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If a Safety Aid is Present, There Must be Danger: The Paradoxical Effects of Hand Sanitizer during a Contamination Exposure Task

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Abstract

Perceptions of danger often arise in the context of feared threat cues, but individuals also rely on other heuristics that lead them to infer danger in ambiguous situations. For example, individuals may interpret their own anxiety or safety-seeking behaviors as indicators of threat. Another potential source of danger information is the mere availability of safety aids in the environment. Although assumed to be helpful, safety aids might paradoxically elicit, rather than alleviate, anxiety. The present study was designed to assess the degree to which concern-relevant safety aids exacerbate distress. Participants (N = 71) completed several self-report measures and engaged in a contamination-related behavioral avoidance task (BAT) in the presence or absence of a 2L hand sanitizer dispenser. Results showed that participants higher in trait contamination aversion and in the presence of hand sanitizer endorsed greater inferences of danger, hypervigilance, peak BAT anxiety and disgust, BAT avoidance, and urges to wash following the BAT. Theoretical and clinical implications of the paradoxical inference of danger from the presence of safety aids are discussed.

Keywords: anxiety; disgust; danger; safety; hypervigilance; contamination

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Introduction

Etiological models posit that pathological anxiety arises in response to overestimations of threat (e.g., Taylor & Rachman, 1994). Although danger may be inferred from cues objectively associated with possible negative outcomes (e.g., a poisonous snake), there are additional stimuli that, to some, communicate threat. For instance, anxious individuals often rely on *ex-consequentia reasoning,* looking to their own anxious responses (Arntz, Rauner, & van den Hout, 1995) or safety behaviors (e.g., disinfecting one's hands after touching public door handles) for information regarding the dangerousness of a situation (Deacon & Maack, 2008; Gangemi, Mancini, & van den Hout, 2012; Olatunji, Etzel, Tomarken, Ciesielski, & Deacon, 2011).

Safety aids are stimuli that suggest the possible absence or offset of a feared event (Lohr, Olatunji, & Sawchuk, 2007). For example, hand sanitizer may be a contamination-related safety aid because sanitizer can be used to prevent contamination and/or facilitate decontamination. Yet the mere availability of a safety aid possibly engenders concern among those for whom the aid-related concern is relevant, for a safety aid might imply the concurrent presence of threat. For example, the presence of hand sanitizer dispensers in a room may denote that the room must be dirty. This inference might take the form of: *if a safety aid is present, there must be danger.* Inferring danger from an available safety aid might provoke hypervigilance toward detecting threat, thereby eliciting increased awareness of threat cues and misinterpretation of ambiguous stimuli as dangerous, resulting in heightened distress and urges to neutralize.

To illustrate, consider a woman with high anxiety sensitivity who carries anxiolytic medication in her purse to slow her heart rate in case of a panic attack. When walking up a flight of stairs, her heart rate quickens from the exercise and increases her concerns about suffering a potential heart attack. Because she is cognizant of her medication's accessibility and effectiveness, she pays increased attention to her heart rate in order to determine when it is necessary to take the medication to prevent cardiac emergency. Her anxiety about experiencing a heart attack exacerbates her body sensations, resulting in increased awareness of potentially threatening physical symptoms and an urge to utilize her safety aid to prevent a medical catastrophe.

When a safety aid can be used to neutralize threat, individuals may be motivated to know when to use it. For example, carrying hand sanitizer in one's pocket in order to prevent contamination might elicit hypervigilance toward potential contaminants in the environment (Deacon & Maack, 2008). This "need to know" process has been examined within the context of panic disorder (PD; Stewart, Westra, Thompson, & Conrad, 2000; Westra & Stewart, 1998). Benzodiazepines (BZs) are frequently prescribed on an "as needed" (prn) basis for people with PD due to their effectiveness in swiftly reducing physiological panic (Wu, Wang, Katz, & Farley, 2012). Because early identification of panic symptoms is imperative for effective prn BZ use, prn BZs may promote attentional bias toward somatic sensations to facilitate timely detection of panic. An individual with PD who carries prn BZs might regularly monitor feared sensations to determine when they are sufficiently intense to warrant prn BZ ingestion. As a result, individuals with PD who carry prn BZs might infer danger from body sensations more quickly and more often than those who do

not (Stewart et al., 2000). Indeed, as catastrophic misinterpretations of feared sensations intensify panic symptoms (Dixon, Sy, Kemp, & Deacon, 2013), hypervigilance toward threat cues elicited by the availability of prn BZs may paradoxically exacerbate the very problem they are prescribed to alleviate.

Although the hypothesized paradoxical effects of safety aids on danger appraisals have not yet been tested experimentally, there is indirect support for this process. Thorpe and Salkovskis (1998) offered preliminary evidence of biased attention toward relevant safety aids. In their study (1998), spider phobic participants, but not controls, were quicker to respond to a visual stimulus when the stimulus was paired with a threat and escape route (a spider placed near the exit) than when the stimulus was paired with a threat but not an escape route (a spider placed opposite the exit). These findings suggest that fearful individuals attend to both threat *and* safety cues, perhaps out of a need to know when to actively seek safety.

