

An Experimental Study of Hand Washing in People With High and Normative Contamination

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Abstract

Compulsions are the hall mark of obsessive-compulsive disorder (OCD) but there has been surprisingly little research on their phenomenology and persistence, and much of this work has focused on checking compulsions. The current study examined hand wash duration in participants ($N = 235$) with high or normative contamination fear who either “contaminated” their hands or not, under high vs. low responsibility/harm conditions. Key findings were: 1) those high in contamination fear only washed “excessively” when under contamination exposure/high responsibility conditions; 2) there was no insidious effect of hand wash duration on memory confidence nor certainty it had been done properly; 3) there was little evidence of behavioural repetition during the hand wash; 4) under contamination/ high responsibility conditions hand wash goals were more likely to be impossible and unverifiable (e.g., “get rid of *all* the germs”). We concluded that contextual factors influence hand washing more so than contamination fear, that repetition and its consequences may be less relevant for understanding excessive washing, and that when treating OCD there could be merit in reframing compulsion goals, and exposing people to uncertainty as to whether or not that goal was met by one performance of the compulsion.

Key Words: OCD, compulsions, hand washing, contamination fear

Highlights

- Contextual factors influence hand washing in people with both normative and high contamination fear, which argues against a general deficits model
- Hand wash duration was not associated with notable repetition of specific actions and had no correlation with memory confidence, memory vividness, nor confidence that the hand wash had been done correctly
- Hand wash goals were more often expressed as proximal (“get hands clean”) as opposed to distal (harm prevention/distress reduction) and under conditions of contamination exposure and high responsibility were more likely to be expressed in terms that were unverifiable and impossible (“get rid of all the germs”)

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Introduction

Obsessive compulsive disorder (OCD) is characterized by the persistent recurrence of unwanted thoughts, images, impulses, and doubts. These typically involve themes of harm and they evoke distress of some kind. Compulsions are deliberate covert or overt acts that are typically performed in response to an obsession. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013) their purpose is to reduce distress and/or prevent harm. Leading cognitive-behavioural models of obsessive compulsive disorder such as those proposed by Salkovskis (1999) and Rachman (2002) have implicated negative appraisal of obsessional thoughts as both the source of distress and of the subsequent need to perform the compulsion as a means of ameliorating that distress. The reduction in distress reinforces performance of the compulsion (for a review see Purdon, 2018).

Cognitive behaviour therapy (CBT) is the most effective treatment for OCD to date. It features two central strategies: 1) exposure to the distress over the obsession while the compulsion is prohibited, which allows the distress to extinguish; and, 2) addressing negative appraisal of the obsession in order to reduce the distress it evokes and the subsequent drive to do the compulsion. Together, these strategies are designed to make the compulsion obsolete. An enormous amount of research has been devoted to understanding the persistence of obsessional thoughts and identifying the range of negative appraisal that evokes the distress and the compulsion, as well as strategies for resolving it (e.g., Obsessive Compulsive Cognitions Working Group, 2005). However, despite this body of work, the efficacy of CBT remains at about 50% when treatment drop out and refusal is taken into account (Öst, Havnen, Hansen, & Kvale, 2015) and “successful” treatment is associated with only a 40% reduction in symptoms

(McKay et al., 2015). This suggests that the CBT model may be underspecified and that key culprits in the persistence of OCD are not being targeted in treatment.

Although we now know a fair bit about obsessional concerns there has been considerably less research on the phenomenology and persistence of compulsions, beyond their role in reducing distress. Salkovskis (1999) observed that the effort put into decision making depends on the perceived stakes of the decision. For people with OCD, decisions such as when to stop washing one's hands are effortful, relying on information from external sources, such as how clean one's hands look, and internal sources, including a heavily weighted felt sense that it is okay to stop, which is elusive. There is support for these assertions, although few studies have examined termination criteria (e.g., Moritz et al, 2007; Salkovskis, Miller, Gregory, & Wahl, 2017).

In his model of compulsive checking, Rachman (2002) observed that the harm people are trying to prevent lies in the future, so there is no terminus for the checking behaviour. The ensuing repetition tarnishes the memory for the check, which fosters further doubt as to whether one has checked properly. A large body of work has consistently found that repetition fosters doubt as to whether an action was done properly. van Dis and van den Hout (2016) found that repeated checking produced a “not just right feeling”, the opposite of the goal of getting the “right” feeling. Repetition of an act has consistently been found to reduce the vividness and amount of detail in memory for the action, as well as memory confidence (e.g., Boschen & Vuksanovic, 2007; Coles, Radomsky, & Horng, 2006; Cogle, Salkovskis, & Wahl, 2007; Hermans et al., 2008; Linkovski et al., 2015; Toffolo, van den Hout, Radomsky, and Englehard, 2016; Radomsky, Gilchrist, & Dussault, 2006; Van den Hout & Kindt, 2003). In their meta-analysis of findings from the virtual stove paradigm, which has been most commonly used to

assess ironic effects of repetition, van den Hout, van Dis, van Woudenberg, and van de Groep (2019) found a large effect size for the negative impact of repeated checking on memory confidence.

