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SHORT PAPER

Did you wash your hands? Evaluating memory for objects touched by healthy individuals and individuals with contagious and noncontagious diseases

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Summary

Prior research suggests that individuals recruit a disease-avoidance system designed to avoid sources of illness through threat detection and memory. Our study evaluated whether disease-related memory benefits reflect the distinctive/salient nature of a diseased state versus the infectious nature of a disease by comparing memory for objects touched by healthy individuals or those with a contagious or noncontagious disease. Participants studied videos depicting an actor interacting with objects in which the actor was described as diagnosed with influenza, an infectious disease, cancer, a noninfectious disease, or was healthy, followed by free-recall and source-recognition tests. Correct recall and source recognition were greater overall for touched versus nontouched items, but source recognition was particularly elevated for items touched by the infectious influenza actor. Further, touched-item recognition was positively related to participants' assessed germ aversion—supplemental evidence that disease concerns may facilitate source recollections for touched objects.

KEYWORDS

adaptive memory, behavioral immune system, contamination, free recall, source monitoring

1 | INTRODUCTION

Exposure to sources of pathogenic contaminants is common in everyday life. Although pathogen exposure is typically not life threatening, the illnesses that follow are often aversive. To thwart the effects of illness, humans have evolved a biological immune system to eliminate pathogens that have entered internally and a behavioral immune system (BIS) to detect and avoid contact with sources of potential contaminants (Murray & Schaller, 2016; Neuberg, Kenrick, & Schaller, 2011; Schaller, 2006). Given these detect-and-avoid processes, an important question regarding the BIS is how it impacts the cognitive processing of stimuli perceived as infected with pathogens. The purpose of our study is to examine whether objects that are infected by a contagious-diseased source are better remembered than objects exposed to either a noncontagious disease or a healthy source.

Avoidance behaviors towards disease-related sources have been well documented in both humans and other animals. For instance, animals have been shown to avoid conspecifics perceived as infected with pathogens (Behringer, Butler, & Shields, 2006; Loehle, 1995) and engage in grooming behaviors of themselves and others to remove potential parasites (Zhukovskaya, Yanagawa, & Forschler, 2013). Humans have similarly shown avoidant behaviors such as greater repelling arm movements towards faces when primed with disease concerns

(Mortensen, Becker, Ackerman, Neuberg, & Kenrick, 2010) and by experiencing disgust towards sources of potential contaminants (Schaller & Duncan, 2007; Schaller & Park, 2011). Sensibly, patterns of avoidant responses precipitating from the BIS likely serve an adaptive function—developing over successive generations to facilitate avoidance of diseased sources.

Like the adaptive nature of disease-avoidant processes, researchers have also examined the adaptive functions of memory systems. Fitness-relevant information, such as the availability of food, water, and shelter, is beneficial to one's survival and therefore may be processed and retained more effectively (Nairne, 2015; Nairne & Pandeirada, 2010). Consistent with this possibility, accumulating evidence has shown a memorial advantage for information processed within survival-related contexts. For instance, rating words for relevance to a survival scenario, such as being stranded in the grasslands of a foreign land, produces a large memory advantage relative to deep, nonsurvival control tasks (Kostic, McFarlan, & Cleary, 2012; Nairne, Thompson, & Pandeirada, 2007) and extends to the processing of words in hunter/gatherer scenarios in which survival is paramount (Nairne, Pandeirada, Gregory, & Van Arsdall, 2009). Enhanced memory has also been found for animate (vs. inanimate) items, given that living beings are more likely to impact survival, potentially resulting in survival benefits (e.g., sources of food, collaborative partners, and mates) or costs (e.g., predators and foes; Bonin, Gelin, & Bugaiska, 2014; Nairne, Van Arsdall, & Cogdill, 2017). Therefore, given consistent memorial benefits for objects and sources of information beneficial to survival, threats to survival, such as sources of infectious diseases, may also be highly memorable to avoid contamination.