In a panic challenge study, Telch and colleagues (2010) demonstrated that specific cognitive vulnerabilities interacted with a threat-enhancing contextual cue to exacerbate panic. The threatening cue used, however, was a defibrillator—a medical safety aid. These researchers found that participants higher in cardiac sensitivity inferred more danger and reported greater fear while engaging in a panic induction task in the presence of the defibrillator. Unfortunately, this finding offers only limited support to the theory that safety aids paradoxically signal danger to concerned individuals, as participants' appraisal of the safety aid (defibrillator) as indicating simultaneous and functionally-related threat (cardiac emergency) was explicitly formed by the experimenters, who warned participants that the defibrillator was needed "just in case of an emergency." As such, it is uncertain whether or not participants would have made this safety aid–danger association independently.

In a study examining the role of safety in exposure therapy for anxiety, Sy, Dixon, Lickel, Nelson, and Deacon (2011) examined treatment engagement and outcome of claustrophobic individuals who had access to safety aids (e.g., a two-way radio used to communicate with the experimenter) during an exposure task. Results showed that the tendency to infer danger from safety aids was associated with greater peak fear during a behavioral avoidance task and poorer claustrophobia cognition outcomes. These findings support the postulation that mere safety aid availability may paradoxically elicit inferences of danger and greater distress when encountering feared stimuli.

In summary, safety aids—innocuous and adaptive as they seem—may actually generate and exacerbate anxiety. This paradoxical safety aid–danger appraisal is hypothesized to be a general cognitive process rather than a phenomenon specific to clinically anxious individuals. Therefore, safety aid-related inferences of danger would be worthy to study because of the possible influence on the general population. Additionally, this paradoxical process is predicted to be dependent on preexisting cognitive vulnerabilities. Specifically, safety aid–danger appraisals are likely to be predominantly activated in contexts where an individual is concerned about the threat associated with the safety aid (Gangemi et al., 2012; Telch et al., 2010). To illustrate, a contamination averse individual might become hypervigilant toward threat cues in the presence of hand sanitizer, whereas a person unconcerned with contamination might find the presence of a hand sanitizer dispenser to be of little consequence. Therefore, intensity of a particular concern (e.g., contamination aversion, anxiety sensitivity, etc.) rather than symptom severity (e.g., excessive washing, interoceptive avoidance, etc.) might be the most appropriate predictor of paradoxical safety aid effects (Telch et al., 2010).

The aim of the present study was to assess the degree to which concerned individuals infer danger from the presence of relevant safety aids. Although this paradoxical safety aid–danger appraisal is speculated to be a broad cognitive process, this study was designed to examine this association within the context of contamination aversion for multiple reasons. First, contamination-related safety aids (e.g., hand sanitizer) are common stimuli in Western cultures, making these cues relevant and feasibly manipulated. Second, contamination concerns are common (Rachman, 2004) and dimensional (Adams, Cisler, Brady, Lohr, & Olatunji, 2013; Olatunji & Broman-Fulks, 2009); accordingly, this context allows for examining safety aid effects in an unselected sample. Recruiting a sample of individuals varying in aid-related concerns permits testing whether safety aid–danger appraisals (a) occur in nonclinical individuals and (b) are dependent on the intensity of underlying concern. Contamination aversion differs from contamination fear along physiological, neural, and emotional experiences (for a discussion of these differences, see Olatunji & Broman-Fulks, 2009). In light of research highlighting the importance of aversion (versus fear or anxiety) in the development

of pathological contamination concerns (e.g., Olatunji & Broman-Fulks, 2009; Olatunji, Cisler, McKay, & Phillips, 2010), contamination aversion was selected to be the assessed moderator in the present study.

Testing the theory that safety aids interact with underlying aid-related concerns to paradoxically elicit inferences of danger and distress, it was hypothesized that exposure to a contamination-related behavioral avoidance task (BAT) in the presence, but not absence, of a contamination-related safety aid would interact with higher trait contamination aversion to elicit (a) greater inferences of danger, (b) greater hypervigilance toward contamination, (c) higher peak anxiety and disgust, (d) greater avoidance, and (e) a stronger urge to wash.

Method

Participants

Participants were undergraduates enrolled in psychology courses at the University of Wyoming taking part in psychology studies for course credit. The analyzed sample (n = 71) was predominantly female (63.8%) and White (87%) with a mean age of 20.33 (SD = 2.96).

