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Exploring the Boundaries of Memory Distrust from Repeated Checking: Increasing External Validity and Examining Thresholds

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Abstract

Checking behavior is among the most common forms of compulsions in OCD. Recent research suggests that repeated checking decreases memory confidence, and supports theoretical models of how repeated checking is maintained. The current paper presents findings from two studies exploring the boundaries of memory distrust from repeated checking. Results of Study One show that repeated checking of a real stove decreases memory confidence, vividness, and detail (i.e., metamemory), and leads to a greater reliance on knowing as a source of memory, without meaningfully altering memory accuracy. Results of Study Two suggest that these changes in metamemory are observed after performing a relatively low number of checks on one occasion. The findings are considered within the context of theoretical models of checking and future directions are delineated.

Keywords: OCD, obsessive-compulsive disorder, checking, memory, remember/know

Exploring the Boundaries of Memory Distrust from Repeated Checking: Increasing External Validity and Examining Thresholds

Research has shown that checking compulsions are extremely common in patients with obsessive-compulsive disorder (OCD). For example, studying 44 patients with OCD, Rasmussen and Tsuang (1986) found that checking was the most common ritual, occurring in 80% of the patients. Similarly, two more recent studies have found checking compulsions to be the most common form of ritualized behavior in OCD. Specifically, Ball, Baer, and Otto (1996) found that 75% of patients with OCD exhibited primarily checking and/or cleaning rituals, and Summerfeldt, Antony, Downie, Richter, and Swinson (1997) found that 81% of their 182 patients with OCD had checking compulsions. Given the dominance of checking in OCD, Rachman (2002) developed a detailed theoretical formulation of repeated checking, including hypothesized consequences and maintenance factors. However, the etiology and maintenance of checking behavior is still unclear (Radomsky, Rachman, & Hammond, 2001; McKay et al., 2004).

Historically, research seeking to elucidate the nature and role of repeated checking in OCD has focused on examining memory deficits. Given the clinical presentation of patients with OCD, and their reports of excessive doubts of having performed actions, memory deficits were proposed. However, there is only weak and conflicting evidence supporting a general memory deficit in individuals with OCD (Rachman & Shafran, 1998). Numerous studies have failed to find OCD-related deficits in distinguishing between performed actions (or words seen) and imagined events (or words; McNally & Kohlbeck, 1993; Constans, Foa, Franklin, & Mathews, 1995). In addition, use of neuropsychological tests to assess general memory deficits in OCD has produced discrepant results and suggest that any observed memory deficits may be driven by difficulties organizing information (see for example Deckersbach, Otto, Savage, Baer, & Jenike 2000; Greisberg & McKay, 2003)[1]. However, studies of memory deficits in OCD increasingly suggested potential reductions in memory *confidence.*

Numerous studies have implicated a role of decreased *memory confidence* in OCD and checking behaviors. In an early study of reality monitoring, McNally and Kohlbeck (1993) found that OCD patients reported less confidence in their memories than did controls, despite similar reality monitoring abilities. Similarly, MacDonald, Antony, MacLeod, and Richter (1997) found that OCD checkers were significantly less confident regarding their recall for words than were OCD non-checkers and clinical controls. In addition, the OCD checkers also demonstrated significantly slower reaction times for judging words during a recognition task, again suggesting decreased memory confidence. Finally, decreased memory confidence for objects has also been demonstrated. For example, Tolin and colleagues (2001) found that individuals with OCD showed a progressive decline in memory confidence for threat-related objects viewed over repeated trials, whereas this decline was not evident for anxious and non-anxious controls. However, there were no group differences on memory accuracy. Therefore, Tolin and colleagues (2001) demonstrated that in individuals with OCD, memory confidence was negatively impacted by repeatedly viewing objects whereas memory accuracy was not altered.

Recently, experimental work has directly examined the impact of repeated checking on memory accuracy and confidence. For instance, in several studies conducted by van den Hout and Kindt (2003, 2004), undergraduate participants engaged in repeated checking of a computerized virtual stove and characteristics of their memories were then assessed. From these experiments, van den Hout and Kindt (2003, 2004) have consistently demonstrated that 20 trials of repeated checking does not alter memory accuracy, but does lead to decreases in memory confidence, memory vividness, and memory detail. In addition, this repeated checking is associated with a greater reliance on a sense of "knowing" (i.e., a sense of familiarity or recollection) compared to "remembering" (i.e., explicit recall of the details of an event; Tulving, 1985). Finally, these studies have shown that "irrelevant checking" (checking virtual light bulbs between pre- and post-tests assessing memory for the virtual stove) does not alter memory characteristics (metamemory).

Building from the work of van den Hout and colleagues, Radomsky, Gilchrist, and Dussault (in press) recently adapted the repeated checking paradigm for use with a real stove. Using an undergraduate sample, Radomsky and colleagues (in press) found that repeatedly checking a real stove lead to decreases in memory confidence, memory vividness, and memory detail. In addition, compared to subjects in the "irrelevant checking" condition (checking a faucet between pre- and post-tests but assessing memory for the stove), more participants in the relevant checking condition relied on a sense of knowing for the memory source as opposed to remembering. These findings regarding memory confidence, vividness, detail, and source were consistent with previous research. Further, Radomsky and colleagues (in press) did not find an interaction of condition (relevant vs. irrelevant checking) and time (pre vs. post checking) on memory accuracy. However, they found that subjects who performed 19 relevant checking trials showed memory accuracy that was significantly below perfect, whereas participants who performed irrelevant checking showed perfect accuracy (at both pre-and post-test). Therefore, Radomsky and colleagues (in press) proposed that repeated relevant checking under ecologically valid conditions (i.e., a real stove) *may* produce small but significant declines in memory accuracy.