To evaluate the effects of diseased sources on memory, Fernandes, Pandeirada, Soares, and Nairne see too Bonin, Thiebaut, Witt, & Méot, in press, for a similar study) presented participants with a series of black-and-white objects alongside a description of a person who had presumably touched the object. Two descriptions were used: one that conveyed sickness (e.g., person with a runny nose) and a control that conveyed no health-related information (e.g., person with green eyes). The study phase consisted of objects paired with descriptions that were tested throughout to ensure that participants were encoding the description/object association. A "surprise" final recall test was then completed in which object recall was greater for objects originally paired with the description of the sick individual than the healthy individual. This pattern was suggested to occur due to activation of the BIS for disease-connoting objects, which received greater processing than objects not associated with a disease. These patterns were also found in a subsequent experiment in which objects were paired with faces that contained either visual blemishes designed to communicate the presence of disease (e.g., rashes, herpes, and eczema) or no blemishes. Again, a memory benefit was found for objects paired with a face containing disease-related cues versus a face without blemishes.

Although diseased sources may activate the BIS, producing greater processing of associated information, disease features are also highly salient and distinctive. The benefits of distinctive features on memory are diverse and well established (see Huff, Bodner, & Fawcett, 2015; Hunt & Worthen, 2006, for reviews) and can benefit memory when a stimulus is perceived as unique or statistically rare. In Fernandes et al. (2017), it is unclear whether the memory improvement found for disease-related objects was due to activation of the BIS or due to general salience of objects associated with diseased versus healthy individuals. To delineate the contributions of the BIS and distinctive processing, the purpose of the present study was to directly compare the effects of two separate disease conditions on memory: a disease that was highly contagious (influenza) and therefore would likely to activate the BIS and a noncontagious disease (cancer) that would not activate the BIS. These disease conditions were then compared to a healthy control condition to triangulate potential memorial effects of a present disease.

In our study, participants viewed a series of videos set in various household scenes containing a variety of objects. In each video, an actor walked through scenes and touched a subset of objects. Importantly, participants were informed prior to viewing the videos that the actor was diagnosed with influenza, cancer, or was healthy and not afflicted with ailments. Following the study phase, participants completed a free-recall test for all objects in the scenes and a source-monitoring test to parse source recollections for touched and nontouched items (Johnson, Hashtroudi, & Lindsay, 1993). Source memory (or the recollection of contextual details) has been shown to improve following survival processing (Kroneisen & Bell, 2018), suggesting a link between adaptive processing and source memory. Thus, the inclusion of both test types allows for an examination of whether disease information affects memory more globally, such as when individuals are freely reporting objects from memory or when they are required to monitor for contextual details of remembered objects.

Our study was therefore designed to evaluate two competing accounts for disease-related effects on memory in an ecologically valid context. According to the *BIS account*, memory for touched objects would only be enhanced for the influenza group over the cancer and healthy groups, as only influenza would be perceived as infectious and avoidance of this diseased source would increase the likelihood of positive survival outcomes. Separately, the *distinctiveness account* predicts that memory for touched items would be enhanced over the healthy group when the actor had either influenza or cancer diseases due to the overall salience of a diseased state. To provide a secondary assessment of the BIS account, participants also completed the Perceived Vulnerability to Disease (PVD) scale (Duncan, Schaller, & Park, 2009), which contains two subscales: germ aversion and perceived infectability, to assess individual dispositional concerns towards pathogens. We expected that, if the BIS regulates processing of potential sources of disease, a positive relationship would emerge between the germ aversion subscale and memory for touched objects given that these objects serve as a source of pathogens. We rationalized that if an individual is averse to germs, he or she may increase attentional processing towards touched (vs. nontouched) objects as these objects would be more likely to serve as disease vectors.

2 | METHODS

2.1 | Participants

One-hundred fourteen English-proficient participants with normal or corrected-to-normal vision were recruited from the undergraduate participant pool at The University of Southern Mississippi. Data from one participant were eliminated due to confusion about source-test instructions leaving 38 participants in the healthy and influenza groups and 37 in the cancer group. A sensitivity analysis using G*Power (Erdfelder, Faul, & Buchner, 1996) indicated that our sample size had sufficient power (.80) to detect medium effect sizes (Cohen's d = 0.50) or larger. Participant characteristics are reported in Table 1. Mean participant age was 20.61 years (SD = 3.43; range = 18–42), and mean years of formal education was 13.72 years (SD = 1.46; range = 12–19).