Other studies have found that repetition decreases confidence in attentional processes and sensory perception (e.g., Hermans et al., 2003; 2008; Taylor and Purdon, 2016) and that inducing memory distrust results in greater checking (Alcolado & Radomsky, 2011). Finally, in a diary study of compulsions in people with OCD, Bucarelli and Purdon (2015) and Bouvard, Fournet, Denis, Acachi, and Purdon (2020) found that compulsions that were terminated because the “just right” or related feeling was achieved were associated with fewer repetitions and greater memory confidence than those terminated for other reasons. Furthermore, distress over the obsessional concern was not associated with the length or number of repetitions of the compulsion, which indicates that once compulsions are initiated other factors drive their persistence.

These findings have obvious implications for helping people overcome OCD. However, most of this work has been conducted on repeated checking, or has not distinguished between washing and checking, as in Bucarelli and Purdon (2015) and Bouvard et al. (2020). Only a handful of studies have examined whether there is an ironic effect of prolonged or repetitive washing. For example, Fowle and Boschen (2011) found that with repeated washing, confidence for memory of which bowls had been cleaned declined, but confidence that the bowls were clean was not affected. Wahl, Salkovskis, and Cotter (2008) found that people with washing compulsions indeed used subjective criteria to terminate a hand wash as compared to people with OCD without washing compulsions and to healthy controls. Furthermore, the higher the perceived stake of the decision to stop, the greater their reliance on internal, subjective criteria. Taylor and Purdon (2016) examined hand washing in participants high and normative in

contamination fears under low and high responsibility conditions. They found that for participants high in contamination fears, the impact of wash duration on confidence in the wash varied according to the task they were required to complete following the hand wash; under low responsibility (sorting paper) longer wash duration was associated with greater certainty that the wash had been effective, but under high responsibility (preparing gift bags for preschoolers) it was associated with less certainty, and with lower confidence in sensory perception.

Although the paradoxical effect of repetition has high relevance for understanding and treating OCD, the impact of repeated washing on memory and sensory confidence has not been well studied and existing results do not seem to mirror those observed in checking behaviour. We do not know if hand washing is actually characterized by repetition; it is possible that there is prolongation, rather than repetition, of the specific acts involved in hand washing. We also do not know if prolonged and/or repetitive washing degrades memory confidence. Second, Rachman and Salkovskis emphasized that excessive safety behaviour will be observed under conditions of high responsibility and high perceived stakes, but not necessarily under neutral circumstances; that is, OCD is not characterized by general deficits but instead excessive behaviour occurs under particular conditions. However, there have been few investigations comparing neutral to high stakes circumstances. In Taylor and Purdon (2016) all participants “contaminated” their hands, so there was no neutral condition. Finally, although the DSM-5 states that the goal of the compulsion is distress reduction or harm avoidance, to our knowledge no one has studied the actual goal people are trying to accomplish when they perform a compulsion. If, as Rachman (2002) proposed, the goal is framed in a way that renders it unverifiable and impossible, helping people define goals other than getting the elusive “right

feeling” or from framing it in terms of absolutes (“make sure I get rid of all germs”) may be a useful complement to CBT.

The purpose of this study was to address these lacunae by examining hand wash duration in people with normative and high contamination fear who have either “contaminated” their hands or not, under high vs. low responsibility conditions. Ratings of harm and responsibility were taken at baseline and before and after the hand wash, and, after the hand wash participants also rated confidence that the wash had been done adequately, confidence in their memory for the wash, and confidence in their sensory perception during it. Finally, just prior to the hand wash participants gave a verbatim report of their hand wash goal. We hypothesized: 1) the high contamination fears/contamination exposure/high responsibility group will wash longest, but hand wash duration in the high contamination fears/no-contamination exposure/low responsibility group will not differ from those with normative contamination fear under the same conditions; 2) those high in contamination fear will have a higher number of contacts with the key objects/places in the hand wash (soap dispenser, taps, hand towels, garbage, area above sink where hands are scrubbed); 3) there will be negative correlations between duration and the confidence ratings, and these correlations will be stronger in the high contamination fears, contamination exposure, and high responsibility groups, with the highest correlations in the high contamination fear/contamination induction/high responsibility group; 4) those in the high contamination fear/contamination exposure condition will report more absolute goals, regardless of responsibility condition.

Method

Participants

Participants were 235 undergraduate students, 49 of whom (21%) were male and 186 (79%) female, ranging in age from 16 to 41 years ($M = 21.14$, $SD = 2.48$). Participants were recruited from the Research Experiences Group (REG) at the University of Waterloo, which is a pool of university students who are willing to participate in research in return for course credit. All members of the REG group complete screening measures at the beginning of the school term which includes demographic data. Unfortunately, the data on ethnicity provided in screening was not available due to a technical problem. However, this participant pool is about 80% Caucasian. As in Taylor and Purdon (2016) the Concern About Germs and Contamination Scale of the Dimensional Obsessive Compulsive Scale (DOCS; Abramowitz et al., 2010) was used to screen participants high and normative in contamination fears. Participants in the REG pool who scored more than 0.5 standard deviations below the non-clinical mean and those who scored greater than 0.5 standard deviations above the mean for people diagnosed with OCD as reported in Abramowitz et al., (2010) were invited to participate. The final sample consisted of 126 participants in the Normative Contamination Fear group (NCF) who had a mean score of 0.73 ($SD = 0.83$) on the DOCS Contamination Fear scale and 109 participants in the High Contamination Fear group (HCF) who had a mean score of 8.71 ($SD = 1.98$) on the scale. Prior to arrival at the lab participants were randomly assigned to their Contamination Induction group (Contamination Exposure; CE or No Contamination Exposure; NCE) and to their Post-Wash Task Group (Paper sorting; P, or Gift-Bag; GB) group. Cell n 's for each group ranged from 26 to 36.