Measures

Contamination Aversion Scale (CAS; Adams et al., 2013). The CAS was administered to assess participants' level of trait contamination aversion. Because the proposed safety aid effect is hypothesized to interact with concern intensity rather than symptom severity to elicit distress, the CAS was deemed a more appropriate measure than any established symptom questionnaire. Items on the CAS were inspired by items featured in contamination subscales of existing peer-reviewed, publicly available, and psychometrically sound measures of OCD, including the Maudsley Obsessive Compulsive Inventory (MOCI; Hodgson & Rachman, 1977), Obsessive-Compulsive Inventory (OCI; Foa Kozak, Salkovskis, Coles, & Amir, 1998), Revised OCI (OCI-R; Foa, Kozak, Salkovskis, Coles, & Amir, 2002) Padua Inventory (PI; Burns, Keortge, Formea, & Sternberger, 1996), Vancouver Obsessive Compulsive Inventory (VOCI; Thordarson et al., 2004), and the Yale-Brown Obsessive Compulsive Scale (YBOCS; Goodman et al., 1989). On the CAS, participants rate how disturbed they would be by coming into contact with 14 directly contaminated (e.g., "by someone sneezing on you") and 14 indirectly contaminated (e.g., "by using someone else's shower") objects and situations on a scale of 0 (*not at all disturbed*) to 4 (*extremely disturbed*). The CAS has shown a two-factor fit and good convergent validity in previous research (Adams et al., 2013), justifying its use as a measure of trait contamination aversion in the present study. The CAS demonstrated excellent internal consistency (Total α = .91; Direct α = .89; Indirect α = .88) in the current sample.

Baseline Anxiety.

To determine the extent to which groups were similar in baseline levels of state anxiety, participants rated the anxiety they were currently experiencing on a scale of 0 (*no anxiety*) to 100 (*maximum possible anxiety*).

Baseline Disgust.

To determine the extent to which groups were similar in baseline levels of state disgust, participants rated the disgust they were currently experiencing on a scale of 0 (*no disgust*) to 100 (*maximum possible disgust*).

Pre-BAT Inference of Danger.

To assess the perceived dangerousness of the context prior to the BAT without explicitly referencing the safety aid, participants rated two items ("I feel that I am entering a potentially harmful or dangerous situation" and "I question the safety of the contamination box") on a 0 (*Completely Disagree*) to 7 (*Completely Agree*) scale. A total scale score was computed by summing participants' responses from both items. Item responses were strongly correlated (r = .79, p < .001) and produced a sum scale with good reliability (α = .86).

BAT Avoidance.

The BAT consisted of a contamination anxiety induction task modeled after BATs used in previous contamination aversion research (e.g., Cougle, Wolitzky-Taylor, Lee, & Telch, 2007; Jones & Menzies, 1998) and was administered to assess participants' anxiety, disgust, hypervigilance, and avoidance associated with exposure to contaminants. The length of time, in seconds, of delay before participants were told to begin the task and when participants fully immersed their hands in the contamination box ("BAT delay time") and the length of time, in seconds for up to three minutes, that participants fully immersed their hands in the box ("BAT immersion time") were separately recorded. Participants were unaware that their delay and immersion times were recorded. Experimenters did not use a stopwatch to record time; rather, a digital clock was placed in view of the experimenter, but not participant, so that the experimenter could surreptitiously record the start and end time for the delay and immersion periods. Greater BAT avoidance was defined as longer BAT delay time and shorter BAT immersion time.

Peak BAT Anxiety.

Peak BAT anxiety ratings were obtained to assess participants' subjective anxiety associated with exposure to contaminants. Immediately after the BAT, participants rated their peak anxiety experienced during the BAT on a scale of 0 (*no anxiety*) to 100 (*maximum possible anxiety*).

Peak BAT Disgust.

Peak BAT disgust ratings were obtained to assess participants' subjective disgust associated with exposure to contaminants. Immediately after the BAT, participants rated their peak disgust experienced during the BAT on a scale of 0 (*no disgust*) to 100 (*maximum possible disgust*).

Post-BAT Urge to Wash.

Post-BAT urge to wash ratings were obtained to assess participants' desire to neutralize following exposure to contaminants. Immediately after the BAT, participants rated their urge to wash their hands on a scale of 0 (*no urge*) to 100 (*maximum possible urge*).

Hypervigilance toward Contamination.

Two items were constructed to assess participants' hypervigilance toward threat (contamination) during the BAT. Participants rated how often they "focused on feeling dirty" and "monitored [their] hands for contamination" during the BAT on a 0 (*not at all*) to 5 (*extremely*) scale. A total hypervigilance scale score was computed by summing participants' responses from both items. Item responses were strongly correlated (r = .63, p < .001) and produced an acceptably reliable sum scale (α = .77).

Manipulation Check.

To ensure that participants in the experimental condition detected the hand sanitizer, participants in this condition answered a yes-or-no verbal manipulation check item ("Did you notice the hand sanitizer on the table during the experiment?") after the experiment. Although the manipulation check would have ideally assessed beliefs directly related to the hand sanitizer's presence (e.g., "did you infer danger from the hand sanitizer?"), ambiguity was necessary to avoid divulging the research question and/or inducing participant demand characteristics. Because no information was provided to participants regarding the implications of the sanitizer's availability (i.e., participants were not explicitly told that the sanitizer denoted a contaminated context), differences in reported inferences of danger can be attributed to participants' independent stimulus appraisals.