2.2 | Materials

Silent digital videos were created, which portrayed a single female actor touching a series of objects in four different household contexts (kitchen, bedroom, bathroom, and garage; see Figure A1 for static examples). The videos were based static household images in the social-contagion paradigm (Roediger, Meade, & Bergman, 2001) that were recently updated by Huff, Weinsheimer, and Bodner (2016).[1] Each video contained an average of 25.25 objects (range = 22–27) and were normed to be schematically consistent with each household context. In each video, 10 items were touched by the actor, which were randomly selected from the normed data and distributed evenly across the scenes to minimize potential serial-position effects. Two versions of videos were created: one for the influenza group and the other for the healthy and cancer groups. The only difference in each version occurred at the beginning of the video in which the influenza actor sneezed prior to touching objects to reinforce the presence of a contagious illness, whereas the healthy and cancer actor did not. To enhance external validity, each version was filmed using two different female actors, yielding four total sets of videos (two video sets for the influenza version, each with a different actress, and two video sets for the healthy/cancer versions, each with a different actress). Participants only viewed one video set depending on their randomly assigned condition, and video sets were counterbalanced across participants to ensure that the different actresses in the videos were used equivalently in each disease group. The items in the videos and the order in which items were touched were identical across versions. The mean video duration was 46.38 s (SD = 5.26 s), which was equivalent across videos, ts < 1.

The 15-item PVD scale (Duncan et al., 2009) was also administered. The PVD consists of two subscales, germ aversion and perceived infectability, which are suggested to measure separate BIS dispositional responses. The germ aversion subscale consists of eight items to assess an individual's emotional aversion to pathogenic threats (e.g., "It really bothers me when people sneeze without covering their mouths"). The perceived infectability subscale consists of seven items to assess susceptibility to diseases (e.g., "I have a history of susceptibility to infectious diseases"). Responses are made using a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*) with higher scores indicating greater perceptions of disease vulnerability. Six items were reverse scored. The overall PVD (M = 3.86; range = 1.73–5.93; α = .79) and the germ aversion (M = 4.30; range = 1.75–6.25; α = .66) and perceived infectability (M = 3.12; range = 1.00–6.80; α = .87) subscales had acceptable reliabilities.

TABLE 1 Participant characteristics and mean (±95% confidence interval) PVD scale responses as a function of healthy, influenza, and cancer disease groups

Variable	Healthy	Influenza	Cancer
N	38	38	37
Age (years)	21.50_a (±1.67)	20.24_a (±0.67)	20.08_a (±1.10)
Education (years)	13.95_a (±0.53)	13.39_a (±0.37)	13.84_a (±0.47)
PVD scale	3.90_a (±0.29)	3.98_a (±0.23)	3.70_a (±0.30)
Infectability	3.28_a (±0.46)	3.17_a (±0.39)	2.89_a (±0.42)
Germ aversion	4.28_a (±0.33)	4.47_a (±0.28)	4.14_a (±0.36)

Note. Infectability and germ aversion are the two subscales of the PVD. Same letter subscripts indicate equivalence across groups, p > .05, two-tailed.

Abbreviation: PVD, Perceived Vulnerability to Disease scale (Duncan et al., 2009).

2.3 | Procedure

Participants were tested individually or in small groups up to four. Testing of individuals versus small groups was distributed evenly across the three disease conditions. Following informed consent, participants were instructed that they would view a series of videos of an individual walking through four household scenes and would touch a subset of objects. Participants were further instructed to remember as many objects as possible in each scene, regardless if the individual touched the object or not. Videos were displayed on a computer monitor for participants tested alone and on a large projector screen for participants tested in groups. Prior to each video, participants were provided with condition-specific disease information about the actor both visually and auditorily. The healthy group was informed that the individual in the video "was healthy and not afflicted with any ailments." The cancer group was informed that the individual in the video was "diagnosed with cancer, a noncontagious disease that can result in anemia, the development of bodily lumps, and changes in digestive movements." The influenza group was informed that the individual in the video was "diagnosed with influenza, a highly contagious disease that can result in fever, sore throat, and muscle or body aches." Participants studied all four scenes in succession in the order listed above with disease/healthy instructions repeated prior to the start of each video.