The two studies reported herein were designed to replicate and extend the work by van den Hout and Kindt (2003, 2004), and Radomsky and colleagues (in press) to further delineate the impact of repeated checking on memory and metamemory. Study One was designed to replicate findings from Radomsky and colleagues (in press) that repeated checking on a *real* stove causes memory distrust. In addition, we sought to further examine the impact of repeated checking of a real stove on memory accuracy, given the potential discrepancy in previous results when using a real stove versus a virtual stove. Consistent with past findings, it was hypothesized that a high number of checks (15) would decrease memory confidence, vividness, and detail, and lead to greater reliance on "knowing" as a source of memory compared to "remembering." In addition, based on the findings of van den Hout and Kindt (2003, 2004), and the failure to find a significant interaction of condition by time by Radomsky

and colleagues (in press), it was hypothesized that memory accuracy would not substantially decrease with repeated checking. Finally, it was hypothesized that the stove would be perceived as threatening (i.e., participants would think that it would be bad for the burners to be left on).

Study Two was designed to examine the threshold at which repeated checking negatively impacts memory confidence. Previous research has shown that high levels of repeated checking (e.g., 20 trials) leads to changes in memory characteristics. However, no research has examined the number of checks needed to decrease memory confidence, despite speculation that "very few checks corrupt memory confidence" (van den Hout & Kindt, 2003, p. 315). Clarifying the number of checks needed to impact confidence could suggest an empirical guideline for considering clinically elevated levels of checking. Further, this would support cognitive-behavioral theories of compulsive checking (e.g., Rachman, 2002) by informing the potential mechanisms by which excessive checking develops and is maintained. Therefore, in Study Two, subjects were randomly assigned to perform varying numbers of checks (0, 2, 5, 10, or 15 repeated checks). It was hypothesized that memory confidence would gradually decline with increased checking, but that memory accuracy would remain relatively stable. Further, it was also predicted that there would be a gradual shift from "remembering" to "knowing" with increased checking. It is important to test the possibility that repeated checking may paradoxically produce a shift to a less vivid sense of knowing, given previous data suggesting that OCD is associated with a desire for very vivid memories (Constans et al., 1995). Finally, it was again hypothesized that the stove would be perceived as threatening.

Study 1

Method

Participants. Fifty-one undergraduate students (18 males and 33 females) participated in this study as partial fulfillment of a psychology course requirement. Initial data screening procedures revealed one case that was a univariate outlier (Tabachnick & Fidell, 1996) on one of the main variables of interest (memory confidence, vividness, and/or detail). Specifically, visual inspection of

histograms of these data revealed one case that was detached from the rest of the distribution (pre memory vividness = 10). Therefore, this case was dropped from subsequent analyses, yielding a final sample of 50 participants (18 males and 32 females). Participants in the study had a mean age of 18.66 (*SD* = 1.02) years, a mean of 12.62 (*SD* = .77) years of education, and were ethnically diverse (70 % Caucasian, 24% Asian/Asian-American, 2 % Latino/a, 2 % Biracial, and 2 % "other" identified).

Participants were randomly assigned to one of 2 conditions: performing either 0 or 15 checking trials between the pre- and post-test. There were 26 participants in the 0 check condition and 24 in the 15 check condition.[2]

Measures.

Memory Characteristics (Metamemory). Memory accuracy, confidence, and source were assessed using procedures developed in previous research on repeated checking (Radomsky, et al. in press; van den Hout & Kindt, 2003, 2004). Specifically, memory accuracy was assessed using a schematic diagram of the stove and having participants mark an "X" on the knobs that were last checked. Memory confidence, vividness, and detail, were rated from 0 to 100 with higher scores representing greater confidence, vividness, and detail. Memory source was assessed by asking participants to indicate whether the source of their memory for the last checking trial was "knowing", or "remembering", that the stove was off. Participants were provided with definitions of the terms "knowing" and "remembering" (Tulving, 1985). Finally, after the initial pre-test checking trial, the perceived threat of the situation was assessed by asking participants to give a rating (between 0 and 100, with higher scores indicating greater threat) of how bad it would be if the burners were not turned off.

Symptom measures. After the experimental tasks, participants completed self-report measures of obsessive-compulsive features (Obsessive-Compulsive Inventory; OCI: Foa, Kozak, Salkovskis, Coles, & Amir, 1998; Simonds, Thorpe, & Elliot, 2000) and depressive symptoms (Beck Depression

Inventory-II; BDI-II, Beck, Steer, & Brown, 1996). These measures were chosen based on their strong psychometric properties and relevance to the constructs being examined.

Procedure. Participants performed the checking tasks with a fully functioning electric stove in a small kitchen. The stove had four burners with four corresponding knobs, positioned horizontally. Each knob was numbered orally by the experimenter (from 1-4) to allow the experimenter to provide instructions regarding which knob to operate. The knobs were removed and each participant was provided with one knob to manipulate the stove burners. Participants were trained to operate the stove and each checking trial consisted of "turning on," "turning off," and "checking" two designated knobs/burners. To "turn on" the stove, participants replaced the knob, turned the knob to toward the quarter mark, and then removed the knob leaving the burner on. To "turn off" the stove, participants replaced the knob and turned it to "Off", wiggled the knob to make sure it was in place, and then removed the knob. Finally, to "check" the stove, participants replaced the knob, turned the knob to "High", to "Off," to "Low", to "Off", wiggled the knob to make sure it was in place, and then removed the knob.