Procedure

Participant Recruitment and Random Assignment to Conditions

Students registered in the Psychology Department participant pool were invited to participate in the study in exchange for course credit and $5 payment. Participants were randomly assigned to the control (no hand sanitizer) condition or experimental (hand sanitizer) condition via a random number generator prior to beginning the study. Both conditions experienced identical study procedures with one exception: participants in the experimental condition performed post-baseline tasks in the presence of a visible 2L hand sanitizer dispenser, but the control condition performed these tasks in the absence of the hand sanitizer.

Baseline Measures

After providing informed consent, participants completed a demographic questionnaire and baseline measures of contamination aversion, anxiety, and disgust.

Behavioral Avoidance Task (BAT)

Prior to the BAT, a hypothesis-blind research assistant told participants in the experimental condition “let me do one more thing to finish setting up” before placing a previously concealed bottle of hand sanitizer on the corner of the BAT table. This procedural step was omitted for participants in the control condition. During the BAT, participants fully immersed their hands in a 19” x 15” x 8” plastic cat litter box filled with various contaminants (potting soil, clumps of hair, dead crickets, and apple cores) for as long as they were willing for up to three minutes. Participants were not told in advance that there was a maximum immersion period. When administering the BAT, experimenters removed the lid to the contamination box, asked participants to complete the Pre-BAT Inference of Danger questionnaire, and instructed participants: “Now I would like you to place your hands all the way down into this contamination box. Please leave your hands in the bottom of the mixture for as long as you are willing. Begin whenever you are ready.” If participants remained fully immersed in the box for three minutes, they were informed that the task was over and permitted to remove their hands. If participants asked the experimenter how long they should leave their hands immersed in the box or asked if there was a time limit to the BAT, the experimenter provided the standardized response, “just leave your hands fully immersed in the box for as long as you are willing.”

Post-BAT Assessments

Immediately after the BAT, participants reported peak BAT anxiety and disgust ratings as well as their urge to wash their hands. After providing these ratings, participants were invited to wash their hands at a sink around the corner at the back of the laboratory. Participants then completed the Hypervigilance toward Contamination questionnaire and Manipulation Check item before being fully debriefed and dismissed.

Results

Standard data screening procedures identified two univariate outliers (dependent measure z-scores fell at least 3 SDs above the group mean) within the full sample (N = 73), which were excluded from the below analyses.

Baseline equivalence of conditions and normality of distributions

Chi-square tests of independence and independent samples t-tests showed that conditions did not significantly differ in gender, age, ethnicity, or year in school (p values ranged .77 to .99), or on baseline measures of contamination aversion, baseline anxiety, or baseline disgust (p values ranged .35 to .89; see Table 1). Sample distributions of all baseline variables were also free of significant skew (all values less than 2) and kurtosis (all values less than 4).

Manipulation check

At the conclusion of the study, all participants assigned to the hand sanitizer condition reported noticing the hand sanitizer bottle on the table during the experiment.

Dependent variable descriptive statistics and tests of main effects of condition

Outcome variable descriptive statistics for each condition are presented in Table 1. Although main effects of condition were not hypothesized, independent samples t-tests were conducted on the data to test for main effects of condition. Bonferroni corrections (corrected α = .05/7 = .007) were applied to control for family-wise error associated with multiple comparisons. Analyses did not detect any significant main effect of condition on any outcome measures (*p*s ranged from .02 to .86).

Table 1:Baseline and outcome measure descriptive statistics and tests of mean group differences

Measure	Control M (SD)	Sanitizer M (SD)	*t*(69)	*p*	*d*
Baseline Measures					
CAS	14.41 (8.12)	16.65 (11.44)	.94	.35	.23
Anxiety	17.26 (15.16)	16.05 (20.01)	.29	.78	.07
Disgust	6.03 (11.20)	5.68 (11.13)	.13	.89	.03
Outcome Measures					
Inference of Danger	4.09 (2.19)	3.70 (2.54)	.68	.50	.16
Hypervigilance	2.06 (1.91)	2.70 (2.17)	-1.32	.19	.31
Peak BAT Anxiety	31.32 (24.52)	30.27 (26.50)	.17	.86	.04
Peak BAT Disgust	30.18 (25.89)	32.00 (32.32)	-.26	.79	.06
Urge to Wash	58.09 (29.65)	68.95 (30.56)	-1.52	.13	.36
BAT Delay Time	8.24 (4.71)	7.32 (2.96)	.987	.33	.23
BAT Immersion Time	117.35 (66.60)	79.61 (69.12)	2.34	.02	.55

Note. CAS = Contamination Aversion Scale; BAT = Behavioral Avoidance Task (immersing hands in contamination box).