Measures

Dimensional Obsessive Compulsive Scale (DOCS; Abramowitz et al., 2010). The DOCS is a 20-item measure designed to assess OCD symptom severity. In the current study, the Concerns

about Germs and Contamination subscale score was used to screen participants who either had normative or high in fear of contamination. The Concerns about Germs and Contamination subscale has shown good internal consistency and convergent and divergent validity in both clinical and non-clinical samples (Abramowitz et al., 2010). This measure was used to select participants with normative and high contamination fear.

Obsessive Beliefs Questionnaire (OBQ-44; OCCWG, 2005). The OBQ-44 was designed to measure three domains of beliefs considered important to the development and maintenance of OCD: Responsibility/Threat Estimation, Perfectionism/ Certainty, and Importance/Control of Thoughts. The scales have good internal consistency (OCCWG, 2005; Tolin, Worhunsky, and Maltby, 2006) and validity in clinical and non-clinical samples (OCCWG, 2005). The OBQ was included to establish the validity of the high contamination group as an analogue to an OCD sample.

Memory and Cognitive Confidence Scale (MACCS; Nedeljkovic & Kyrios, 2007).

This 28-item measure assesses confidence in decision-making abilities, concentration, and attention. The scale has four subscales, including memory mistrust, mistrust of concentration, high need for certainty, and mistrust of decisions. Participants provide responses based on a 5-point Likert scale (1= *Strongly Disagree* to 5 = *Strongly Agree*). The MACCS has demonstrated good internal consistency and adequate validity (Nedeljkovic and Kyrios, 2007). This scale was included to establish validity of the high contamination fear group as an analogue to people with OCD who are known to have poorer trait memory and cognitive confidence.

Visual Analogue Scales (VAS) Electronic visual analogue scales ranging from 0 (*not at all/none*) to 100 (*very much/a lot*) were used to rate contamination, harm severity and likelihood, and responsibility for that harm at four points in the study: 1) upon arriving in the lab (baseline; all

participants); 2) after receiving the experimental instructions (NCE group only) or after the contamination induction (CE group only); 3) 30s into the wash (only participants who both opted to wash and were still washing at 30s); and, 4) post-wash (only participants who opted to wash). At point 4 they also rated how much they trusted their senses during the wash, the vividness and detail of their memory for the wash, their confidence in that memory, and how certain they were that their hands were adequately washed.

Verbatim Report of Hand Wash Goals

Prior to commencing their hand wash and at 30s into their hand wash participants were asked why they were washing their hands; that is, what was the goal of the hand wash. Their verbatim account was audio recorded and transcribed.

Assessment of Wash Duration and Number of Steps

The hand wash was videotaped. Two raters blind to group/condition reviewed the videos and determined a wash duration score for each participant, defined as the time between the moment a participant began the first action in their wash (e.g., turning on the tap, pressing on the soap pump) and the moment they completed the last action in their wash (e.g., throwing out the last paper towel). There was almost perfect agreement on Wash Duration across the two raters (Cronbach's $\alpha = 1.0$), with the largest difference between the two coders being 2 seconds. Wash duration was averaged across the two coders to calculate the final Wash Duration score.

In order to measure the number of steps of participants' hand wash we adopted the spatial coding scheme of Eilam and colleagues (2012), who describes specific actions in terms of the number of visits to and actions at the locations and objects involved in the ritual. Visits were thus defined as movement to and interaction with: the taps, the soap dispenser, the stream of water from the tap, the space in front of the participant while they scrubbed or dried their hands, the

paper towel dispenser, and the garbage. Two raters who were blind to participant group and condition coded the number of visits in each wash. The variable *Total Visits* was calculated by averaging the number of visits coded by the two raters. Inter-rater reliability for this variable was .95.

Procedure

Participants provided informed consent for participation and audio and video recording and completed the OBQ and MACCS and the baseline administration of contamination, harm, and responsibility ratings. Upon completion of these measures, participants assigned to the Gift Bag (GB) condition were informed that they would be asked to assemble three gift bags that would be given to the children in the onsite preschool. Those assigned to the Paper (P) condition were informed that they would be given papers to sort into piles for recycling and shredding. All participants were told they could wash their hands prior to completing the task if they wished. Participants in the contamination exposure condition (CE) were further informed that prior to the task, they would be asked to rub their hands with a damp sponge that “may have come into contact with trace amounts of dirt, chemicals, or bacteria”. Next, participants were shown an instructional video by Public Health Ontario on how to properly wash one’s hands. The hand wash duration in the video from start (turning on the water) to stop (reaching for paper towels) is 60s and includes the instruction to scrub for 15s. The video was shown to guard against people prolonging their washing as a result of the experimenter’s presence and/or because the duration of their wash was being timed.

After the video participants in the NCE group completed VAS ratings of contamination, harm likelihood and severity, responsibility for harm, and trust of their senses; these served as the prewash ratings for the NCE group. Participants in the NCE group were then asked if they

wanted to wash their hands before doing their assigned paper sorting or gift bag assembly task. Meanwhile, participants in the CE group underwent the contamination induction. The experimenter picked up one of two damp sponges from a clean container and asked participants in the CE group to do the same, reminding the participant that the sponges “may have come into contact with trace amounts of germs, dirt, or bacteria”. The researcher instructed participants to copy her movements, rubbing the front and back of her hands with the sponge in a set pattern. Participants then completed VAS ratings of contamination, harm, responsibility and trust of senses; these served as the prewash ratings for the CE group. Participants in the CE group were then invited to wash their hands.

