6-2022

OCD: The Effects of Doubt on Memory Confidence

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Submitted in partial fulfillment of the requirements for the degree of Bachelor of Science

Union College

March 2022

ABSTRACT

Raisner, Amber OCD: The Effects of Doubt on Memory Confidence. Department of Neuroscience, March 2022.

ADVISOR: DANIEL BURNS

Obsessive compulsive disorder (OCD) is an anxiety disorder that affects 1% of the United States population, and is categorized by both obsessive thoughts and compulsive behaviors. The most prevalent compulsive behavior is checking, which is an attempt to mitigate anxiety about a situation the person believes will be harmful if not addressed. Previous studies suggest a negative correlation between checking and metamemory (memory confidence, vividness and detail); however, there has been limited research on the effects of doubt, one of the main causes of checking behaviors, on metamemory. The current study used an online stove-checking task, first used by van den Hout and Kindt (2003), to investigate the influence of doubt on memory accuracy and metamemory in checking versus no checking groups as well as comparing people with high versus low levels of OCD symptomatology. Doubt was not shown to have any effect on metamemory, however, when comparing the low and high OCD groups, significant results were found for both accuracy and memory confidence. Checking had an effect on memory accuracy, but only for the high OCD symptomatology group. The high OCD group also had overall higher confidence levels. Some of these results contradict previous findings.

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Department of Neuroscience, March 2022.

Anxiety disorders are the most common mental disorder in the United States and as such, affect 18.1% of the population. These disorders range from General Anxiety Disorder (GAD), Social Anxiety Disorder (SAD), Post Traumatic Stress Disorder (PTSD) and Obsessive Compulsive Disorder (OCD). They are rooted in "excessive fear and anxiety or avoidance of perceived threats that are persistent and impairing" and are caused by dysfunctions in specific neural circuitry associated with threat and other danger perception (Holmes and Reif, 2021 p.1). The criteria needed to diagnose an anxiety disorder depends on the cause of the anxiety as well as the succeeding behavior. OCD in particular affects 1% of the United States population and involves repetitive, intrusive thoughts which lead to specific behaviors (Ruscio, Stein, Chiu & Kessler, 2008). To be diagnosed with OCD in the Diagnostic Statistical Manual, the person must meet specific criteria about both their obsessions and compulsions displayed in Table 1.

Both the obsessions and compulsions in OCD, as addressed in the diagnostic criteria, are critical to understand on a neurological level when identifying the impairing behaviors associated with the disorder. There are many neural structures involved in OCD. Two structures located in the cortex are of importance: the orbitofrontal cortex (OFC), important for reward and decision making, and the anterior cingulate cortex (ACC), necessary for emotion and mood regulation. The OFC and ACC have been shown to be hyperactive in people with OCD. The OFC specifically has been targeted as an important brain region due to its activity during symptom provocation when targeting compulsive behaviors (Ursu & Carter, 2009).

Another critical brain structure relevant to behaviors associated with OCD is the basal ganglia. The basal ganglia is composed of the striatum (housing the caudate, putamen, and globus pallidus) and the subthalamic nucleus (STN). The striatum can be further divided into two subregions: the dorsal striatum (DS) and ventral striatum (VS). Focusing on the caudate and putamen which make up a part of the striatum, the DS contains the majority of the structures, where the VS contains only the ventral areas. Both play important roles in functioning. The DS is important for decision making and cognitive flexibility, while the VS centers around learning, motivation and reward (Hiebert et al., 2020). OCD patients typically exhibit hyperactivity in the VS but hypoactivity in the DS which directly relate to the obsessions and compulsions. Hyperactivity in the VS can account for the increased amount of obsessive thoughts and the inability to detect and reinforce responses to natural rewards. Conversely, the DS hypoactivity correlates with the lack of proper decision making based on the obsessions that lead to compulsions (Hiebert et al., 2020). Another important part of the basal ganglia is the STN. In the limbic portions of the STN less frequent but longer bursts of action have been discovered in individuals with OCD. The checking behaviors, as well as other behaviors associated with OCD, can be attributed in part to the dysregulation of the STN (Mulders et al., 2016).

The primary circuit studied in patients with OCD is the cortico-striatal-thalamo-cortical (CSTC) network. This circuit incorporates each of the previously identified structures in the cortex as well as the basal ganglia. This pathway is necessary for cognitive processes such as decision making and reward-based learning. It also aids in motor functioning, such as action selection and regulation of impulsivity. These all are necessary for internal thoughts as well as subsequent external actions (Calza et al., 2019). In the CSTC loop, unprocessed information is

received by the OFC, processed, and eventually routed back to the same region as recognizable and usable information. This circuit involves both direct and indirect pathways which regulate one another to produce the proper information processing and behavioral responses, and the pathways function properly in people without OCD. While the overall structure of the loop in people with and without OCD remains the same, people diagnosed with OCD show various irregular responses (Rădulescu et al., 2017). The direct loop begins with neurons in the frontal cortex projecting first to the striatum, the internal globus pallidus (GPi) and substantia nigra (SN). The loop then projects to the thalamus and finally back to the frontal cortex. The indirect loop also begins with projections from the frontal cortex to the striatum. The difference being the subsequent projection to the external globus pallidus (GPe) and subthalamic nucleus (STN). The indirect loop then reconnects to the direct pathway projecting to the GPi and SN and then to the thalamus and cortex (Calzà et al., 2019). The direct loop is known as the positive feedback loop which involves the execution of various behaviors. The indirect loop regulates these actions through an inhibitory response. In an appropriately functioning CSTC loop, the two loops work together for proper execution of behaviors centered around habitual action, reward and motor execution. However, in people with OCD, hyperactivity has been detected in the CSTC with a lack of regulation of the positive loop, leading to impulsive behaviors or compulsions. It is believed that the worry signal, which is entered into the pathway of people with OCD, encroaches on the inhibitory signals sent by the indirect loop, specifically the connection between the globus pallidus and thalamus (Calzà et al., 2019). Without the thalamus sending the proper inhibitory signal in the loop, the hyperactivity beginning with the OFC is reinforced which contributes to the cycle.

As already discussed, the hyperactivity of the CSTC is known to contribute to the symptomatology of OCD, and it is important to note that irregular neurotransmitter activity also plays a critical role. Glutamate is the primary excitatory neurotransmitter in the brain, and is the most important neurotransmitter in the CSTC alongside dopamine. The cortical neurons which project to the striatum form synapses onto medium spiny neurons (MSN's) which then project to the GPi and the SNR in the direct loop. The synapses which form are glutamatergic, and regulate the signal of the loop. This direct loop is modulated by dopamine (D1) receptors which project directly to the GPi and the rest of the loop, whereas the indirect loop is modulated by dopamine (D2) receptors which project to the GPe and subsequently the STN. In a study conducted by Burguière et al. (2013), activation of the glutamatergic afferents with both D1 and D2 receptors triggered OCD behavior in mice, whereas the inhibition of the dopamine receptors relieved the behavior, further supporting the role of glutamate and dopamine in the balance between excitation and inhibition in the CSTC.