Primary analyses: The moderating effects of contamination aversion on BAT responses in each condition

An insufficient number of participants enrolled in this study; therefore, regression models with interaction terms were underpowered to detect statistically significant effects. Consequently, linear regression analyses were conducted on each of the dependent variables separately within each condition to test the moderation hypothesis that contamination aversion would be a significant predictor of each of the outcome measures for the hand sanitizer condition, but not the control condition. Bonferroni corrections (corrected α = .05/14 = .004) were applied to control for family-wise error associated with multiple comparisons. As hypothesized, contamination aversion was not a significant predictor of inferred danger, hypervigilance, peak anxiety, peak disgust, BAT immersion time, or urge to wash following the BAT within the control condition. Among these measures, CAS scores explained no more than 8% of outcome variance and *p* values ranged .02 to .60 (see Table 2). Contamination aversion did, however, significantly predict BAT delay time within the control condition, β = .51, *t*(31) = 3.33, *p* = .002. In contrast, contamination aversion was a significant predictor of inferred danger, hypervigilance, peak anxiety, peak disgust, BAT delay time, and urge to wash following the BAT in the hypothesized direction within the hand sanitizer condition (see Table 2). Specifically, CAS scores explained 22% to 57% of outcome measure variance and *p* values ranged from < .001 to .004 (see Table 3). CAS scores were marginally significant predictors of BAT immersion time in the experimental condition, β = -.45, *t*(35) = -3.02, *p* = .005. Thus, the hypothesis that safety aids would paradoxically interact with aid-related concerns to exacerbate distress was largely supported. As an illustrative example of the paradoxical safety aid effect, Figure 1 shows the effect of contamination aversion and safety aid condition on participants' urge to wash following the BAT.

Table 2: Regression analyses within control condition for all outcome measures

Outcome Measure	R^2	B [95% CI]	SE_B	β	*t*	*p*
Inferred Danger						
CAS	.05	-.06 [-.16, .03]	.05	-.22	-1.30	.204
Hypervigilance						
CAS	.08	.07 [-.01, 1.5]	.04	.29	1.69	.101
Peak BAT Anxiety						
CAS	.07	.79 [-.26, 1.84]	.52	.26	1.52	.137
Peak BAT Disgust						
CAS	.04	.66 [-.46, 1.79]	.55	.21	1.21	.237
Urge to Wash						
CAS	.01	.34 [-.97, 1.65]	.64	.09	.53	.602
BAT Delay Time						
CAS	.26	.31 [.12, .49]	.09	.51	3.33	.002
BAT Immersion Time						
CAS	.16	-3.30 [-6.00, -.60]	1.33	-.40	-2.49	.018

Note. CAS = Contamination Aversion Scale.

Table 3: Regression analyses within hand sanitizer condition for all outcome measures

Outcome Measure	R^2	B [95% CI]	SE_B	β	*t*	*p*
Inferred Danger						
CAS	.22	.11 [.04, .17]	.03	.47	3.18	.003
Hypervigilance						
CAS	.47	.13 [.08, .18]	.02	.68	5.55	<.001
Peak BAT Anxiety						
CAS	.30	1.27 [.61, 1.94]	.33	.55	3.89	<.001
Peak BAT Disgust						
CAS	.28	1.50 [.68, 2.32]	.40	.53	3.72	.001
Urge to Wash						
CAS	.57	2.01 [1.40, 2.61]	.30	.75	6.75	<.001
BAT Delay Time						
CAS	.22	.12 [.04, .20]	.04	.47	3.11	.004
BAT Immersion Time						
CAS	.21	-2.75 [-4.59, -.90]	.91	-.45	-3.02	.005

Note. CAS = Contamination Aversion Scale.