After orienting participants to the basic procedures, further instructions were administered by the experimenter from outside the room via two-way radios. This arrangement was utilized to increase perceived responsibility during the checking trials. In addition, before starting the checking trials, participants were informed that the stove was not entirely reliable, and that it was important that they go through the procedure of wiggling and checking the knobs properly because the knobs are sometimes easily mistaken as off when they really are not. Participants were also reminded that the stove was fully operational and to take care to not get burned. Finally, participants were told that they would be given the responsibility of carrying out the tasks properly and that they were being trusted for their responsible nature.

Participants started the experiment with a pre-test checking trial followed by completion of an initial memory recall and characteristics form. Next the participants completed either 0 or 15 additional

checks according to their assigned condition. To equate the time interval between the pre and post-tests across conditions, participants in the 0 check condition performed a filler task (completed word find puzzles) after the pre-test. Finally, a post-test checking trial was administered to each participant, followed by the completion of a second memory recall and characteristics form, the remaining study questionnaires, and a debriefing.

Results

Sample means for each of the symptom measures were calculated to provide a description of the sample. This revealed the following sample scores: OCI Frequency Total: M = 42.28, SD = 29.35, OCI Frequency Checking Subscale Mean Item Score M = .92, SD = .76, and BDI-II Total M = 8.28, SD = 6.79. These scores were consistent with the unselected nature of the sample, with both OCI and BDI-II scores below the means for clinical samples. Independent samples t-tests were conducted to compare participants in the two conditions on the self-report symptom measures. Results failed to reveal any significant differences between conditions (all p's > .20) on the OCI, OCI Checking, or the BDI-II, supporting acceptable random assignment.

Memory Accuracy. The mean number of knobs accurately identified as just checked (maximum score of 2) according to condition and time are presented in Figure 1 and revealed that participants were generally very accurate in their recall of which knobs they had last checked. A 2 "Condition" (0 checks, 15 checks) x 2 "Time" (Pre, Post) repeated measures ANOVA failed to reveal main effects of condition, F (1, 48) = 2.83, p = .10, or time, F(1, 48) = .18, p = .68. Further, there was not a significant interaction between condition and time on memory accuracy scores, F(1, 48) = 1.31, p = .26. This suggests that memory accuracy was not substantially impacted by 15 trials of repeated checking.

Memory Confidence, Vividness, and Detail. Mean ratings for the memory characteristics according to condition and time are presented in Figure 1 and revealed that at the initial time point, participants were generally very confident in their report of which knobs they had last checked and that their memories were vivid and detailed. 2x2 repeated measures ANOVAs were conducted on memory

confidence, vividness, and detail. These analyses revealed significant main effects of time for all three variables: memory confidence, $F(1, 48) = 8.44$, $p = .01$; vividness, $F(1, 48) = 7.75$, $p = .01$; and detail, $F(1, 48) = 9.22$, $p = .01$. Further, there were also significant main effects of condition for all three variables: memory confidence, $F(1, 48) = 9.26$, $p = .01$; vividness, $F(1, 48) = 7.82$, $p = .01$; and detail, $F(1, 48) = 7.16$, $p = .01$. Additionally, these main effects were modified by significant interactions between time and condition for memory confidence, $F(1, 48) = 11.83$, $p = .001$, vividness, $F(1, 48) = 13.77$, $p = .001$, and detail, $F(1, 48) = 17.67$, $p < .001$. Follow-up independent samples t-tests within time point failed to reveal significant group differences at pre-test (all t's < 1 and p's > .4). In contrast, at post-test the 15 check group reported significantly lower memory confidence ($t(48) = 3.34$, $p = .01$), significantly less vivid memories ($t(48) = 3.44$, $p = .001$), and significantly less detailed memories ($t(48) = 3.82$, $p = .001$) than the 0 check group. This suggests that although the two groups had similar memory characteristics initially, participants who completed 15 trials of repeated checking subsequently had less confidence in their memories and felt that their memories were less vivid and detailed.

Memory Source. Chi square analyses were used to examine potential differences in memory source (remembering vs. knowing) according to condition. As would be predicted, at the pre-test participants in the two conditions were not found to differ significantly on their memory source ($\chi^2(1) = 1.38$, $p = .24$), and the majority of participants reported "remembering" as the source of their memory (85% and 71% in the 0 and 15 check conditions, respectively). Also as hypothesized, at post-test, there was a significant interaction of condition and memory source, $\chi^2(1) = 8.10$, $p = .01$. Specifically, at post-test, the majority of participants in the 0 check condition reported "remembering" the last checking trial (81%), whereas less than half (42%) of the participants in the 15 check condition reported "remembering" the last checking trial (therefore, 58% reported "knowing").

Perceived Threat. As hypothesized, ratings of perceived threat revealed that participants found the prospect of the burners being left on as very bad, $M = 83.00$, $SD = 27.21$.