The obsessive thoughts and urges as well as behavioral compulsions for people with OCD vary from person to person, but it is agreed upon that the compulsions are engaged in to relieve anxiety associated with the unwanted thoughts. The amplified worry signal in the CSTC causes increased anxiousness associated with the hyperactivity, and the compulsions aim to combat the thoughts and feelings. Since intrusive thoughts can vary from cleanliness to completeness and order to aggression, the subsequent behaviors aimed at preventing the thoughts vary from person to person. A study conducted by Starcevic et al. (2011) investigated various compulsions in 108 adults with OCD using the Yale-Brown Obsessive Compulsive Scale (Y-BOCS). The categories for the compulsions were cleaning/washing, mental compulsions,

symmetry and checking. Hoarding and miscellaneous categories were also recorded. For people with the cleaning compulsion, 76.7% attributed the function as decreasing anxiety or distress. The mental compulsion group also desired the same goal, however only 47.4% attributed the compulsion to the associated feelings. For the symmetry group, 75.9% felt a desire to correct things to be perfect, and for the checking group, 75.9% said the checking was to ease anxiety or distress. Almost three quarters of the checking group believed something bad would happen if the compulsion was not carried out. It is also interesting to note that across all compulsions, on average 71.6% were performed automatically and without conscious thought about the actions (Starcevic et al., 2011). It is imperative to further investigate OCD with checking, due to the fact that it is the most commonly identified compulsion, with over half of the subjects engaging in this automatic and uncontrollable response.

The National Comorbidity Survey Replication Epidemiological Study which gathered information between February 2001 through April 2003 found that the compulsion of checking is the most common of all compulsions affecting 79.3% of people with OCD. The goal of checking is to mitigate or reduce anxiety surrounding fears of harming oneself or others due to carelessness or negligence, such as forgetting to lock a door or turn off a stove (Williams et al., 2013). The checking behaviors have also been found to have implications on memory accuracy and memory confidence surrounding the task. One of the heavily researched topics involving OCD and memory accuracy has focused on the veracity of the memory deficit hypothesis. This hypothesis states that people with OCD have less accurate memory of events than those without OCD. These possible deficits have been hypothesized to be the catalyst behind repeated checking. Various studies have sought to uncover the truth behind the role of memory accuracy

in OCD. Although the memory deficit hypothesis provides a succinct explanation for checking behaviors, there have been many studies which discovered memory accuracy was not lower in people with OCD than control groups. One example of this is in an experiment conducted by Moritz et al. (2005) where participants were given 48 word riddles. In an alternating fashion, the participant either had to unscramble the riddle themselves with the help of a written cue, or the riddle was presented and then solved by the computer. Following the task, participants were given a recognition task where they had to identify whether they solved the presented word, solved by the computer or was a completely new word. The results of this study did not support the memory deficit hypothesis. The OCD group did not differ from the control group in source memory, whether they distinguished properly which category the words originated from, or overall memory accuracy.

Although memory accuracy does not necessarily seem to be affected in people with OCD, memory confidence has consistently been shown to be affected. People with OCD have been shown to have lower memory confidence, particularly in situations of potential danger, compared to healthy controls. A study conducted by Moritz et al. (2007) compared memory confidence for OCD participants to control participants. Participants were randomly assigned to a responsibility scenario or non responsibility scenario and asked a series of questions depending on the group. The participants in the responsibility group were told they were selected as helpers in a region struck by an earthquake and needed to select 15 items through a computer program to help the town. The participants in the non responsibility scenario were asked to select 15 items from a-do it-yourself store. After selection, both groups were shown their items as well as 15 distractor items and asked to decide which ones they had previously chosen and how confident

they were in their memory. The OCD participants did not differ from the healthy control in the amount of correct items selected in either condition or in memory confidence in the neutral condition. There was a significant difference, however, in memory confidence between OCD and control participants in the high responsibility group. The OCD group displayed lower memory confidence in the high responsibility group than the control group. These findings of lowered memory confidence in people with OCD are important to note specifically for the situations in which there is a perception of danger, which ties directly into the compulsion of checking.

Another study investigating memory confidence was conducted by Radomsky et al. (2001). This study tested a group of people with OCD under conditions of a heightened perceived sense of responsibility and a low sense of responsibility while engaging in a task followed by checking. The heightened perceived sense of responsibility that is felt is one of the main reasons why people with OCD report engaging in checking behaviors because failure to complete the task correctly could lead to potential danger or harm. In the study, 11 people with OCD participated in a within-subjects experiment aiming to test aspects of memory based on the level of threat of a situation. During the experiment, the participants completed tasks that elicited high distress if left unchecked. In the high responsibility condition, the participants signed a contract accepting all responsibility for the check and potential consequences during the task, whereas in the low responsibility condition they signed a separate contract which stated that they would complete the check, but the experimenter would recheck the situation afterward to confirm the task was properly completed. Before the task the participants were told there would be a memory task afterward, and during each check the experimenter would complete a few threat irrelevant tasks such as coughing or reciting a span of digits out loud during the task. In

the Memory and Confidence Interview following the task, the participants were asked questions about the irrelevant tasks as well as threat relevant ones pertaining to the task at hand such as how many times the participant touched the stove. The interview also assessed the confidence level the participants felt regarding their answers to each of the questions on a scale of 0-100. A week after the experiment, the participants watched the video tape of themselves completing the task and were asked the same questions. The results of the study showed that the participants had a higher tendency to remember threat relevant information than threat irrelevant information for both the high responsibility group and low responsibility group with a stronger effect for the former. In the two no threat conditions, which were the participants later watching the video of themselves responding to the task, there was no difference in memory, potentially because of the lack of threat associated with the fact that the task already occured. More importantly, in regards to memory confidence, the participants displayed the lowest confidence in the high responsibility group compared to the other two groups.