Participants who did not opt to wash their hands proceeded to do the paper sorting or gift bag task. Participants who opted to wash their hands were asked about the goal of the hand wash and proceeded to wash. Participants’ verbal responses were audio recorded and their hand wash was video recorded. Once participants completed their hand wash, they completed the VAS ratings one final time. In addition, they rated how certain they were that the hand wash was adequate, and their memory for and confidence in the wash. Participants then completed the gift bag or paper sorting task, after which they were debriefed.

Results

Analyses were conducting using SPSS-26. Prior to each analysis data were screened for outliers, defined as +/- 3 SD from the mean and discontinuous from the distribution. Unless otherwise noted there were no outliers. The analyses of hand wash duration and confidence in the wash were only conducted on those who opted to wash their hands ($n = 177$).

Preliminary Analyses

High and Normative Contamination Fear Group Characteristics

To establish that the High Contamination Fears group differed in expected ways from the Normative Contamination Fear group, the two groups were compared on OBQ and MACCS scores using multivariate analyses of variance. Means and standard deviations are presented in Table 1. The High Contamination Fear group scored significantly higher on the OBQ scales; $F(3, 218) = 7.48, p < .0001, \eta^2 = .09$. Univariate tests indicated that all three scale scores were higher in the HCF group. The HCF group also scored higher on the MACCS scales; $F(4, 216) = 3.20, p < .014, \eta^2 = .06$, and again, univariate scores were all significantly higher in that group, indicating greater distrust.

Table 1

Means and standard deviations of OBQ and MACCS scale scores across normative and high contamination fear groups

	Normative Contamination Fear Group ($n = 117$)	High Contamination Fear Group ($n = 105$)
OBQ-Responsibility	57.04 (14.83)	66.16 (13.92)
OBQ-Perfectionism	61.44 (15.04)	68.64 (15.33)
OBQ-Importance and Control of Thoughts	31.42 (12.37)	36.55 (11.05)
MACCS- Mistrust of Memory	37.97 (10.51)	42.10 (10.68)
MACCS- Mistrust of Concentration	10.09 (3.25)	11.23 (3.36)
MACCS-Need for Certainty	9.90 (3.34)	11.37 (3.56)
MACCS-Mistrust of Decisions	12.40 (3.99)	14.27 (4.12)

OBQ=Obsessive Beliefs Questionnaire; MACCS=Memory and Cognitive Confidence Scale

Who Chose to Wash?

Of the 235 individuals who participated in this study, 75% ($n = 177$) chose to wash their hands prior to completing the paper sorting or gift bag task. The frequency and percentage of participants who chose to wash across groups is presented in Table 2.

Table 2

Frequency and percentage of participants who chose to wash within each experimental group

	Normative Contamination Fear				High Contamination Fear			
	Paper Sorting		Gift Bag		Paper Sorting		Gift Bag	
	NCE	CE	NCE	CE	NCE	CE	NCE	CE
No Wash	19 (53)	9 (31)	5 (16)	3 (10)	14 (50)	3 (10)	4 (15)	1 (4)
Wash	17 (47)	20 (69)	26 (84)	27 (90)	14 (50)	26 (90)	22 (85)	25 (96)

NCE=No contamination exposure; CE=Contamination Exposure. Column percentage appears in brackets.

In order to determine if there were group differences in the decision to wash or not, we conducted a logistic regression in which Contamination Fears, Contamination Exposure, and Task were entered simultaneously as predictor variables of wash/did not wash. Those in the GB group were significantly more likely to wash their hands prior to the task, $\text{exp}\beta = 4.88$, 95% CI = [2.40, 9.95], $p < .001$, as were those in the Contamination Exposure group, $\text{exp}\beta = 3.50$, 95% CI = [1.77, 6.93], $p < .001$. However, Contamination Fear group was not a significant predictor

wash the decision to wash, $\exp\beta = 1.63$, 95% CI = [0.85, 3.15], $p = 0.14$. There were no significant two-way or three-way interactions.

We also conducted a multivariate analysis of variance on pre-wash ratings of contamination, harm severity and likelihood, and responsibility for harm, comparing those who chose to wash and those who did not. There was a significant group difference, $F(4, 230) = 10.11$, $p < .0001$, $\eta^2 = .15$. All univariate effects were significant, indicating that those who chose to wash had higher ratings on all four scales. The standardized discriminant function loadings revealed that the difference was primarily driven by ratings of contamination and perceived harm severity, which had loadings of $-.51$ and $-.67$, respectively, as compared to loadings of $-.14$ and $.21$ for responsibility for harm and harm likelihood, respectively.

Manipulation Checks

Contamination: We conducted a 2 (time; baseline vs pre-wash) by CI (contamination exposure; CE vs. no contamination exposure; NCE) x 2 (CF group) by 2 (responsibility group) ANOVA on contamination ratings. If the contamination induction was effective there should be a two-way interaction of time such that there are no differences in Contamination Induction group at baseline, but the CE group should have higher scores than the NCE at pre-wash. Means and standard deviations of contamination ratings are presented in Table 3. The Time x Contamination Induction was significant; $F(1, 168) = 75.05$, $p < .0001$, $\eta^2 = .31$. Post-hoc follow up of simple main effects revealed that there was no difference in contamination scores at baseline; $F(1, 174) = 1.77$, $p < .20$ but those in the CE condition had significant higher ratings at pre-wash, $F(1, 175) = 33.41$, $p < .0001$. There were no higher order effects. Thus, the contamination induction was successful.