Discussion

In the current study, fifteen trials of repeated checking of a real stove lead to significant decreases in memory confidence, vividness, and detail. These results replicate those of Radomsky and colleagues (in press) who found similar results with 19 trials of repeated checking with a real stove. In combination, results of these two studies suggest that the findings of van den Hout and Kindt (2003; 2004), using a computerized stove, generalize to real checking situations. In addition, the magnitude of decreases in confidence from repeated checking are markedly similar across the studies, with each checking trial associated with approximately 1-point decrease in confidence. In contrast to the effects of repeated checking on memory confidence, detail, and vividness, results of the current study showed that the number of checks performed (condition) did not significantly interact with time (pre vs. post repeated checking) on memory accuracy. These results are consistent with the accuracy data of van den Hout and Kindt (2003, 2004) and Radomsky and colleagues (in press). Further, our results suggest that repeated checking is associated with a shift in memory source from remembering to knowing. Indeed, after 15 trials of checking, 58% of the subjects reported *knowing* as their memory source. Results of the current study are important in demonstrating that repeated checking of a real object that is perceived as threatening reduces memory confidence and alters memory source. Study Two addresses how much checking is needed to observe changes in metamemory (e.g., reduce confidence, vividness, and detail).

Study 2

Participants. A separate sample was collected for Study Two, independent of Study One. Eighty-one undergraduate students participated in Study Two as partial fulfillment for a psychology course requirement. Initial data screening procedures revealed three cases with univariate outliers (Tabachnick & Fidell, 1996) on the main variables of interest (memory confidence, vividness, and/or

detail). Specifically, visual inspection of histograms of these primary variables revealed three cases with data that was unattached to the rest of the distribution (case 1: pre memory confidence = 10; case 2: pre memory confidence = 40 & pre vividness = 20; case 3: pre vividness = 30 & detail = 30). Therefore, these three cases were dropped from subsequent analyses, yielding a final sample of 78 participants (36 males and 42 females). Participants in the study had a mean age of 19.55 (*SD* = 2.55), a mean of 13.06 (*SD* = 1.18) years of education, and were ethnically diverse (54% Caucasian, 26% Asian/Asian-American, 5% African American, 9% Latino/a, 1% Biracial, 1% "other" identified, and 4% did not report ethnicity).

Participants were randomly assigned to one of 5 conditions: performing 0, 2, 5, 10, or 15 checking trials between pre- and post-test. Sample size for the 0, 2, 5, 10, and 15 conditions were as follows: 17, 16, 15, 15, and 15, respectively.[3]

Measures. The same measures were utilized in the second study as the first study to assess memory characteristics, as well as levels of emotional distress related to obsessive-compulsive and depressive symptoms (i.e., OCI and BDI-II).

Procedure. The procedures were the same as Study One except that 2, 5, and 10 check conditions were added and the amount of time participants performed the filler task (word find puzzles) was modified for participants in these conditions in order to equate the delay between pre and post test across all participants.

Results

Descriptive statistics for each of the symptom measures were calculated to provide a description of the sample. This revealed the following sample scores: OCI Frequency Total: *M* = 35.06, *SD* = 21.41, OCI Frequency Checking Subscale Mean Item Score *M* = .70, *SD* = .51, and BDI-II Total *M* = 7.57, *SD* = 7.45. As in Study One, these scores were again consistent with the unselected nature of the sample, with both OCI and BDI-II scores below the means for clinical samples. One-way ANOVAs were conducted to compare the five conditions on the self-report symptom measures.

Results failed to reveal any significant differences between conditions (all *p*'s > .45) on the OCI, OCI Checking, or the BDI-II, indicating acceptable random assignment.

Memory Accuracy. The mean number of knobs accurately identified as just checked (maximum score of 2) according to condition and time are presented in Figure 2 and again revealed that participants were generally very accurate in their recall of which knobs they had last checked. A 5 "Condition" (0, 2, 5, 10, or 15 checks) x 2 "Time" (Pre, Post) repeated measures ANOVA failed to reveal a main effect of condition, F (4, 73) = 1.55, p = .20, but did reveal a significant main effect of time, F(1, 73) = 6.01, p = .02, indicating that across conditions accuracy was significantly worse at the post-test. However, interestingly, there was *not* a significant interaction between condition and time on memory accuracy scores, F(4, 73) = 1.55, p = .20, indicating that decreases in memory accuracy over time did not appear to vary by the number of checks completed.

Memory Confidence, Vividness, and Detail. Mean ratings for the memory characteristics according to condition and time are presented in Figure 2. 5 "Condition" (0, 2, 5, 10, or 15 checks) x 2 "Time" (Pre, Post) repeated measures ANOVAs were conducted on memory confidence, vividness, and detail.

These analyses revealed significant main effects of time for all three variables: memory confidence, F(1, 73) = 7.87, p = .01; vividness, F(1, 73) = 10.53, p = .01; and detail, F(1, 73) = 11.46, p = .001**.** There was also a significant main effect of condition for detail, F(4, 73) = 2.83, p = .03, and trends in this direction for memory confidence, F (4, 73) = 2.32, p = .065; and vividness, F(4, 73) = 2.39, p = .058.

Most importantly, time significantly interacted with the number of checks performed (condition) on all three outcome variables [memory confidence, F(4, 73) = 4.94, p = .001, vividness, F(4, 73) = 3.51, p = .01, and detail, F(4, 73) = 5.57, p = .001]. These results indicate that performing more checks led to greater decreases in memory confidence, vividness, and detail. Follow-up one-way ANOVAS within time point failed to reveal significant group differences at pre-test (all F's < 1 and

p's > .6), supporting the relative equality of participants in the different conditions before repeated checking. In contrast, at post-test there were significant differences according to group for all three variables of interest [memory confidence ($F(4,77) = 4.57$, $p = .01$), vividness ($F(4,77) = 3.55$, $p = .01$), and detail ($F(4,77) = 4.89$, $p = .01$)]. Post-hoc Student-Newman-Keuls revealed that participants in the 15 check condition had significantly lower confidence in their memories, and reported that the memories were significantly less vivid and detailed, than participants in the 0, 2, and 5 check conditions. Participants in the 10 check condition also showed reduced confidence, vividness and detail, not differing significantly from the 15 check condition. However, the 10 check condition appeared to take an intermediate position, also not differing from the 0, 2, or 5 check conditions. These findings show that although the 5 groups had similar memories at the pre-test, decreases in confidence, vividness, and detail over time were particularly pronounced for participants who conducted more checks.