While a sense of responsibility seems to lower memory confidence, the act of checking may, in itself, also lower confidence. A key study by van den Hout and Kindt (2003) was the first to provide evidence for this paradoxical effect of checking on memory confidence. The reason people check is to increase memory confidence, however, these researchers showed it actually increases uncertainty and produces lower confidence than before the check. In their computerized experiment, participants first practiced with both six light bulbs and six burners on a gas stove, first turning on three of the corresponding objects, then turning them off, and then finally checking to make sure they were off. After practicing with both objects, half of the participants were assigned to the irrelevant checking group and half to the relevant checking

group. Both groups completed the first trial with the gas stove and answered questions pertaining to memory accuracy, confidence and vividness and detail of the memory. Following the first trial, the irrelevant checking group completed 18 trials with the light bulbs and then the final trial was once again with the stove, whereas the relevant checking group completed all trials with the stovetop. After the final trial the participants were asked the same questions about memory accuracy, confidence, vividness, and detail of their memories for the last trial with the stove. In regards to accuracy, the results showed no change between the relevant and irrelevant checking groups. For memory confidence, vividness and detail, there was a decrease across trials for all three measures in the relevant checking group but no decrease in the irrelevant checking group. These results suggest that repeated checking across trials decreases memory confidence but not memory accuracy. Numerous studies have replicated these findings (e.g., Ashbaugh & Radomsky, (2007), Dek, E. C. P., van, d. H., Giele, C. L., & Engelhard, I. M., (2010)).

Burns et al. (2020, Experiment 3) replicated the stove task study of van den Hout and Kindt (2003) with the hopes to distinguish whether or not the lower memory confidence was necessarily due to checking. Participants were given one practice trial with the stove task as well as one practice trial with the six light bulbs. Each participant was then given a real trial with the stove and then depending on the condition, the next four trials were either the stove or light bulb task. The final trial was the stove task again and each participant completed questions about accuracy and metamemory as well as psychological scales for OCD, depression, and anxiety. Additionally, whereas half of the participants checked that the burners were off one time on each of the trials, the other half checked six times on each trial, allowing the researchers to study the effects of within-trial checking as well as between-trial checking. The results of this experiment

replicated van den Hout and Kindt (2003) and others showing that metamemory scores for the relevant checking group decreased from the first trial to the last. However, the results also showed that checking six times within a trial did not cause an accuracy decrease, but instead showed an almost significant memory accuracy increase on both the first and last trial. Another important finding showed no significant effect of within-trial checking on memory confidence or vividness, however, more checking caused significantly lower rating of detail of the memory.

Another experiment conducted by Burns et al. (2020) built off of these findings by giving no check, one check, or six checks on each trial with each of the 364 participants completing six trials. After the sixth trial, the same psychological scales given in the previous experiment were presented. The results of this study showed no effect of within-trial checking on accuracy scores or metamemory, despite considerable power to detect differences. When looking at metamemory, within-trial checking also did not have a significant effect on metamemory, which generally replicates their Experiment 3 and is a new finding compared to previous research. Across trials metamemory decreased, replicating previous work showing that between-trial checking decreases confidence, but accuracy actually improved across trials. When comparing participants with high and low OCD scores, the people with higher OCD scores had lower accuracy and lower metamemory. The results also showed that within-trial checking increased the accuracy performance of the participants in the group with high OCD symptomatology, but there was no difference in the metamemory scores across as a function of OCD symptomatology level.

Doubt and the distrust of reality by people with OCD play a large role in the thoughts that lead to compulsions. Although the person with OCD is aware that they turned off the stove, as they remember the event, doubt creeps in and thoughts surrounding possible alternatives of their

actions leads to inferential confusion (Aardema et al., 2009). Hence, it seems possible that instilling doubt during the event may also affect memory confidence. There has been limited research surrounding doubt and its effects on accuracy or confidence. One study conducted by Ashbaugh and Radomsky (2007) instilled doubt in their subjects but did not manipulate it. In this experiment which investigated peripheral versus central attenuation to stimuli, mistakes during checking were emphasized to increase feelings of doubt. At the beginning of the task participants were told that the knobs on the stove were unreliable, and later in the experiment, after answering memory confidence and accuracy questions, the participants were brought back into the room with the stove and were told they had not properly turned off one of the burners and needed to check again. Half of the participants were then told to focus on the stove itself to improve their memory and half were told to focus on the surroundings as well. Afterwards, their memory accuracy and confidence were tested. The results were that the group attending to their surroundings had more accurate memory for the stove, but did not have better memory confidence. This peripheral attention group also had higher accuracy and confidence for peripheral items as well. Based on this study and others involving doubt, my experiment aims to see if instilling and manipulating doubt decreases memory confidence during either within-trial checking or between-trial checking.

The basis of the manipulation of doubt in my study is similar to the study conducted by Ashbaugh and Radomsky (2007) where participants were brought back into the lab to solidify the way they had to check the stove and then followed up with questions about memory accuracy and confidence. To manipulate doubt, half of the participants in both the checking and non checking groups received a prompt after trial three informing them that they made an error in

selecting the correct burners, and instructing them to be more careful for the future trials. This warning was meant to instill the sense of doubt which will then, I predicted, decrease their memory confidence. In accordance with the previous literature on checking and memory confidence, it is predicted that between-trial checking in our experiment will decrease confidence as well, and the doubt manipulation in my experiment will cause an even greater drop in memory confidence. On the basis of Burns et al.'s (2020) results, I also predict that within-trial checking will have no effect on memory accuracy or confidence.

METHOD

Participants

This was an online study conducted through MTURK and participants were 18 years and older, with the following qualifications; hit approval percentage > 95, and location = United States. There were 168 participants, 103 males, 64 females and one other, with an age range of 19-71 years old (M=36.91) Each participant was compensated $3.00 for their participation. The participants were randomly assigned to one of the four experimental groups. The first group was the check group with doubt manipulation (38 participants), the second group was the check group with no doubt manipulation (40 participants). The third group was the non-check group with doubt manipulation (45 participants) and the fourth group was the non-check group with no doubt manipulation (45 participants).

Materials

This study was conducted using Qualtrics, a survey generation program. In the program, the participants were first shown a diagram representing the eight burners (see Figure 1), and then after were shown a virtual stovetop with the eight burners (see Figure 2). To turn the burners

on the participants were required to click directly on the knob which turned the knob red, and to turn the burner off, another click would turn the knob back to being black. For the group prompted to check that the burners are off, the knobs were presented in yellow and once they are checked and clicked once they turn to black. An 18-question OCI scale was also given at the end of the study to assess the level of OCD symptomatology the participant displayed. The scale ranged from one being not at all describing the participants to five extremely describing the participant. A few questions that were asked were “I find it difficult to touch an object when I know it has been touched by strangers or certain people" and “I repeatedly check doors, windows, drawers, etc."