Responsibility: We conducted the same analysis as above on ratings of responsibility.

Means and standard deviations are presented on Table 3. There was no two-way interaction of time x Task; $F(1, 168) = 0.15, p < .70$, nor any other interactions with time. Responsibility ratings did not increase as a function of the Task manipulation. However, there was a Contamination Induction x Task interaction. Examination of simple main effects revealed that for those in the Paper condition, responsibility ratings did not differ across the NCE and CE groups at either baseline or pre-wash. For those in the Gift Bag condition, responsibility ratings did not differ across Contamination group at baseline, but at pre-wash, those in the CE group had higher responsibility ratings; $F(1, 98) = 11.88, p < .001$. Thus the responsibility induction was successful only for those who had contaminated their hands.

Table 3

Means and standard deviations of VAS contamination ratings, ratings of harm and responsibility for harm at baseline, pre-wash, and post-wash, and hand wash duration, across groups.

	Normative Contamination Fear				High Contamination Fear			
	Paper Sorting		Gift Bag		Paper Sorting		Gift Bag	
	NCE	CE	NCE	CE	NCE	CE	NCE	CE
<i>Contamination</i>								
Baseline	39.65 (23.52)	27.00 (21.66)	36.15 (18.28)	25.67 (20.53)	48.57 (23.28)	36.92 (25.84)	29.32 (22.24)	40.00 (23.02)
Pre-Wash	43.63 (26.56)	49.75 (27.02)	37.42 (20.11)	58.85 (23.76)	52.79 (21.05)	66.23 (21.87)	39.36 (26.70)	75.48 (19.52)
Post-Wash	3.82 (4.70)	9.60 (12.13)	8.31 (8.21)	5.19 (4.50)	13.21 (11.68)	12.73 (13.45)	7.64 (11.72)	8.80 (8.17)

<i>Harm</i>								
Baseline	8.57 (11.01)	5.82 (9.08)	7.71 (10.95)	8.30 (13.52)	31.93 (23.56)	15.83 (15.66)	11.86 (15.00)	21.76 (23.70)
Pre-Wash	9.65 (12.88)	28.07 (27.01)	11.37 (14.31)	33.30 (27.16)	40.36 (26.98)	45.73 (23.30)	18.71 (19.66)	54.50 (25.40)
Post Wash	3.15 (5.38)	4.63 (4.45)	5.11 (5.89)	4.54 (5.00)	12.25 (15.15)	9.29 (12.36)	4.32 (5.68)	9.56 (6.00)
<i>Responsibility</i>								
Baseline	32.19 (37.31)	41.05 (38.46)	21.62 (23.98)	23.74 (30.22)	66.29 (27.14)	37.19 (29.06)	41.73 (29.55)	49.32 (33.22)
Pre-Wash	36.81 (35.95)	55.70 (35.48)	23.69 (25.86)	39.30 (31.64)	68.93 (27.87)	58.31 (30.81)	41.59 (29.67)	69.40 (30.05)
Post-Wash	18.18 (29.76)	24.60 (30.04)	15.04 (22.86)	17.89 (28.40)	41.29 (35.90)	32.62 (34.10)	23.82 (27.75)	31.08 (34.40)
Hand Wash Duration	53.18 (17.14)	45.75 (22.06)	59.09 (23.76)	68.85 (29.23)	68.43 (23.57)	65.63 (26.42)	67.59 (26.96)	82.95 (34.93)
Number of actions in hand wash	11.11 (2.34)	11.00 (2.31)	11.17 (2.52)	12.85 (3.66)	13.86 (4.70)	12.46 (3.28)	12.41 (4.24)	13.67 (4.844)

NCE= No contamination exposure; CE=Contamination Exposure

Hypothesis 1: Hand wash duration across groups

We hypothesized that there would be a three-way interaction such that those in the high contamination fear/contamination exposure/gift bag condition would wash longer than all other

groups, but that the high contamination fear/no contamination exposure/paper group would not differ from those with normative contamination fear in the same conditions. We conducted a 2 (CF; High vs Normative) x 2 (Contamination Induction; Exposure vs. No Exposure) x 2 (Task; Gift bag vs Paper) ANOVA on wash duration. Of the participants who chose to wash their hands 10 had missing data on wash duration due to technical difficulties with the video software. The wash scores of 2 participants were identified as outliers and were winsorized to be 1 second greater than the next highest wash time within their group/condition in order to maintain their rank without unduly influencing the mean. Means and standard deviations of wash duration across groups are presented in Table 3.

There was a main effect of Group, $F(1, 159) = 12.07, p = .001, \eta_p^2 = .07$ such that those in the HCF group washed longer. There was a main effect of Task, $F(1, 159) = 7.49, p = .007, \eta_p^2 = .05$ but this was qualified by a significant Task x CI interaction, $F(1, 159) = 4.52, p = .035, \eta_p^2 = .03$. Post hoc tests within each level of CI revealed that in the CE condition, wash duration differed across task such that those in the GB condition washed significantly longer than those in the Paper condition, $F(1, 87) = 11.26, p < .001, \eta_p^2 = .12$, whereas for those in the NCE condition there was no difference in wash duration across task, $F(1, 87) = 0.21$. This was partial support for our hypothesis. There were no other significant two-way interactions, and, contrary to our hypothesis, no three-way interaction.

