| Area of attention | LCB<br>M<br>(SD) | HCB<br>M<br>(SD) | *t*-value (df) | *p*-value |
|---|---|---|---|---|
| Proportion fixation duration on stove | .896<br>(.076) | .879<br>(.051) | 0.779 (32) | .476 |
| Proportion fixation count on stove | .868<br>(.084) | .835<br>(.055) | 1.354 (32) | .185 |
| Proportion fixation duration on neutral | .055<br>(.019) | .049<br>(.042) | 0.563 (29.462[a]) | .589 |
| Proportion fixation count on neutral | .079<br>(.026) | .063<br>(.038) | 1.683 (37.262[a]) | .101 |

*Note*. LCB= low checking behaviour group; HCB= high checking behaviour group. [a]Levene's Test for Equality of Variances was significant, so equal variances were not assumed.