Procedure

All of the participants first gave consent to participate in the study and then were given instructions about the stove task. Each participant completed a practice trial to become familiar with the stove and then engage in eight following trials. The non-check groups were told that they would be turning on four of the eight burners indicated by yellow dots on the presented diagram, and then after turning the burners on they would be prompted to turn them off.
On each trial the diagram was presented for 3 s and then was replaced with the picture of the stove top. Participants were then given unlimited time to click on the four knobs they thought corresponded with the burners depicted in the diagram. Then, the participants were asked to turn off the four burners. Each group completed eight total real trials.

After the first and last trial, a distractor task was presented where the participants were shown a series of seven numbers one at a time at a 1-s rate and then were asked to write out the correct sequence. Following the task the participants were prompted to remember the four

burners they turned on and off from the previous trial by reselecting those burners. After remembering the burners, the participants were presented with three scales from 0-100 asking how confident they were that they selected the correct burners, how vivid their recollection was when they selected the burners, and the level of detail of their memory. After the eight trials are completed the participants were instructed to fill out the Obsessive Compulsive Inventory scale (OCI) as well as questions about their demographics.

The checking group's procedure was the same as the non-check group's, with the only exception being that at the end of each of the trials after the participants turned on and off the burners they were prompted to check that the burners were off. For this check they were shown another image of the burners and instructed to click each of the knobs of the burners they just turned off one more time to check that they are off. For each of the two groups (non-checking and checking) there was a manipulation of doubt for a randomized half of the participants. All groups were told at the beginning of the task that the computer would randomly check on some of the trials to make sure that the participants were turning on and off the correct burners. They were also informed that if they make a mistake, they will be notified of the error and allowed to complete that trial again. Immediately following the third trial, participants in the doubt groups were told that they had made an error on that trial and to try to be as accurate as possible for future trials. All participants were asked an additional question at the end of the experiment which was a manipulation check. This question asked: Thinking across all of the trials with the stove, how confident do you feel that you performed the task well? This question assessed whether the introduction of the doubt manipulation during the third trial was felt by the participants.

RESULTS

It was necessary to investigate how the manipulation of doubt affected the participants in this study, and it appears that there was a small effect of doubt, but it was not significant. The doubt group had slightly lower scores for the manipulation check (Ms = 73.19 and 75.68, respectively). A t-test was conducted to see if the manipulation check had an effect, however there was no significant effect, $t(166) = 0.74$, $p = 0.461$. First, metamemory scores were calculated by averaging the three questions asking how confident, vivid, and detailed the participant's memory was of the task. To see if doubt had an effect on metamemory, a 2 (doubt) x 2 (check group) x 2 (trial) ANOVA was conducted. The main effect of doubt was not significant and also did not interact with any other independent variables (smallest $p = 0.479$). Because the doubt manipulation had no effect on performance, I collapsed across that variable in all of the following analyses.

The accuracy scores are presented in Figure 3 and show that accuracy actually seems to have increased across trials. A 2 (check group) by 2 (trial number) ANOVA on accuracy was conducted and and the main effect of trial number was significant $F(1, 166) = 9.25$, $p = 0.003$, however the main effect of check group was not significant $F(1,166) = 0.45$, $p = 0.506$. The interaction between trial and check group was also not significant $F(1,166) = 0.87$ $p = 0.353$. The significant effect of trial number showed that people get better on the last trial compared to the first trial regardless of checking. This finding contradicts previous research and suggests that between-trial checking actually improves memory accuracy.

The metamemory scores are presented in Figure 4 and show that there was little difference in metamemory scores across the different conditions. A 2 (check group) by 2 (trial

number) ANOVA on metamemory was conducted and there was no significant main effect of trial number, $F(1,166) = 0.70$, $p = 0.796$, or check group, $F(1,166) = 0.11$, $p = 0.740$. The interaction between trial number and check group also wasn't significant, $F(1,166) = 0.32$, $p = 0.573$. This showed that there was no influence on metamemory based on whether participants were in the check group or no check group regardless of trial.

The results suggest that within-trial checking had no effect on accuracy or metamemory, and between-trial checking actually increased accuracy. Next, I explored the extent to which OCD symptomatology may have moderated these effects. The accuracy scores for the low versus high OCD symptomatology groups are presented in Figures 5 and 6. The participants were split into low and high OCD symptomatology groups with the cutoff for the groups at 3.5. A 2 (OCD level) by 2 (check group) by 2 (trial number) ANOVA was conducted on accuracy scores and overall, the high OCD symptomatology group had lower accuracy than the low OCD symptomatology group. The ANOVA revealed a significant interaction between check group and OCD, $F(1,164) = 4.40$, $p = 0.038$, as well as main effects of trial number, $F(1, 164) = 6.54$, $p = 0.011$ and OCD $F(1,164) = 20.86$, $p < .001$. Due to the significant interaction between the check group and OCD, two follow up t-tests were conducted for both low and high OCD symptomatology groups. The t-test for the low OCD group was not significant, ($t(113)$) = 0.69, $p = 0.493$), however the t-test for the high OCD symptomatology group was significant, ($t(51)$ = 2.54 $p = 0.014$). These results showed that for the low OCD group, checking had no effect on accuracy; however, checking did have a significant effect for the high OCD symptomatology group, as accuracy increased with checking.

The metamemory scores for the high and low OCD symptomatology groups are presented in Figures 7 and 8 and show that the higher OCD group displayed higher metamemory scores. A 2 (OCD level) by 2 (check group) by 2 (trial number) ANOVA on metamemory was conducted and these findings revealed that the only significant effect was the effect of OCD group $F(1, 164) = 10.87$, $p = .001$. None of the other effects approached significance, smallest $p = 0.362$. These data showed that the higher OCD group had overall higher metamemory scores regardless of check group or trial number, but that was the only significant finding.

DISCUSSION

This experiment investigated the effects of checking on accuracy and metamemory, with the addition of a doubt manipulation included due to its significant role in OCD. Previous literature has found that checking decreases memory confidence, and with mixed findings for the effects of checking on accuracy, overall checking is believed to hurt memory accuracy slightly (van den Hout et al., (2019). In this experiment, the manipulation of doubt as a variable was added to categorize how it affects metamemory and accuracy. High versus low OCD symptomatology with and without checking was explored to determine its effects on different aspects of memory.