Trend Analyses for Memory Characteristics. Analyses were then conducted to examine whether the relationship between the number of checks conducted and changes in memory characteristics was the same at each point along the continuum of increasing checks. That is, checking may have linear or non-linear (e.g., quadratic or cubic) effects on observed changes in memory characteristics. Therefore, we tested for the presence of linear, quadratic, and cubic patterns in the data. The results of the trend analyses conducted on change scores (Post minus Pre) are summarized in Table 1. In summary, there was not support for significant linear, cubic, or quadratic relationships between the number of checks and changes in memory accuracy. In contrast, for changes in memory confidence, vividness, and detail there was support for significant linear, quadratic, and cubic trends. Inspection of the cubic trends (see Figure 3) revealed that the most substantial reductions in memory confidence, vividness, and detail occurred between 2 checks and 10 checks, and that there was less change between 0 and 2 checks, and between 10 and 15 checks.

Memory Source. Chi squared analyses were used to examine differences in memory source (remembering vs. knowing) according to condition. As was predicted, participants in the various conditions were not found to differ significantly on their memory source ($\chi^2(4) = 6.45$, $p = .17$) at the pre-test, and the majority of participants reported "remembering" as the source of their memory (77%, 56%, 87%, 87%, and 87% across the 0, 2, 5, 10 and 15 check conditions, respectively). However, as hypothesized, at post-test there was a significant interaction of condition and memory source, $\chi^2(4) = 15.31$, $p = .01$. At post-test, the percentage of participants that reported "remembering" in each condition was as follows: 88%, 44%, 80%, 47%, and 33%, for the 0, 2, 5, 10 and 15 check conditions, respectively. Therefore, whereas only 12% of participants in the 0 check condition reported "knowing", 53% and 67% of participants in the 10 and 15 check conditions reported "knowing."

Perceived Threat. Ratings of perceived threat again revealed that participants found the prospect of the burners being left on as very bad, $M = 80.35$, $SD = 30.38$.

Discussion

Results of Study Two again showed that repeated checking of a real stove (that was again perceived as threatening) lead to decreased memory confidence, vividness, and detail. Extending the results of Study One, Study Two revealed significant linear, quadratic, and cubic trends for the relationships between the number of checks performed and changes in memory confidence, vividness, and detail. Specifically, the cubic trends revealed that the greatest changes in these memory characteristics might occur between 2 and 10 checks. Consistent with these findings, 10 and 15 trials of checking were associated with decreased memory confidence, vividness, and detail, and an increased reliance on knowing as a memory source. In summary, these findings suggest that there are consequences of repeated checking at levels lower than used in previous studies (20 trials in van den Hout & Kindt, 2003; 19 trials in Radomsky et al., in press) and that the relative impact of repeated checking may vary for different number of checks.

Further, results of Study Two suggest that the changes in confidence, vividness, and detail may be greater in magnitude than any potential changes in accuracy. In the current study, checking did not meaningfully alter accuracy, and there was not support for linear or non-linear trends in the relationship between number of checks and changes in memory accuracy. It is worth noting that Radomsky and colleagues (in press) found that the accuracy data for participants who completed 19 trials of checking a real stove was significantly below perfect performance. Visual inspection of the accuracy data from the current study suggest that the participants that completed 10 and 15 checking trials were *slightly* less accurate (although there was not a significant interaction) at post-test compared to the other groups (and compared to the accuracy at pre-test). Perhaps a potential negative impact of repeated checking on memory accuracy occurs at a higher threshold than the impact observed on memory confidence. In other words, it is possible that a relatively low number of checking trials (e.g., 10) may decrease memory *confidence*, but more checking trials (e.g., 20 or more) may be needed to decrease memory *accuracy*. However, this is speculative at this point and awaits empirical examination.

General Discussion

Results of the two studies presented herein show that repeated checking of a real stove leads to changes in memory confidence, vividness, detail, and source in a non-clinical sample. These findings add to a growing body of literature showing that repeated checking paradoxically leads to decreased memory confidence (Radomsky et al., in press; Tolin et al., 2001; van den Hout & Kindt, 2003, 2004), and are consistent with the theoretical formulation of checking presented by Rachman (2002). Specifically, Rachman (2002) proposed that repeated checking tarnishes memory, decreasing the likelihood of achieving certainty, and serving as a self-perpetuating mechanism by which repeated checking is maintained. Findings that repeated checking was associated with greater reliance on knowing as a memory source were also consistent with previous work and support the validity of the phenomenon. Finally, extending previous findings, the results of Study Two suggest that changes in

memory confidence and source are apparent after a relatively low number of checking trials (e.g., 10 to 15) and that the relative impact of increased checking may be strongest between 2 and 10 checks.