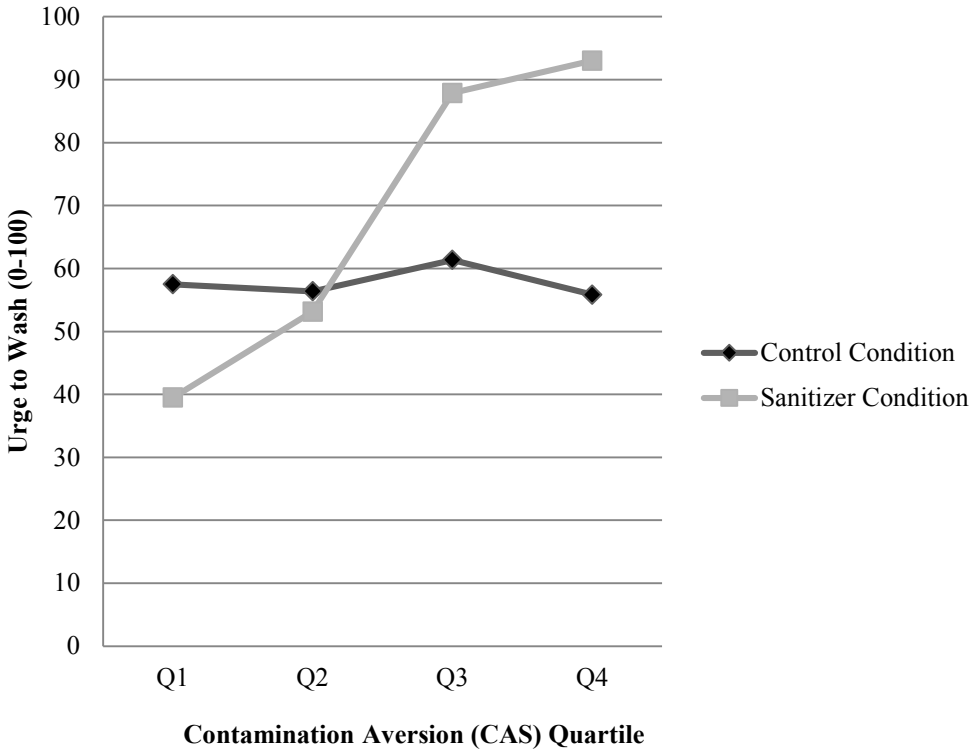

Figure 1: The paradoxical effect of safety aids on urge to wash following a contamination BAT

Note. Q1 = First quartile; Q2 = Second quartile; Q3 = Third quartile; Q4 = Fourth quartile.

Discussion

The present study investigated the paradoxical effect of safety aids on inferences of danger and other outcomes related to a threatening context. As hypothesized, stronger contamination aversion was associated with greater contamination-related inferences of danger, hypervigilance, peak disgust, peak anxiety, and urges to wash during a contamination exposure task when hand sanitizer was present. In contrast, contamination aversion did not significantly predict inferences of danger, hypervigilance, peak BAT anxiety or disgust, BAT immersion time, or urges to wash when hand sanitizer was absent. Contrary to hypotheses, contamination aversion did predict BAT avoidance in the absence of hand sanitizer, and contamination aversion did not significantly predict BAT immersion time in the presence of hand sanitizer. Together, these findings partially support the theory that detecting safety aids in the environment paradoxically exacerbates danger inferences and distress in people with greater preexisting aid- related concerns. Because this study was underpowered to conduct formal moderation analyses, however, replication of these preliminary findings is needed.

Interestingly, contamination aversion significantly predicted BAT delay time and was a marginally significant predictor of BAT immersion time regardless of whether or not hand sanitizer was present. One possible explanation for why the paradoxical effects of hand sanitizer were weaker on objective outcomes is that demand characteristics motivated participants to fully engage in the BAT despite personal aversion or anxiety about contacting contaminants. Alternatively, it could be that contamination aversion may not drive significant distress when safety aids are not available, but does affect one's willingness to come into contact with contaminants regardless of whether or not safety aids are present. Other researchers should consider these possibilities in future replications. Also noteworthy is the group difference in BAT immersion time. Although this difference did not remain significant after controlling for multiple comparisons, the possibility that individuals might be more avoidant during a contamination BAT when in the presence of hand sanitizer *regardless* of their trait contamination aversion is worth consideration in future work.

Although results from this study suggest that individuals with greater aid-related concerns may infer threat from the presence of relevant safety aids, the psychological processes underlying this paradoxical appraisal remain ambiguous. One explanation for this effect is that the availability of safety aids implies simultaneous aid-related threat.

This possible assumption, akin to appraisals made via affirmation of the consequent errors (e.g., Cummins, 1995) or ex-consequentia reasoning (e.g., Arntz et al., 1995; Gangemi et al., 2012), might be experienced as *if a safety aid is available, there must be danger*. If danger is inferred from the presence of a related safety aid, hypervigilance toward detecting threat is a logical consequence. This possibility is supported by findings that contamination averse participants in the presence of sanitizer reported greater efforts at monitoring for contamination than contamination averse participants without access to hand sanitizer. As the BAT contained actual contaminants (e.g., dead crickets), it is not surprising that these participants also reported elevated disgust, anxiety, and urges to wash in addition to their hypervigilance. Greater reports of hypervigilance and distress precipitated by danger inferences observed in this study are consistent with cognitive-behavioral models of pathological anxiety (e.g., Abramowitz, Deacon, & Whiteside, 2010). For example, cognitive-behavioral models of PD purport that frequent scanning for feared body sensations (i.e., hypervigilance) amplifies perceptions of danger (e.g., Schmidt, Lerew, & Trakowski, 1997). Additionally, individuals who excessively perform contamination-related safety behaviors report increased attention paid toward noticing contaminants as well as a heightened awareness of contaminants in their environment (Deacon & Maack, 2008). Unfortunately, participants in this study's experimental condition did not document specific appraisals made regarding the hand sanitizer's presence; therefore, explanations for the demonstrated safety aid effects (e.g., participant appraisals akin to affirmation of the consequent or ex-consequentia reasoning) are tentative and should be explored in future research.