The overall investigation of how doubt impacts memory confidence and accuracy did not lead to the anticipated results. The doubt manipulation was hypothesized to cause a significant drop in memory confidence, however, the data do not reflect this. Doubt did not have an effect on memory confidence. The manipulation check which asked: “Thinking across all of the trials with the stove, how confident do you feel that you performed the task well?” had slightly lower scores for the doubt groups compared to the no doubt groups. However, the manipulation tactic

did not cause a significant difference between the scores, nor was the doubt implementation strong enough to produce a significant difference in memory confidence. Doubt, which was manipulated by informing participants that their burner selections were not entirely correct, was only artificially induced in one out of the eight trials and occurred relatively early (on trial 3) during the stove task. This artificial induction of doubt early in the trials may be the reason why this specific manipulation method was not effective at instilling doubt. I had considered introducing the doubt manipulation on two trials. However, if participants were reintroduced to the same doubt manipulation there was a risk that participants may have recognized this as a doubt tactic diminishing its effectiveness. Feelings of doubt in people with OCD contribute greatly to reverting back to check a stimulus, whereas this study's manipulation just asked the participants to be more careful on later trials. For people without OCD, who were the participants in the study, the notification on their screen and the small task of checking a trial may not have been powerful enough to cause feelings of doubt.

Checking was also investigated to see if it would have an effect on memory confidence with the assumption that between-trial checking would decrease memory confidence. Checking was not shown to have any effect on memory confidence, therefore opposing this assumption. Van den Hout and Kindt (2003) found that memory confidence, vividness and detail all decrease across trials due to relevant checking. One reason for this decrease may be that the increased familiarity of the stimuli over trials increases conceptual processing. This focuses attention to information from memory and in turn inhibits perceptual processing which takes in information from the external world. Additionally, within-trial checking was hypothesized to not affect

metamemory, which was supported by the data. These data replicate the findings of Burns et al. (2020) and should be investigated further.

When considering the results for accuracy, across trials accuracy increased regardless of checking. These findings failed to replicate previous research because it has been frequently shown that accuracy either decreases across trials or remains constant in previous studies (see van den Hout et al., 2019). One possible explanation for the increase in accuracy was due to the repetition of the task. Although familiarity may decrease confidence due to less perceptual processing, it may increase accuracy due to more conceptual processing. As the participants were exposed to the stove trials multiple times, an increase in familiarity may have caused an increase in accuracy, although this explanation does not explain why previous studies produced different results.

Another explanation for the increase in accuracy across trials may lie in methodological differences between my study and others. First, it is important to note that previous research took place in lab settings, whereas this was an online study. There is a chance the participants did not fully understand the procedures which would lower accuracy on the first trial. In previous studies such as those by van den Hout and Kindt (2003), accuracy was almost perfect on the first trial, whereas accuracy in this experiment for the first trial was much lower. Another important difference that may contribute to the increase in accuracy across trials is that this study used an eight burner stove whereas previous studies used six, potentially causing a lack of understanding with a more complex task. Therefore, it is possible that, for this experiment, accuracy was lower on the first trial as the participants were attempting to navigate the stove. This was further exacerbated by the fact that this experiment took place online, possibly leading to lower

accuracy. By the end of the experiment the participants were more aware of the task due to repetition which typically causes an increase in accuracy.

Another possibility for the increase in accuracy is related to a potential oversight in the set up of the study. The distractor task given after the first and last trial was a digit span task where the participants were asked to recall a series of seven numbers. Since the digit span task was given both for the first trial and last, it is possible that the participants saw the task for the last trial and guessed that they would soon be asked to remember which burners they selected, similar to the task on the first trial. This knowledge could have potentially caused the participants to quickly store their responses to which burners they selected right before completing the digit span task and then recalling the answers shortly after. It is interesting to note that when looking at the mean number of correct digits reported, in the eighth trial the participants correctly recalled 5.59 out of the seven digits, whereas in the first trial only 4.83. The superior digit recall on the last trial suggests that this explanation is unlikely.

Perhaps most interesting, the high OCD symptomatology group showed lower accuracy in this study. Previous research has shown that people with OCD do not have a memory accuracy problem, but this notion is not completely accepted. Studies by Jaafari et al. (2013) and Heinzel et al. (2021) have shown that people with OCD have lower memory accuracy and memory performance. It is important to note that people with OCD are more likely to show a memory deficit in visual tasks (Dirson et al., 1995), which would align with the findings of this experiment, as the stove task is highly visual. Although the OCD group had lower accuracy, within-trial checking did improve their accuracy, which is highlighted when comparing the checking versus no checking groups with high OCD symptomatology. Checking for people with

OCD temporarily alleviates anxiety, and research suggests a possible connection between anxiety and a negative impact on memory (Vytal et al., 2013). It is possible that due to this connection the checking, which benefits the people in the high OCD symptomatology group, causes a better memory accuracy outcome because it reduces anxiety for those with high OCD symptomatology. This finding is extremely interesting due to the fact that people with OCD repeatedly check whereas people without OCD rarely do so. It is a possibility that the checking may impact them more than people without OCD, which would cause them to continue to check.

One of the biggest limitations of this study was that the participants were not diagnosed with OCD. The OCI scores were used to split the participants into high versus low OCD symptomatology groups and to draw conclusions about memory confidence and accuracy, however these individuals were not diagnosed with OCD. No conclusions can be firmly drawn about people with OCD versus healthy controls based on the findings.

The present study adds to the current literature and provides a springboard for future research, particularly in regards to the doubt manipulation. If this experiment were to be replicated in the lab versus an online study, there is potential for the manipulation to be significant. It would also be beneficial to compare people with and without OCD to observe the effects of doubt on accuracy and confidence in this population. One specific finding which would be interesting for future research is that the high OCD symptomatology group had lower accuracy than the low OCD group, however checking caused an increase in accuracy for the high OCD symptomatology group. This is a very interesting result because people with OCD check because they are doubtful about the accuracy of the task they just completed, causing their confidence to be low. If checking in fact increases accuracy for people with OCD

symptomatology, then there may be implications for how to increase confidence as well, if accuracy is higher. It would be important to replicate these findings for people with OCD, rather than just high OCD symptomatology. OCD and doubt must be further studied to continue uncovering its implications on memory confidence and accuracy.