Success of hand wash

In order to better interpret data on post-wash memory and sensory confidence, and certainty that the wash had been completed adequately we examined whether there were group differences in ratings of contamination following the wash using a mixed between (CF x CI x Task) and within participants (Time; prewash v post-wash contamination ratings) ANOVA.

There was a main effect of Time such that contamination ratings decreased significantly pre- to post-wash, $F(1, 169) = 644.76, p < .0001, \eta_p^2 = .79$, a main effect of CI, $F(1, 169) = 23.00, p < .0001, \eta_p^2 = .12$, such that the CE group ratings were higher at prewash but the same at post-wash, and a Time x Group interaction, $F(1, 169) = 4.68, p < .0001, \eta_p^2 = .79$ such that the HCF contamination ratings were higher than the NCF group at prewash, $F(1,175) = 10.02, p < .002$ and post-wash, $F(1,175) = 5.81, p < .02$ (although they declined significantly from pre- to post-wash, $F(1,175) = 339.03, p < .0001$). Finally, there was a Time x CI x Task interaction, $F(1,169) = 9.98, p < .002, \eta_p^2 = .06$. Examination of simple main effects revealed that in the NCE condition there were no differences in contamination ratings across Task at pre- or post-wash. In the CE condition, prewash contamination ratings did not differ across task, but at post-wash, those in the Paper condition had significantly higher contamination ratings than those in the gift bag condition, $F(1, 96) = 4.76, p < .03$.

Number of Actions in Washing

To determine the extent to which people repeated specific actions during the hand wash we examined number of actions across groups. We predicted that higher fears of contamination and a greater sense of responsibility would be associated with increased repetitions of the behaviours involved in washing. We conducted a 2x2x2 ANOVA on Total Visits. There was a main effect of CF, $F(1, 159) = 3.96, p = .048, \eta_p^2 = .02$, such that those in the HCF group visited the sites involved in the wash a significantly greater number of times ($M = 12.81, SD = 3.94$) than those in the NCF group ($M = 11.82, SD = 3.03$). There were no main effects of Task or CI and no significant two-way or three-way interactions.

Effect of wash duration on post-wash certainty and memory and cognitive confidence

It would have been desirable to conduct regression analyses of post-wash certainty and memory and cognitive confidence, examining main effects of experimental group and wash duration, and the interactions, but the sample size was too small to do so¹. However, if there is an ironic effect of washing, we would expect to see negative correlations between hand wash duration and post wash sensory trust (controlling for pre-wash sensory trust), confidence in memory of the wash, and certainty the wash had been completed properly, regardless of experimental group. We would expect to see stronger correlations in the HCF, CE, and GB groups than in their counterparts, with the strongest in the HCF/CE/GB group. These correlations are presented in Table 4. There were seven outlying cases on harm ratings; three were in the NCF/NCE/GB group (one at baseline, one at prewash, and one at post wash), two in the NCF/CE/P group (one at baseline, one at post wash), one in the NCF/CE/GB (baseline) and one in the HCF/CE/GB group (post wash). All were adjusted to one unit above the next highest rating.

Table 4

Zero-order correlations between hand wash duration and post-wash ratings

	Normative Contamination Fear	High Contamination Fear
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¹In order to determine whether the effect on certainty observed by Taylor and Purdon (2016) replicated we conducted an analysis of post-wash certainty on those in the CE group, entering Task, CF group, and wash duration on the first step, followed by the 2-way interactions on the second step, and the 3-way interaction on the third. There was no significant change in R^2 at any step.

	Paper Sorting		Gift Bag		Paper Sorting		Gift Bag	
	NCE <i>n</i> = 17	CE <i>n</i> = 20	NCE <i>n</i> = 23	CE <i>n</i> = 26	NCE <i>n</i> = 14	CE <i>n</i> = 24	NCE <i>n</i> = 22	CE <i>n</i> = 21
Sensory Trust	-.12	.07	-.19	.46*	-.33	.18	.19	.20
Memory Confidence	-.05	.14	-.30	.40*	-.47	.28	.06	.06
Certainty wash done adequately	.11	.21	.13	.37	-.12	.24	.20	.18

NCE = No contamination exposure; CE=Contamination Exposure. * $p = .05$

As is clear from these correlations, hand wash duration was not a strong predictor of post-wash confidence in memory, senses, or certainty that the hand wash had achieved its purpose. For those in the normative contamination fear /contamination exposure/gift bag group, greater wash duration was modestly associated with *greater* sensory and memory trust.

Hand wash goals

We had no a priori expectations as to how participants would frame the goal of their hand wash. The verbatim reports of the goal were listed in random order and the authors, blind to participants' experimental group, identified the range of themes expressed in the goal, with particular attention to whether the goal was oriented to harm avoidance or distress reduction, and to the semantic construction of the goal; that is, was the goal expressed such that it was impossible and/or unverifiable. Of the 177 people who washed, there was missing data on the wash goal for one participant. In 75% of cases, the goal was expressed in terms of the hand wash

itself (e.g., “Feel clean”, “Get rid of all the germs”), with only 25% expressing it explicitly in terms of distress reduction (e.g., “That they are clean or feel clean so that I feel less anxious”) or harm avoidance (e.g., “To wash off the germs so I don't get anyone sick”).