[1]The norms in Huff, Weinsheimer, and Bodner (2016) asked 18 undergraduates to list items they would expect to see in each scene. From these norms, the most common items reported as objects in the scenes with the exception of two to three less common items in each scene that were relegated as control items for the source memory test.

Following study of the videos, participants completed a 2-min arithmetic filler task followed by a scene-cued recall test. Participants were provided with a recall sheet with the scene name listed and were asked to recall as many objects from that scene as possible for 2 min, regardless if the objects were touched or not. Scenes were tested separately and in the same order that they were studied with no delay between tests. Immediately following the recall tests, participants completed a 34-item source-recognition test that was forced choice. The test consisted of 24 presented items (three touched and three nontouched items randomly selected from each scene) and 10 nonpresented household items that were listed as uncommon in the scenes from the norming study. Items in the source test were once randomized and presented in the same order to all participants. Participants classified their memory for each item as *touched* (indicating that the actor touched the item), *nontouched* (indicating that the actor did not touch the item), or *neither* (indicating that the object was not presented). Finally, participants completed the PVD and a demographics questionnaire followed by a full debriefing. The experimental session lasted approximately 30 min.

3 | RESULTS

For significant comparisons, effect sizes were calculated using partial-eta squared (η_p^2) for analyses of variance (ANOVAs) and Cohen's *d* for *t* tests. We further tested all nonsignificant comparisons found using traditional null hypothesis significance testing by using a Bayesian estimate of the strength of evidence supporting the null hypothesis (Masson, 2011; Wagenmakers, 2007). This analysis compares two models: one that assumes an effect and another that assumes a null effect. The Bayesian analysis provides a probability estimate that the null is retained and produces a *p* value termed p_{BIC} (Bayesian information criterion). This analysis is sensitive to sample size and increases confidence in reported null effects. Data collected are posted via OSF (osf.io/qbrgm).

TABLE 2 Mean (±95% confidence interval) proportions of correct recall, number of intrusions per list recall, and source attributions for touched and nontouched items or nonpresented items as a function of healthy, influenza, and cancer disease groups

Item type/"attribution"	Healthy	Influenza	Cancer
Free-recall test			
Touched items	.55 (±.03)	.57 (±.03)	.53 (±.04)
Nontouched items	.27 (±.03)	.24 (±.03)	.25 (±.03)
Difference	.28 (±.04)	.34 (±.04)	.28 (±.04)
Intrusions per video	.33 (±.10)	.24 (±.08)	.32 (±.10)
Source-monitoring test			
Touched items			
"Touched"	.60 (±.06)	.72 (±.05)	.64 (±.05)
"Nontouched"	.31 (±.06)	.20 (±.04)	.27 (±.05)
"Neither"	.09 (±.03)	.08 (±.03)	.09 (±.03)
Nontouched items			
"Touched"	.12 (±.03)	.11 (±.04)	.10 (±.03)
"Nontouched"	.51 (±.05)	.54 (±.05)	.55 (±.04)
"Neither"	.36 (±.06)	.35 (±.05)	.35 (±.03)
Nonpresented items			
"Touched"	.04 (±.02)	.04 (±.02)	.05 (±.03)
"Nontouched"	.21 (±.06)	.17 (±.05)	.21 (±.04)
"Neither"	.74 (±.07)	.78 (±.05)	.72 (±.06)