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FIGURES AND TABLES

Disorder Class: Obsessive-Compulsive and Related Disorders
Presence of obsessions, compulsions, or both:
Obsessions are defined by (1) and (2): 1. Recurrent and persistent thoughts, urges or images that are experienced, at some time during the disturbance, as intrusive, unwanted, and that in most individuals cause marked anxiety or distress. 2. The individual attempts to ignore or suppress such thoughts, urges, or images, or to neutralize them with some thought or action (i.e., by performing a compulsion).
Compulsions are defined by (1) and (2): 1. Repetitive behaviors (e.g., hand washing, ordering checking) or mental acts (e.g., praying, counting, repeating words silently) that the person feels driven to perform in response to an obsession, or according to the rules that must be applied rigidly. 2. The behaviors or mental acts are aimed at preventing or reducing distress or preventing some dreaded event or situation. However, these behaviors or mental acts either are not connected in a realistic way with what they are designed to neutralize or prevent or are clearly excessive.
The obsessions or compulsions are time consuming (e.g., take more than 1 hour per day) or cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.
The disturbance is not better explained by the symptoms of another mental disorder (e.g., excessive worries, as in generalized anxiety disorder; preoccupation with appearance, as in body dysmorphic disorder; difficulty discarding or parting with possession, as in hoarding disorder; hair pulling, as in trichotillomania [hair-pulling disorder]; skin picking, as in excoriation [skin-picking] disorder); stereotypies, as in stereotypic movement disorder; ritualized eating behavior, as in eating disorders; preoccupation with substances or gambling, as in substance-related and addictive disorders; sexual urges or fantasies, as in paraphilic disorders; impulses, as in disruptive, impulse-control, and conduct disorders; guilty

ruminations, as in major depressive disorder; thought insertion or delusional preoccupations, as in schizophrenia spectrum and other psychotic disorders; or repetitive patterns of behavior, as in autism spectrum disorder).
The disturbance is not due to the direct physiological effects of a substance (e.g., drug of abuse, a medication) or a general medical condition.
Specify if: With good or fair insight: The individual recognizes that obsessive-compulsive beliefs are definitely or probably not true or that they may or may not be true. With poor insight: The individual thinks obsessive-compulsive disorder beliefs are probably true. With absent insight/delusional beliefs: The individual is completely convinced that obsessive-compulsive disorder beliefs are true. *Specify* if: Tic related: The individual has a current or past history of a tic disorder.

Table 1. DSM 5 Criteria for OCD.

Figure 1. Image Presented to the Participants of the Stovetop and Burners.

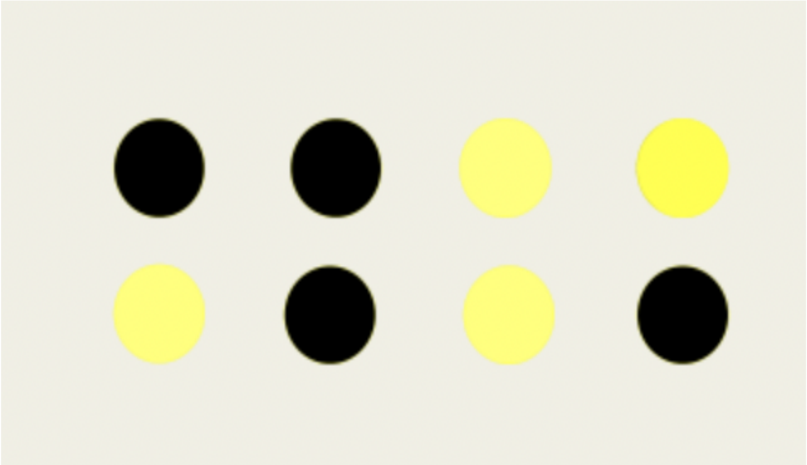

Figure 2: Image Presented to the Participants of Which Burners Should be Turned On.

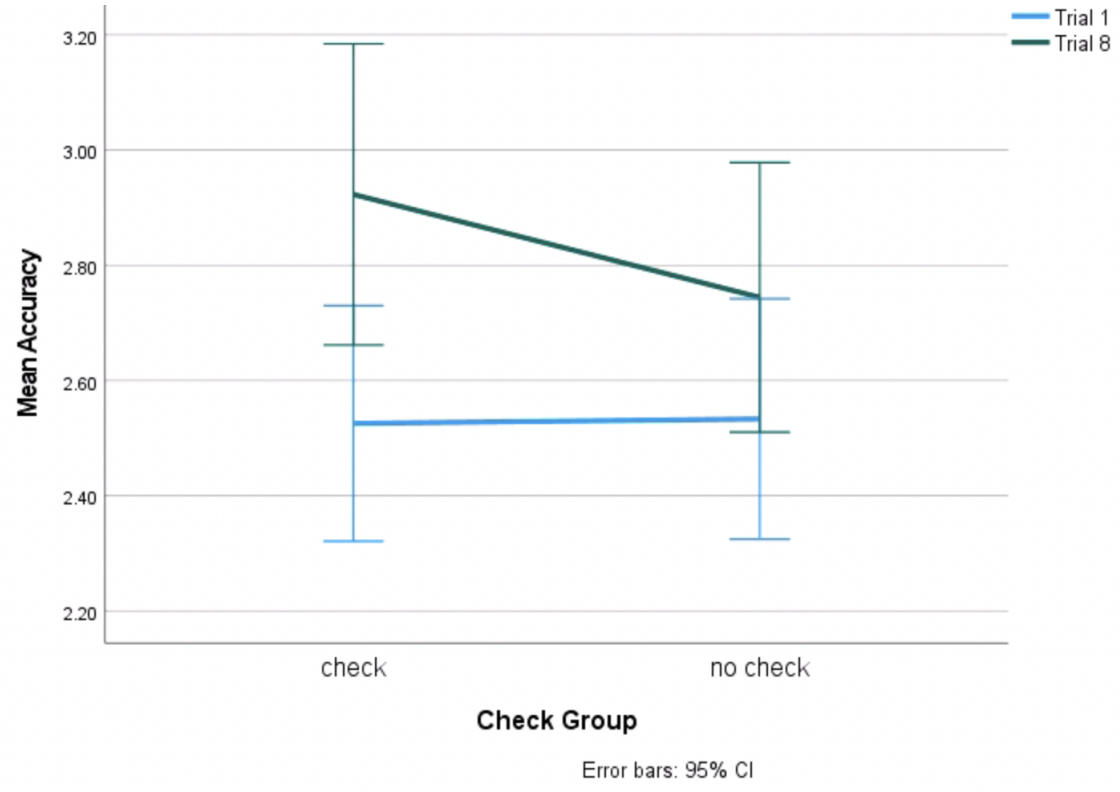

Figure 3. The Relationship between Check Group and Accuracy Scores.