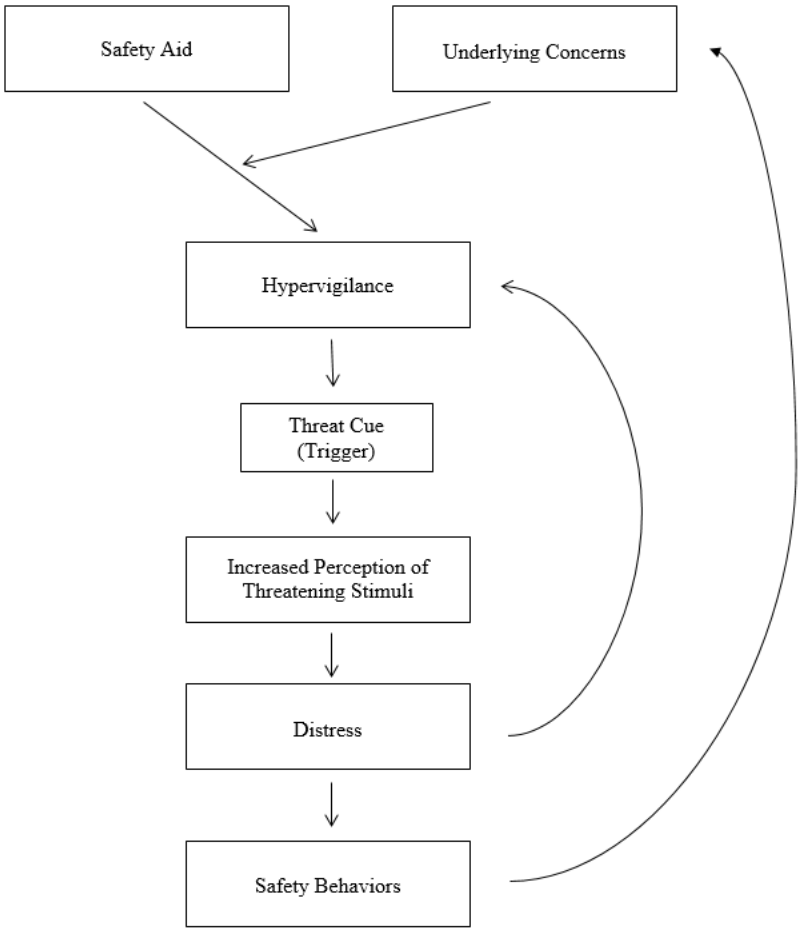

Figure 2: Cognitive-behavioral model of the speculated role of safety aids in pathological anxiety

Figure 2 illustrates the proposed role of safety aids on pathological anxiety. This speculative model elaborates upon current cognitive-behavioral models of pathological anxiety (e.g., Abramowitz et al., 2010) by incorporating the hypothesized safety aid pathway. The updated model suggests that an individual's maladaptive beliefs regarding specific stimuli (i.e., concern-specific cognitive vulnerabilities) interact with the presence of a relevant safety aid to lead one to appraise the environment as threatening. Attention is hypothesized to become biased toward detecting threat cues to facilitate prompt safety-seeking. Because hypervigilance fosters misinterpretation of ambiguous stimuli

as dangerous, stimuli in the environment may be increasingly (mis)perceived as threat cues. Finally, distress engendered from increased perception of threat cues might not only intensify hypervigilance (e.g., Brewin, Dalgleish, & Joseph, 1996; Dalgleish, Moradi, Taghavi, Neshat-Doost, & Yule, 2001), but also prompt urges to engage in safety behaviors that serve to immediately reduce the associated distress, yet also reinforce maladaptive beliefs (e.g., Salkovskis, 1991). This speculative model is consistent with other cognitive-behavioral models of pathological anxiety (e.g., Schmidt et al., 1997), but incorporates the current study's preliminary finding that awareness of present safety aids might paradoxically elicit distress in vulnerable individuals through increased inferences of danger and hypervigilance toward noticing aid-relevant threat cues.

Findings from this study suggest that individuals who endorse specific concerns (e.g., contamination aversion) may paradoxically anticipate a negative outcome after detecting safety aids—stimuli intended to communicate a negative outcome's absence or offset (Lohr et al., 2007). Consequently, well-intended provision of safety aids may actually elicit, in certain individuals, the worries that the aids were intended to assuage. To illustrate, sanitation advertisements following the H1N1 pandemic may have exacerbated distress among nonclinical illness-fearful individuals (Wheaton, Abramowitz, Berman, Fabricant, & Olatunji, 2012). Similarly, a woman walking alone at night with pepper spray on her person may misinterpret ambiguous noises as signals of an approaching attacker more often than she might if she did not have access to pepper spray.