3.1 | Free recall

Table 2 (top panel) reports mean proportions of objects correctly recalled based on whether the object was touched or not touched in the videos and mean number of intrusions recalled per video as a function of disease group. Correct recall was calculated by taking the total number of nonrepeated objects recalled (i.e., only recalled once), divided by the total number of objects presented in each scene. Proportions of recalled objects were then analyzed using a 3 (disease group: healthy vs. cancer vs. influenza) × 2 (object type: touched vs. nontouched) mixed ANOVA. Correct recall did not differ across disease groups as indicated by a nonsignificant main effect of group, $F(2, 110) = 1.11$, $MSE = .01$, $p = .33$, $p_{BIC} = .97$, but a significant main effect of object type indicated that recall was greater for objects that were touched versus not touched (.55 vs. .25), $F(1, 110) = 753.02$, $MSE = .01$, $\eta_p^2 = .87$, $p < .001$. Importantly, a significant interaction was found, $F(2, 110) = 3.47$, $MSE = .01$, $\eta_p^2 = .06$, $p = .03$. This interaction reflected a greater difference between recall for touched and nontouched items in the influenza group than either the healthy group (.34 vs. .28), $t(74) = 2.31$, $SEM = .02$, $p = .02$, $d = 0.53$, or the cancer group (.34 vs. .28), $t(73) = 2.27$, $SEM = .02$, $p = .03$, $d = 0.52$, which in turn, were equivalent (.28 vs. .28), $t < 1$, $p = .96$, $p_{BIC} = .91$. Thus, knowledge that the actor was infected with a contagious disease, but not a noncontagious disease, produced a greater increase in the recall of touched over nontouched items, a pattern consistent with the BIS account. The mean number of extra-video intrusions per list was also compared. Intrusion rates were low across groups and did not differ, $F(2, 110) = 1.34$, $MSE = .08$, $p = .27$, $p_{BIC} = .97$.

3.2 | Source recognition

Table 2 (bottom panel) reports mean proportions of source attributions for touched, nontouched, and nonpresented items. Beginning with touched items, correct attributions (computed as touched items attributed as "touched") were analyzed using a one-way ANOVA. Critically, a significant effect was found, $F(2, 110) = 4.85$, $MSE = .03$, $p = .01$, $\eta_p^2 = .08$, which indicated that correct touched-item attributions were greater in the influenza group than either the healthy group (.72 vs. .60), $t(74) = 3.03$, $SEM = .04$, $p < .01$, $d = 0.70$, or the cancer group (.72 vs. .64), $t(73) = 2.18$, $SEM = .04$, $p = .03$, $d = 0.51$, but did not differ between the healthy and cancer groups (.60 vs. .64), $t < 1$, $p = .34$, $p_{BIC} = .84$. Correct attributions were similarly analyzed for nontouched items

(nontouched items attributed as "not touched") and nonpresented items (nonpresented items attributed as "neither"); however, for both attribution types, no differences were found across disease groups, $F < 1$, $p = .59$, $p_{BIC} = .99$, and $F(2, 110) = 1.17$, $MSE = .04$, $p = .32$, $p_{BIC} = .97$, for nontouched and nonpresented items, respectively. Thus, source attributions were enhanced in the influenza group, but importantly, this pattern was only found for touched items. Again, this pattern is consistent with the BIS account as source attributions were not enhanced for the cancer group over the healthy group and were only found for touched items that were most likely to be contaminated by the contagious actor.

3.3 | Correlations with the PVD scale

Correlations between the PVD scale, the two subscales (infectability and germ aversion), and recall and source attributions for touched and nontouched items are reported in Table 3. No reliable correlations were found between PVD measures and the recall of touched items, *r*s < .04, *p*s > .66, or nontouched items, *r*s < .17, *p*s > .09. Importantly however, a significant positive relationship was found between the germ aversion subscale of the PVD and correct source attributions to touched items, $r(113) = .22$, $p = .02$, but not nontouched items, $r < .04$, $p = .86$. To test whether the positive relationship between germ aversion and touched source attributions depended upon the disease group, we examined the germ aversion by disease group interaction using an analysis of covariance. No interaction was found, $F < 1$, $p = .63$, $p_{BIC} = .99$, demonstrating that the positive relationship between germ aversion and touched source attributions was equivalent across disease groups, which is not surprising given that the PVD scale is a dispositional measure and likely not sensitive to instructions presented in the different disease groups. This pattern is noteworthy as it suggests that overall, individuals averse to germs were more likely to selectively remember whether an object was touched by the actor than items that were not touched. Though not moderated by disease condition, this pattern supports the BIS account, suggesting that high pathogen concerns may naturally facilitate processing of touched objects. No reliable correlations were found between touched and nontouched source attributions and the overall PVD scale or the infectability subscale, *r*s < .18, *p*s > .05.