Clarifying the phenomenology of repeated checking is important given the dominance of checking compulsions in OCD. In a detailed theoretical formulation of checking, Rachman (2002) proposes that repeated checking occurs when individuals have an elevated sense of personal responsibility for preventing harm and are uncertain that the threat has been eliminated. From this, Rachman proposes that checking is maintained by four factors: 1) an unsuccessful search for certainty, 2) decreases in memory confidence with repeated checking, 3) elevations in the predicted likelihood of harm when one feels personally responsible, and 4) increases in perceived responsibility with repeated checking. Findings from the current studies add to the body of support for the 2nd factor, decreased confidence with repeated checking. Other research also supports a link between intolerance of uncertainty (the 1st factor) and OCD (OCCWG, 1997; Steketee, Frost, & Cohen, 1998), and OCD characterized by checking specifically (Tolin, Abramowitz, Brigidi, & Foa, 2003). However, we are unaware of any studies specifically investigating the relationship between the desire for certainty and the mechanisms of repeated checking. In partial support of the 4th hypothesized factor, a link between perceived responsibility and urges to check has previously been demonstrated. For example, decreases in perceived responsibility have been shown to lead to decreased urges to check (Lopatka & Rachman, 1995). However, we are unaware of any studies directly examining whether repeated checking leads to subsequent increases in perceived responsibility or estimates of the probability of harm.

Given the emphasis of the current studies on Rachman's 2nd hypothesized factor for maintaining repeated checking, that repeated checking decreases memory confidence, it is worth considering the mechanisms by which this may occur. Rachman (2002) proposes that elevations in anxious arousal during repeated checking serve to focus the individual's attention towards threat material, thereby decreasing attention to the event itself and reducing subsequent recall of it. This proposal is largely consistent with memory models from cognitive psychology. Both Rachman (2002)

and memory models (Roediger, 1990; Johnston & Hawley, 1994) propose that repeated checking increases attention to semantic processing and decreases attention to perceptual processing (e.g. processing of visual characteristics such as color, shape, etc.). However, cognitive models of this repetition-induced familiarity differ from Rachman (2002) in that they do not invoke anxiety as potentiating this attentional shift. Cognitive models propose that repetition serves to decrease clarity and vividness of memories via a shift away from perceptual processing, resulting in decreased memory confidence (for further discussion see van den Hout & Kindt, 2004).

Following from Rachman's (2002) model of checking, many unanswered questions remain. First, additional research on memory source and preference in OCD is warranted. Van den Hout and Kindt (2004) propose that OCD is associated with greater reliance on knowing. Combined with research showing that individuals with OCD desire stronger vividness of their memories than controls (Constans et al., 1995), it is easy to imagine that a sense of knowing (compared to remembering) could lead to repeated checking in an attempt to increase the clarity of one's memory. In addition, it will also be interesting to consider the factors associated with the termination of checking behavior. For example, additional research is warranted on the internal rules used to stop checking (see MacDonald & Davey, 2005), and how these rules interact with other factors (e.g., mood state, responsibility beliefs, etc). Finally, future research can also examine the impact of perceived threat on changes in memory confidence from repeated checking. In combination, results of previous studies (Tolin et al. 2001; van den Hout & Kindt, 2003) suggest the possibility that repeated checking of any object (unsafe or safe) may decrease memory confidence, but that the magnitude of this effect may be greater for objects that are perceived as threatening. The data presented herein suggest that our participants perceived the stove to be very threatening. However, we cannot conclude that memory distrust was impacted by this perceived threat. Future studies can directly examine whether perceived threat interacts with the number of checks performed in predicting declines in memory confidence, vividness, and detail.

It is important to note some of the limitations of the current studies. First, although findings from the second study suggest that repeated checking may have the strongest impact on memory confidence, vividness, and detail, between 2 and 10 checks, the precise threshold at which checking most strongly impacts memory characteristics (i.e., metamemory) remains elusive. In addition, although the results of these studies showed statistically significant declines in confidence, they do not speak to what is meaningful change. For example, how many checks are required to change behavior (e.g. lead to increased checking) the next time the stove is used? Another limitation of the current studies (and other studies examining repeated checking) is that the repeated checking was conducted entirely within one session on one day. What is the impact of repeated checking across days? Are the effects of repeated checking cumulative? Finally, the use of experimental designs that instruct participants to conduct a certain number of checks on a particular object (e.g., stove, sink) maximize internal validity, at the expense of external validity. To increase external validity, it will be important to study how individuals with OCD determine that a sufficient number of checks have been performed. There is only one study that we are aware of that allowed participants to determine the number of checks they conducted (MacDonald & Davey, 2005), but that study did not investigate memory confidence. Future studies can utilize paradigms of varying levels of internal and external validity to comprehensively assess the impact of repeated checking.

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Footnotes

[1] There is some support for possible impairments in the recall and recognition of visual information in individuals with OCD characterized by compulsive checking. For additional information see Tallis et al. (1999).

[2] There were no significant differences between subjects in the two conditions (0 checks and 15 checks) on any demographic variables (gender, age, years of education, race/ethnicity). Additional information is available upon request.

[3] There were no significant differences between subjects in the five conditions (0, 2, 5, 10 or 15 checks) on any demographic variables (gender, age, years of education, race/ethnicity). Additional information is available upon request.

Table 1

Results of Trend Analyses Predicting Memory Characteristics (Study 2)

Predictor and trend	*df*	F
Memory Accuracy		
Linear	1, 76	1.19
Quadratic	2, 75	.93
Cubic	3, 74	1.07
Memory Confidence		
Linear	1, 76	19.38***
Quadratic	2, 75	9.64***
Cubic	3, 74	6.43***
Memory Vividness		
Linear	1, 76	14.21***
Quadratic	2, 75	7.05**
Cubic	3, 74	4.74**
Memory Detail		
Linear	1, 76	22.50***
Quadratic	2, 75	11.11***
Cubic	3, 74	7.41***

Note. ** $p < .01$, *** $p < .001$.