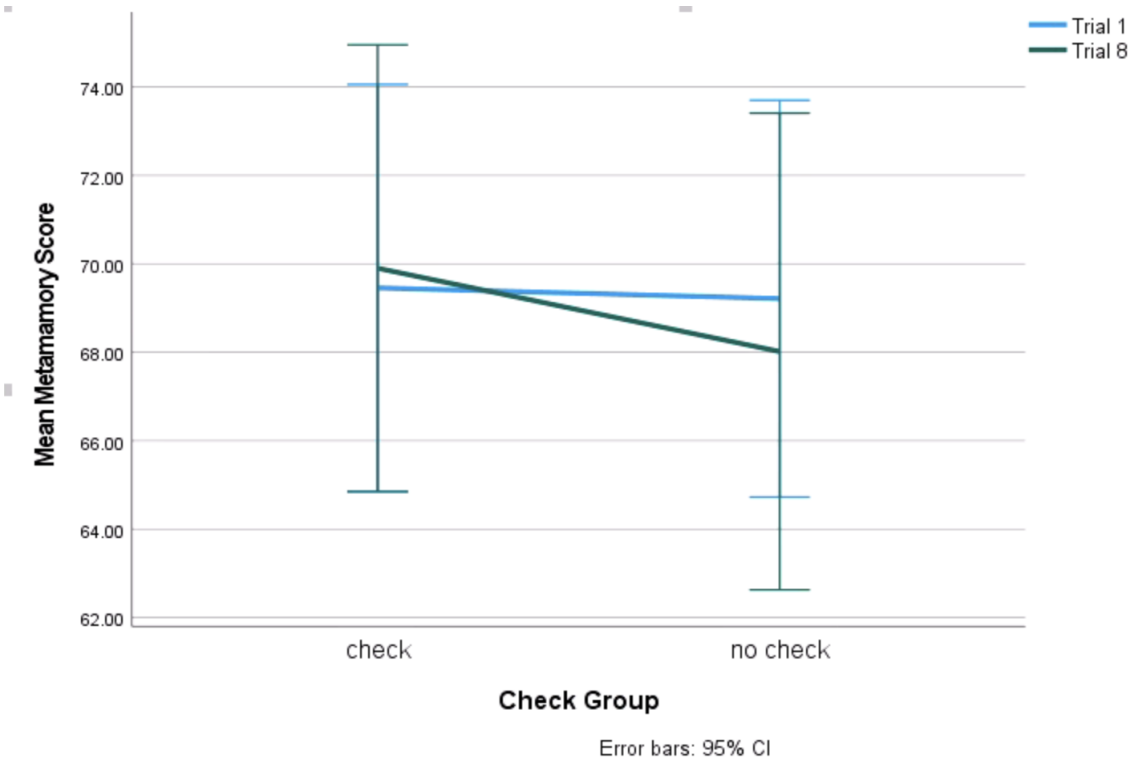

Figure 4. The Relationship Between Check Group and Metamemory Scores for First and Last Trials.

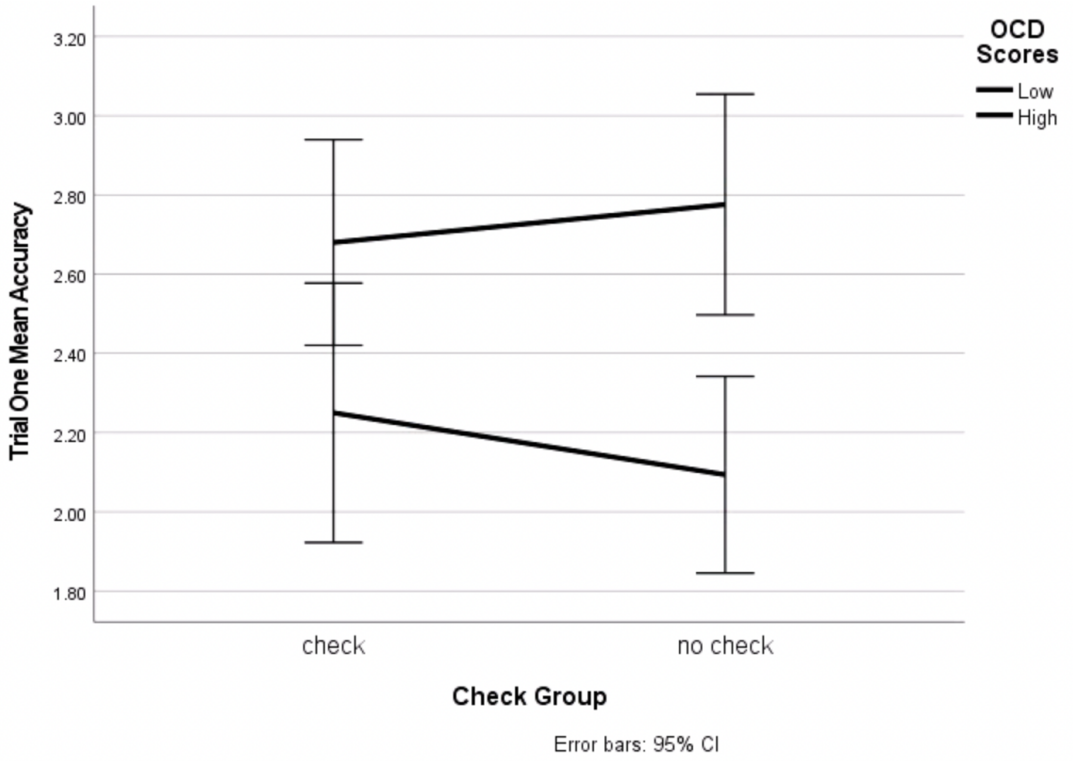

Figure 5. The Relationship Between Check Group and Accuracy for High Versus Low OCD Symptomatology Groups for Trial One.