4 | DISCUSSION

The present findings provide empirical evidence that the activation of the BIS can facilitate memory for objects contaminated by a threatening disease. Participants who were instructed that an actor in a series of videos was diagnosed with influenza, a highly contagious disease, showed a greater difference in free recall of touched and nontouched objects and a greater rate of correct source attributions for touched items relative to actors either diagnosed with cancer or who were healthy. Comparisons to these latter conditions are critical as they provide a key test between the BIS account and the distinctiveness account. Our finding of greater source attributions for touched objects in the influenza group over the cancer and healthy groups suggests that knowledge of a contagious disease facilitates memorial processing of objects potentially contaminated by a contagious disease. The memory benefit for objects ostensibly contaminated by disease is consistent with prior work, though our additional comparison to a noncontagious disease comparison (cancer) is novel (see Bonin et al., in press; Fernandes et al., 2017). Additionally, the influenza group showed no memory benefit for nontouched objects in either recall or source tests relative to the other groups and only showed a benefit for touched items in the source test. Thus, the presence of the contagious influenza did not facilitate memory for all objects in the scenes (i.e., there was not a global memory improvement), only the source memory for touched objects that were contaminated by the diseased source.

As an additional analysis of the BIS, our study examined the relationship between responses on the PVD and memory for touched objects. Our analyses found a positive correlation between the germ aversion subscale and correct source attributions for touched objects, and this pattern was equivalent across disease groups. This finding suggests that individuals concerned with pathogens were more likely to recollect source details for touched objects. Of note, no relationship was found between touched source attributions and the perceived infectability subscale of the PVD, demonstrating that one's concern about their general susceptibility to disease was insufficient to facilitate memory for touched objects. To our knowledge, the PVD scale has not been compared with recognition performance for disease sources. Only when individuals were concerned about the presence

TABLE 3 Correlations with the PVD scales and subscales and correct recall and source attributions for touched items

Variable	1	2	3	4	5	6	7
1. PVD scale	—						
2. Infectability	.78**	—					
3. Germ aversion	.74**	.19*	—				
4. Touched recall	.00	−.04	.03	—			
5. Nontouched recall	−.16	−.05	−.17^	.23*	—		
6. Touched source	.18^	.06	.22*	.31**	−.32**	—	
7. Nontouched source	−.03	−.02	−.02	−.05	.21*	−.09	—

Note. Infectability and germ aversion are the two subscales of the PVD.

Abbreviation: PVD, Perceived Vulnerability to Disease scale (Duncan et al., 2009).

**$p < .01$. *$p < .05$. ^$p < .10$, two-tailed.

of pathogenic threats, as assessed by the germ aversion subscale, were they more likely to remember the correct source of touched objects that were more likely to be contaminated.

Our goal in this study was to separate the contributions of disease distinctiveness from disease infectability; however, we assume that the influenza and cancer disease states are indeed similarly distinctive from the healthy condition. To lend credence to our assumption, we conducted a secondary norming study in which 46 online participants were asked to rate the healthy, influenza, and cancer actor descriptions used in our study on the basis of distinctiveness (i.e., whether the description makes an individual distinguishable) and emotionality (i.e., whether the description elicits a high or low emotional response, either positive or negative). Disease conditions were presented in a random ordering, and participants made their ratings using a 1 (*low*) to 7 (*high*) scale (see Table A1). Participants rated the influenza and cancer descriptions as equally more distinctive than the healthy description. Moreover, cancer was rated as being more emotional than the influenza and healthy conditions, yet despite this greater rating, the cancer group produced no memory advantage over the healthy or influenza groups. These ratings therefore suggest that the source advantage in the influenza group was likely due to BIS activation rather than an increase in perceived distinctiveness or emotionality.