Figure Captions

Figure 1. Memory Accuracy, Confidence, Vividness, and Detail According to Condition and Time (Study One).

Figure 2. Memory Accuracy, Confidence, Vividness, and Detail According to Condition and Time (Study Two).

Figure 3. Cubic Trends for Relationships between Number of Checks and Changes in Memory Confidence, Vividness, and Detail (Study Two). In each figure, the solid line represents a cubic trend and the circles represent the observed data.

Figure 1.

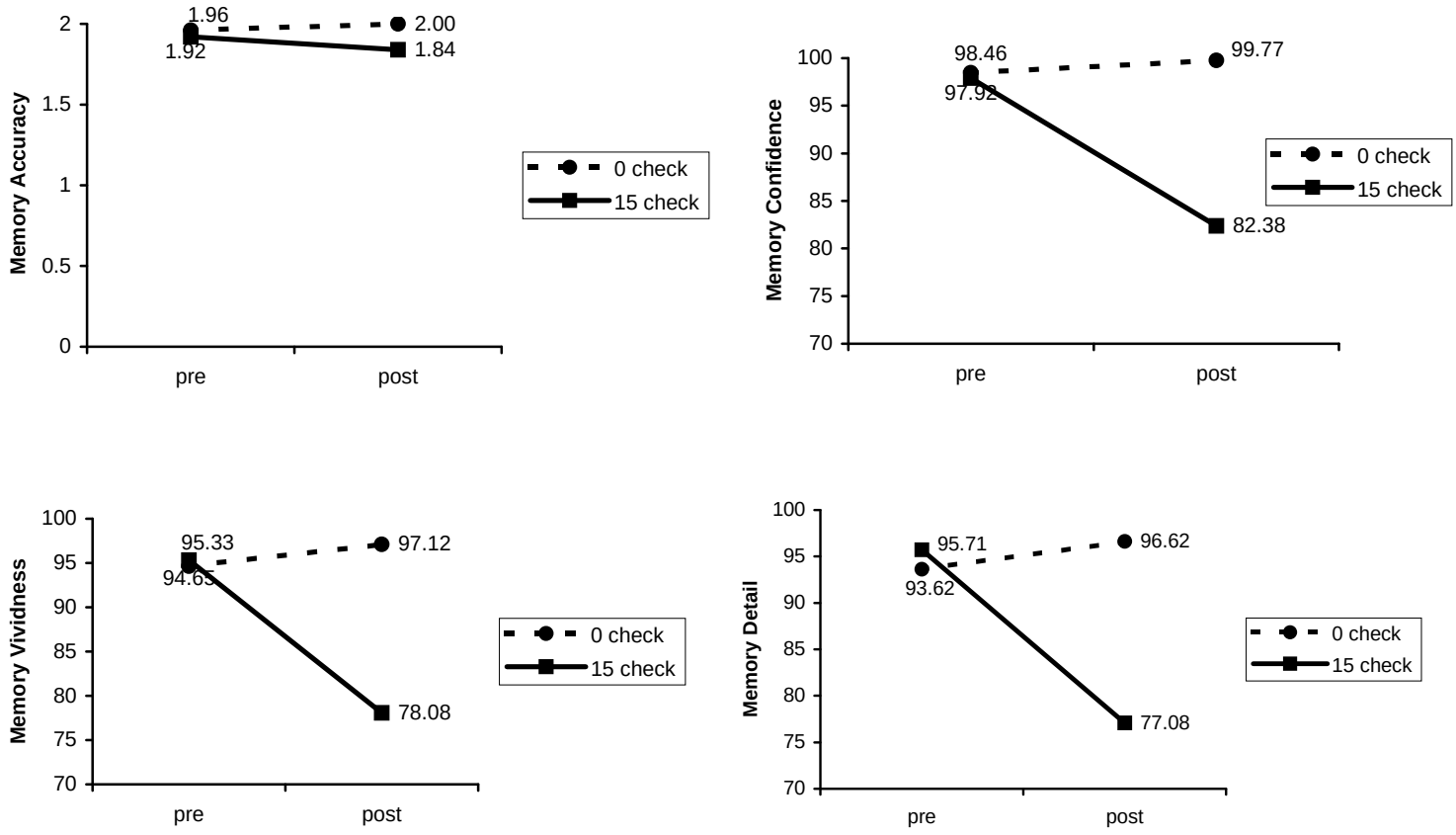

Memory Accuracy
2
1.5
1
0.5
0
1.96
2.00
1.92
1.84
pre
post
0 check
15 check
Memory Confidence
100
95
90
85
80
75
70
98.46
99.77
97.92
82.38
pre
post
0 check
15 check
Memory Vividness
100
95
90
85
80
75
70
95.33
97.12
94.65
78.08
pre
post
0 check
15 check
Memory Detail
100
95
90
85
80
75
70
95.71
96.62
93.62
77.08
pre
post
0 check
15 check

Figure 2.