In 63% of cases the goal was framed in terms of escaping an undesired state (e.g., “To get rid of germs or anything like dirt that may lie between them”, “To rid the feeling of not feeling clean”) whereas in the other 37% of cases the goal was expressed in terms of achieving a desired state (e.g., “Having cleaner hands”). Goals were expressed in a flexible, or non-absolute way 77% of the time (e.g., “To prevent as much contamination as possible and have clean hands too”) and in the other 23% of cases were framed in absolute terms (e.g., “To remove all bacteria or chemicals that I could have come into contact with”). Goal categories were not mutually exclusive (e.g., “Get rid of all the germs” was coded as both an absolute and an avoidance goal).

Do goals vary by group? We were interested in whether expression of the goal as absolute vs. flexible and approach vs. avoidance varied by group. Logistic regressions were used to examine group differences in goal categories. We found that CI was a significant predictor of the presence of avoidance goals, $\text{exp}\beta = 2.37$, 95% CI = [1.25, 4.47], $p = .0098$, such that those in the CE condition (69%) were more likely to report avoidance goals than those in the NCE condition (53%). There were no other main effects or significant two-way or three-way interactions. With respect to absolute vs. flexible goals, Task was a significant predictor, $\text{exp}\beta = 3.96$, 95% CI = [1.70, 9.25], $p = .001$, such that those in the GB condition (32%) were more likely to report absolute goals than those in the P condition (8%). There were no other main effects or significant two-way or three-way interactions.

Discussion

This study was designed to: 1) examine hand wash duration in people with normative and high fear of contamination fear under different contextual circumstances; 2) determine whether actions within an hand wash are repeated; 3) if so, if there is an ironic effect of hand wash duration on memory and sensory confidence, and certainty that the wash has been done properly, and, 4) to determine how hand wash goals were framed.

Hand wash duration across groups

We found that contamination fears did influence hand washing, but so did contextual factors. First, regardless of contamination fear status, the manipulation of Task resulted in higher prewash ratings of responsibility for harm for those assigned to assemble gift bags, but only if they underwent the contamination induction; the manipulation had no effect on those who did not contaminate their hands. Second, hand washing was optional in the study, and contamination fear was not a factor in choice to wash. However, those who received the contamination induction and were assigned to assemble gift bags were more likely to choose to wash. When we compared ratings of contamination, harm, and responsibility between those who chose to wash and those who did not, we found that the group difference was best explained by degree of perceived contamination and perceived harm severity.

Third, it was the case that those high in contamination fears washed longer, overall, than those with normative contamination fear, and had higher contamination ratings at pre- and post-wash than those with normative contamination fear (although their ratings of contamination still declined significantly pre- to post-wash). However, hand wash duration was influenced by contextual factors; whereas there were no differences in hand wash duration across task in those who did not undergo the contamination induction, participants who received the contamination induction and were assigned to prepare gift bags washed longer than those assigned to sort paper,

regardless of contamination fear. The latter was unexpected; we anticipated that people high in contamination fears might be especially sensitive to context and wash to a greater extent. However, it was interesting that whereas in the contamination induction/paper sorting task condition, hand wash duration was on par with that recommended in the hand washing instructional video, in the gift bag condition duration was about 30% longer. Participants' hands were equally "contaminated" so it is reasonable to assume that the goal of the hand wash was what influenced the duration.

Taken together, these findings indicate that people high in contamination fears do not wash their hands longer than people with normative contamination fear whenever they have the opportunity to wash. Rather, they do so only under particular circumstances. It was noteworthy that responsibility increased as a function of both contamination induction and task; in the absence of contamination, people assigned to the gift bag condition felt no more responsibility for harm than those assigned to sort paper. This is consistent with leading models of OCD and underscores the importance of approaching treatment with a case formulation that explicates the circumstances that trigger prolonged washing for each individual client. This will allow the client and therapist to develop exposure-based exercises that trigger the excessive behaviour.

Interestingly, whereas contamination ratings for those in the contamination exposure/gift bag group did not differ at pre- or post-wash, those in the contamination exposure/paper sorting group had higher contamination ratings at post-wash. Those in the paper sorting group had lower ratings of responsibility at pre-wash than those in the gift bag group and washed for less time. It is possible that while washing, participants higher in responsibility wanted to be sure they would feel clean after the wash, whereas those lower in responsibility were less concerned about the outcome of the wash, but then they subsequently felt less clean.

Repetition within hand wash and post wash confidence and certainty

The second and third goals of the study were to examine whether washing is, in fact, characterized by repetition; and b) if so, whether that repetition is associated with poorer sensory and memory confidence, and less certainty that it was done adequately. Our analysis of wash duration and the number of actions in the hand wash found that people high in contamination fears had longer duration and more actions than those with normative contamination fear. However, although statistically significant, the mean number of actions was only higher by one. Furthermore, the same action may not have even been repeated twice in sequence. One important difference between washing and checking is that checking may involve considerably fewer actions (e.g., turn the lock, wiggle the knob, check the position of the lock), so repetition may be an easily accessible strategy to achieve the sense of certainty the action had been done properly. Hand washing comprises a range of sequential actions (pump the soap, turn on the taps, rub, rinse, turn off the taps, dry) that would be quite inefficient to repeat. Perhaps instead people achieve certainty by prolonging the steps while attending carefully to doing it properly. In future research it could prove quite useful to code video data of hand washing for sequences of acts, as opposed to just number of acts, and assessing whether these sequences are done mindfully or quite automatically.