Although knowledge of influenza improved source memory for touched objects, our study was careful to ensure that disease information was salient to participants across groups. In addition to repeating disease information about the actor prior to each video, actors in the influenza condition provided a sneeze at the beginning of each video to further reinforce contagious disease information. Although our methods made disease information overt (as was the case in both Bonin et al., in press, and Fernandes et al., 2017), it is likely that a similar pattern may occur when disease information is relatively muted. For example, Miller and Maner (2011) reported that individuals who were ill within the past week showed greater attention towards disfigured faces (a potential marker of disease). In this study, no overt disease-related cues were provided, yet attentional effects were found, suggesting that disease information need not be explicitly available, provided that individuals were recently ill. Of course, examining whether the BIS becomes activated to increase memory for contagious-diseased sources with more covert cues would be informative. If the BIS is sensitive, increased processing of disease-related information may be commonplace, which would be highly adaptive to protect oneself from possible biological threats. Indeed, relatively subtle cues such as benign birthmarks have been shown to induce perceptions of contamination (Ryan, Oaten, Stevenson, & Case, 2012), which may suggest that subtle cues can activate the BIS even in instances where contamination is minimal or nonexistent.

Further, it is possible that the BIS activation found in our influenza group may instead reflect a more strongly activated BIS rather than a BIS that is activated in an all-or-none process. Given BIS activation following relatively subtle cues (e.g., Ryan et al., 2012), it is possible that the mere mention of disease to participants is sufficient to activate the BIS, but the threat of contagion may increase the activation even more. Our study does not allow for the differentiation between an all-or-none and a more graded activation of the BIS given that our healthy description mentioned that the actor was indeed healthy and not afflicted with ailments. Simply mentioning the healthy status may have activated the BIS, albeit at a low level. Regardless of these possible qualitative differences in how the BIS is activated, we would still expect that infectious sources would be better remembered than noninfectious sources based on our source data.

In addition to examining potential triggers of the BIS and whether activation is graded, it will also be important for researchers to determine the specific cognitive mechanisms that contribute to better memory for contagious-diseased sources. Given the potential for enhanced attentional processes following recent illness (e.g., Miller & Maner, 2011), the BIS may operate to enhance attentional processing of stimuli that are associated with potential contaminants, facilitating their encoding. Conversely, the BIS may instead enhance monitoring for potentially contaminated sources during retrieval. Our finding of better source discrimination for touched items in the influenza group supports the notion that contagious pathogens facilitate monitoring for contaminated sources, suggesting a retrieval-based locus. However, given that source details are often bound to target objects at the time of study, the patterns may also reflect encoding processes. Researchers have utilized a variety of methods to separate encoding and retrieval processes including manipulations at study or test to disrupt processes such as a secondary task to disrupt attention (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996), the use of metamemory judgments (Metcalfe & Dunlosky, 2008), and/or estimating processes through recognition response models by using a signal-detection analysis or the drift-diffusion model (Huff & Aschenbrenner, 2018; Ratcliff, 1978). Separating contributions of encoding and retrieval using any one or a combination of these methods may improve our understanding of how BIS activation can affect memory processes in both basic and applied research settings.

5 | CONCLUSION

The present research provides important insights into how the BIS can affect the cognitive system and provides evidence against disease distinctiveness as a potential alternative. The ability to avoid sources that may compromise an individual's survival is an adaptive feature of the BIS that requires the ability to effectively encode and later retrieve these sources. Our data support these processes and add to the growing body of evidence that cognitive processes are tuned towards processing fitness-relevant information (Fernandes et al., 2017; Nairne & Pandeirada, 2016). Greater understanding of those mechanisms responsible for the activation and operation of the BIS, such as whether activation is all-or-none versus graded and how this avoidance-based system impacts encoding and retrieval processes, will be useful for greater specification of how the cognitive system evaluates biological threats.

CONFLICT OF INTERESTS

The authors report no conflict of interests with this study.

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APPENDIX A

FIGURE A1 Sample still images taken from the bathroom (top panel) and kitchen (bottom panel) household videos [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE A1 Mean (±95% confidence interval) distinctiveness and emotionality ratings for the influenza, cancer, and healthy condition descriptions

Disease description/characteristic	Healthy	Influenza	Cancer
Distinctive	3.48_a (±0.57)	4.20_b (±0.55)	4.43_b (±0.58)
Emotional	2.07_a (±0.45)	2.39_a (±0.45)	3.54_b (±0.64)

Note. *N* = 46. Same letter subscripts indicate equivalence across groups, $p > .05$, two-tailed. Ratings were made using a 1 (*low on a dimension*) to 7 (*high on a dimension*) scale.