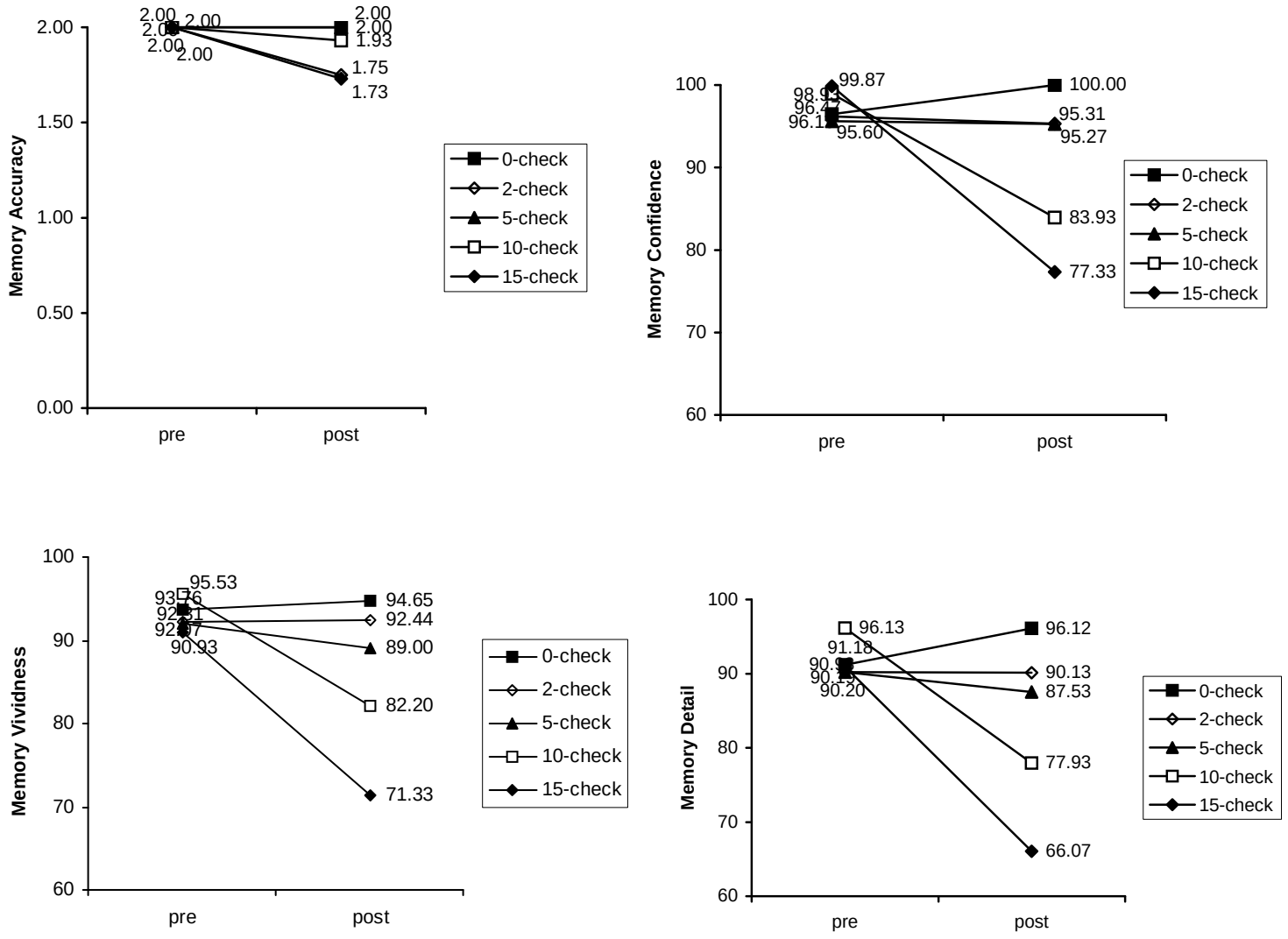
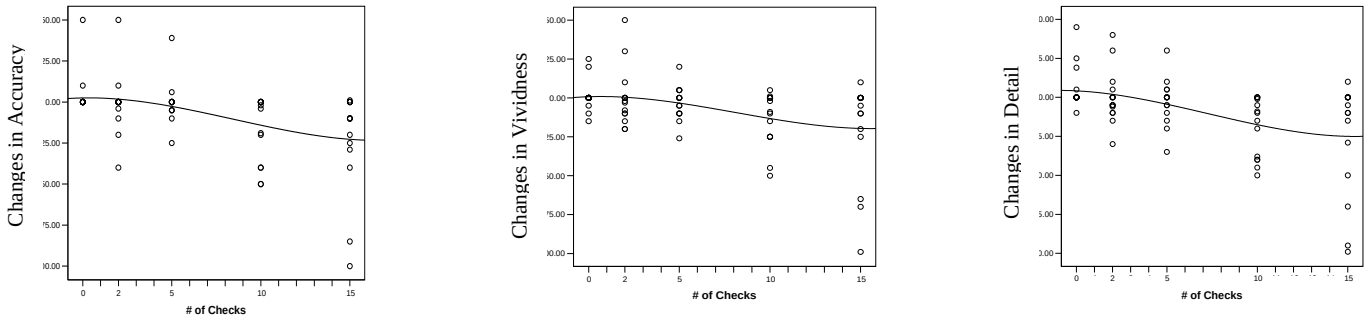

Memory Accuracy
2.00
1.50
1.00
0.50
0.00
pre
post
2.00
2.00
2.00
2.00
2.00
2.00
1.93
1.75
1.73
0-check
2-check
5-check
10-check
15-check
Memory Confidence
100
90
80
70
60
99.87
100.00
95.31
95.27
95.60
83.93
77.33
Memory Vividness
95.53
94.65
92.44
89.00
90.93
82.20
71.33
Memory Detail
96.13
96.12
91.18
90.13
87.53
90.20
77.93
66.07

Figure 3.


Changes in Accuracy
Changes in Vividness
Changes in Detail
# of Checks
# of Checks
# of Checks