This study's findings potentially hold clinical significance, for safety aids in a concerned individual's environment may paradoxically fuel the maladaptive psychological processes that trigger and maintain pathological anxiety. Consider a scrupulous OCD client with blasphemous obsessions who keeps religious icons in his house to facilitate praying as a safety behavior in response to perceived immoral intrusive thoughts. If this client notices his icon (the safety aid) while at home, he may be reminded of—and thus hypervigilant for—his intrusions and consequently experience the unwanted blasphemous thoughts and associated anxiety. Similarly, although prn BZs effectively relieve acute anxiety, their presence may also be a continual reminder of panic-related dangers, which could promote hypervigilance toward threatening body sensations and exacerbate panic symptoms (Stewart et al., 2000). This supposition counters Woody and Rachman's (1994) safety signal perspective of GAD. That is, rather than clinically anxious individuals overestimating threat as a result of insufficient safety cues, clinically anxious individual might paradoxically overestimate threat as a direct consequence of available safety cues. Additional research on the role of safety aids in clinically anxious samples is desirable.

In the context of exposure therapy, the presence of safety aids might interfere with successful extinction of fear and other disorder-related constructs (e.g., disgust). If the paradoxical inference of danger from safety aids occurs during exposure tasks, clients may be hypervigilant toward threat cues, more likely to notice them, and less likely to appraise objectively safe contexts as non-threatening (e.g., Sloan & Telch, 2002; Thorpe & Salkovskis, 1998). In this manner, the presence of safety aids during exposure tasks over the full course of therapy might obstruct maximal violation of danger expectancies, which is a theorized requisite of successful fear extinction in exposure therapy (e.g., Craske et al., 2008). The effect of encouraging safety behavior use in exposure therapy is mixed (see Helbig-Lang & Petermann, 2010, for a review), yet the role of mere access to safety aids has not been thoroughly examined. In light of preliminary findings from the present study, future research should continue to explore the potential effects of safety aid availability (but non-use) on the processes and outcome of exposure therapy for anxiety.

A strength of this study is the finding that concerned individuals formed paradoxical inferences of danger independently. All participants in the hand sanitizer condition reported noticing the sanitizer, but they were not explicitly told that the environment was contaminated or that sanitizer use was recommended to neutralize contamination. In this matter, the present study improves upon Telch and colleagues' (2010) defibrillator study, which provided only indirect evidence that concerned individuals paradoxically infer danger from a safety aid. This study also advances research on the effect of safety access on distress by isolating safety aids from safety behaviors. Because several previous studies (e.g., Deacon & Maack, 2008; Olatunji et al., 2011) merged aids (e.g., carrying hand sanitizer) and behaviors (e.g., using hand sanitizer) within single conditions, the paradoxical effect of safety resources could not be unambiguously attributed to the utilization of safety aids above and beyond their mere availability. Therefore, the present findings offer initial support to the theorized subtle and automatic safety aid-specific paradoxical effects on inferences of danger and distress.

A limitation of the present study is that use of a nonclinical sample precludes conclusions regarding the role of safety aid-related inferences of danger in clinically diagnosed psychopathology. Because this study represents the first direct test of the paradoxical effects of safety aids, an unselected sample was used to conserve participant-associated resources (e.g., those related to recruitment and compensation) and demonstrate that paradoxical safety aid effects might be independent of diagnostic status. However, demonstrating the above findings in an unselected sample is also one of this study's strengths. Because participants exhibited heterogeneous levels of contamination aversion, the relationship between contamination aversion and distressed BAT responses could be linearly and continuously analyzed. Although the current study was underpowered to test a single linear regression model containing a computed interaction term, our findings nevertheless suggest that the amount of danger inferred from safety aids is proportional to the intensity of an individual's aid-related concern. It follows that paradoxical safety aid effects might be particularly likely among individuals who meet diagnostic criteria for anxiety disorders. Therefore, future research should examine safety aid effects in larger samples of individuals with clinical levels of anxiety.

Similarly, although paradoxical safety aid effects are not hypothesized to be specific to contamination—and previous research provides indirect support for this notion across multiple anxiety domains (Stewart et al., 2000; Sy et al., 2011; Telch et al., 2010)—future research should examine safety aid effects within other areas of concern (e.g., social contexts). The inference of danger from safety aids may denote a transdiagnostic process in anxiety and related disorders. Future investigators of paradoxical safety aid effects should also be careful to select the most appropriate aid-related concern to test moderation of safety aid effects. The present study tested the effect of contamination related safety aids among participants endorsing various levels of contamination aversion. Contamination aversion is related to, but distinct from, contamination fear; in fact, the construct of contamination aversion resembles disgust sensitivity or propensity more than it does fear (Olatunji & Broman-Fulks, 2009). As a result, future research might test whether disgust sensitivity, rather than contamination aversion, more strongly predicts paradoxical safety aid effects observed in the present study. Various qualities of the safety aid (e.g., the perceived effectiveness and immediacy of the safety aid), in addition to specific areas of concern, are also deserving of future research. Finally, the present study examined the negative consequences of safety aid availability on the development of anxiety. Therefore, hypotheses regarding the effect of safety aids in the treatment of anxiety require independent experimental investigation. In conclusion, future research should examine paradoxical safety aid effects in varying contexts and samples to further elucidate their role in the etiology, maintenance, and treatment of pathological anxiety.

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