We also did not find strong evidence of an ironic effect of hand wash duration on post-wash memory and sensory confidence or certainty in the adequacy of the wash. We did find that hand wash duration of those in the high contamination fear/no contamination exposure/paper group had a modest negative correlation with memory and sensory confidence (although the r 's were not statistically significant). However, hand wash duration of those with normative contamination fear in the contamination exposure/gift bag group was positively correlated with

memory and sensory confidence. We did not replicate Taylor and Purdon's (2016) finding that, in people high in contamination fears assigned to paper sorting, hand wash duration was associated with greater certainty that the wash was adequate, whereas for those assigned to preparing gift bags, hand wash duration was associated with less certainty.

These findings are difficult to reconcile. It may be that the sample sizes in both Taylor and Purdon (2016) and in the current study were too small to yield reliable effects. It may also be that when responsibility is not primed, people high in contamination fears attend less to the steps involved and then, when asked, question their sensory experiences and memory. That is, behavioural parsing and careful attention to hand washing steps may be useful strategies when one wants to be careful (at least to a point), as apparently experienced by those with normative contamination fear in the contamination exposure/gift bag group. That compulsions can secure certainty is consistent with Bucarelli and Purdon (2015) and Bouvard et al. (2020), who found that compulsions were terminated more often than not because they had met their goal. As Purdon (2018) observed, we would do well to better understand the circumstances in which compulsive behaviours evoke a sense of certainty vs. evoke doubt.

Hand wash goals

The fourth purpose of the study was to examine how people articulated the goal of their hand wash. In 75% of cases, the goal was proximal ("Get my hands clean/Get rid of all the germs") and did not reference harm or distress reduction. It may be the case that harm and/or distress reduction are implicit, distal goals, the route to which is success in achieving the proximal goal. Those who underwent the contamination induction were more likely to frame their goal in avoidance terms ("get rid of germs"). In 23% of cases, the goal was expressed in absolute terms ("get rid of all the germs"), and this was more likely to occur in those assigned to

prepare gift bags than those assigned to sort paper. Thus, it was the case that under some circumstances the goal of the hand wash was both impossible to achieve and its success unverifiable. These were also the conditions under which greater hand wash duration was observed.

When a goal is unverifiable and impossible to achieve there may be a reliance on internal, felt sense that the behaviour has been done enough (e.g., Szechtman & Woody, 2004) that is elusive. If the internal, felt sense is not achieved, then perhaps the distal goal of harm/distress reduction is not met, leading to continued performance of the compulsion. These findings suggest that in treatment of OCD there may be considerable merit in asking people to define the goal of their compulsion and include goal restructuring as part of cognitive restructuring. There may also be merit in focusing exposure on the uncertainty as to whether the proximal goal has been achieved following one performance of the compulsion, rather than focusing on distress reduction over the obsessional concern.

Limitations of this study include relatively small cell n 's. In order to get normative data on hand washing we thought it was important to make the hand wash voluntary. We did not anticipate that such a large number of people would choose not to wash, particularly those in the contamination exposure condition. This, as well as technical issues with the recording equipment reduced our sample for analyses involving hand wash duration by 58 participants. The study sample was also over-representative of women, and although we do not have reason to expect men and women would differ we need to be circumspect about generalizing. Although the high contamination fear group all scored above the reported mean for the DOCS-Contamination scale for people with OCD in the initial validation study. However, in the absence of a formal diagnosis we cannot assume they met criteria for OCD. Regardless, the study findings contribute

to our understanding of the phenomenology of handwashing, which has some implications for understanding and treating hand washing compulsions, and it provides normative data on hand wash duration in people without contamination fears under neutral circumstances.

Conclusions

In sum, the results from this study suggest that hand wash duration in those with normative and high contamination fear is heavily influenced by contextual factors. Although people high in contamination fears washed longer, they rated their hands as more contaminated following the wash than did those with normative contamination fears. Future research could examine the period in between the end of one hand wash and the start of the next, when no recontamination has occurred, in order to better understand the internal triggers for the wash. It may be the case that there is post-event analysis of the wash and its adequacy in meeting its goal. Hand washing did not seem to be characterized by repetition, but future research should examine sequences of actions within a wash to better establish how much repetition there is. In turn, the findings did not provide strong evidence of an ironic effect of hand wash duration on subsequent memory and sensory confidence and certainty the hand wash had been done properly. Future research is required to get better clarity on whether repetition in handwashing increases doubt, as appears to be the case in checking. Finally, the goal of the hand wash was seldom framed in terms of distress or harm reduction, and, for participants who had undergone the contamination induction and were assigned to prepare gift bags, was more likely to be framed in absolute terms (e.g., “be certain I get rid of all the germs”). The findings suggest that in treatment of OCD there could be merit in identifying and restructuring the goal for a compulsion.

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Conflict of Interest

Neither author has a conflict of interest.

Author Statement

Jasmine Dean - Data curation; Formal analysis; Funding acquisition; Investigation; Project administration; Visualization; Roles/Writing - original draft; Writing - review & editing.

Christine Purdon - Conceptualization; Formal analysis; Funding acquisition; Methodology; Resources; Supervision; Validation; Writing - review & editing.