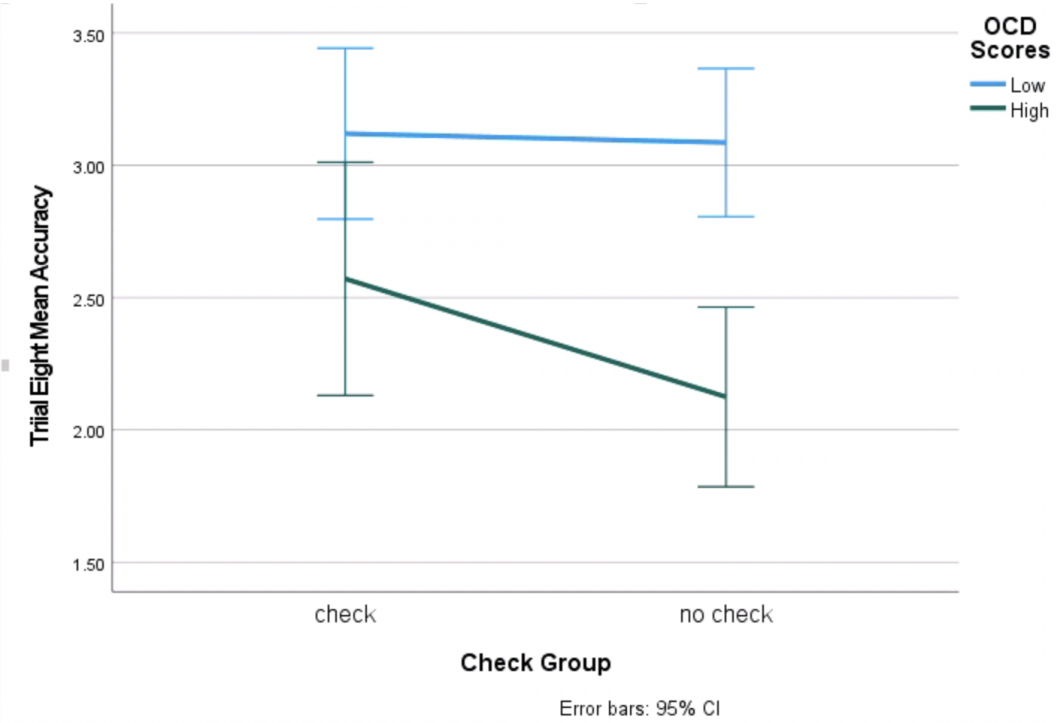

Figure 6. The Relationship Between Check Group and Accuracy for High Versus Low OCD Symptomatology Groups for Trial Eight.

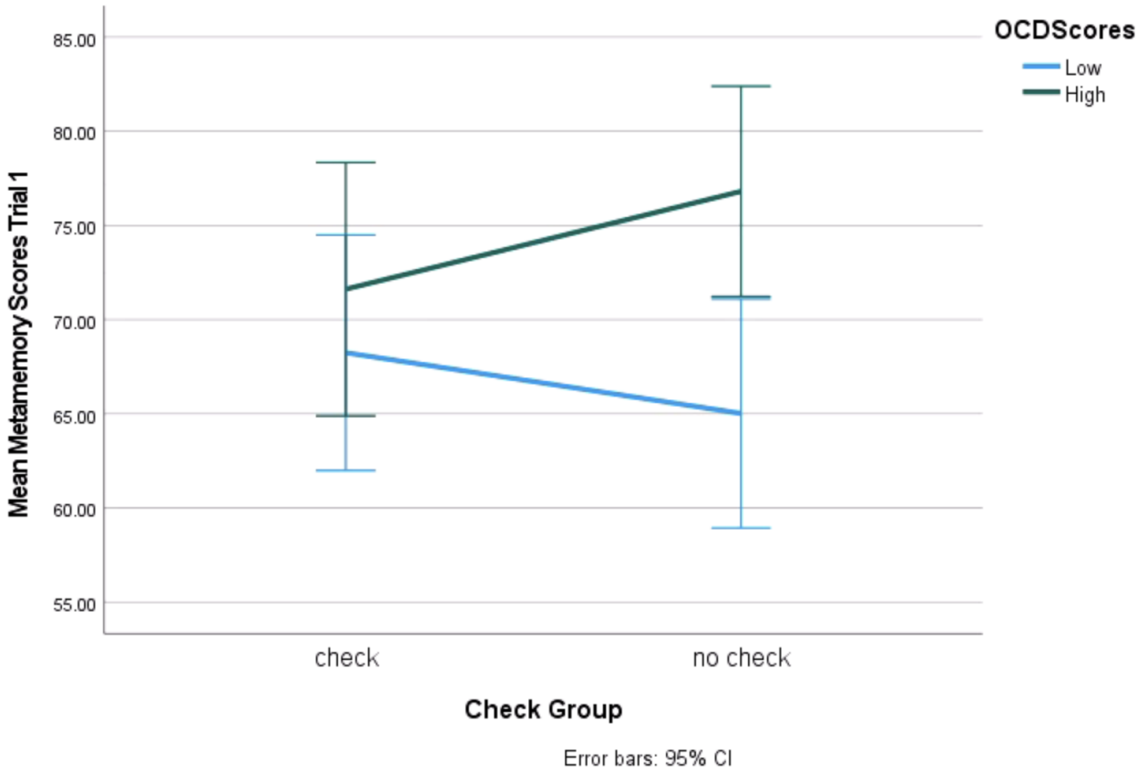

Figure 7. The Relationship Between Check Group and Metamemory for High Versus Low OCD Symptomatology Groups for Trial One.

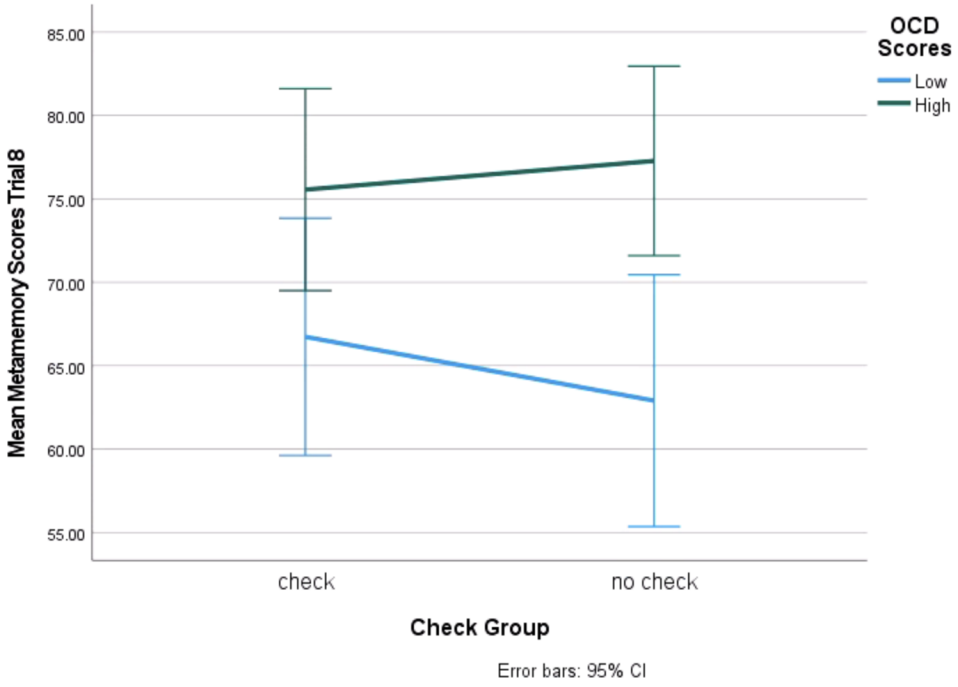

Figure 8. The Relationship Between Check Group and Metamemory for High Versus Low OCD Symptomatology Groups for Trial Eight.