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COVID-19 and Memory: A Novel Contamination Effect in Memory

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Abstract

The Behavioral Immune System (BIS, Schaller & Park, 2011) is a defense system whose function is to protect against pathogen exposure. Memory is an important component of this system (Fernandes et al., 2017). We investigated "contamination effects" in memory in relation to COVID-19. Photographs of everyday objects were shown to adults ($N = 80$) in the hands of either a healthy or a contagious person who had contracted SARS-CoV-2. "Contaminated objects" were recalled better than "non-contaminated objects" suggesting that a contamination effect in memory in humans is easily acquired in the absence of apparent visual cues of disease.

Keywords

COVID-19, pathogens, adaptive memory, behavioral immune system

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"Do not underestimate the small adversaries: a lion is seen, not a virus". This anonymous proverb reminds us that pathogens (e.g., viruses, bacteria), even though they are not visible with the naked eye, represent a hostile force of nature and exert strong selection pressures on the evolution of living organisms (Ewald, 1993; Lagrue, 2020; Van Blerkom, 1993). At the time of writing, the COVID-19 pandemic is still present and the coronavirus SARS-CoV-2 has already caused the death of more than 6 million people around the world (https://www.worldometers.info/coronavirus/). Pathogens have been present on earth for a much longer time than humans (bacteria have existed from the very beginning of life on Earth at least 3 billion years ago [Homann et al., 2018; Nutman et al., 2016] while the emergence of Homo occurred about 2 million years ago [Pin, 2015]) and they have been responsible for more deaths in our species than any other cause. Indeed, diseases have caused more deaths than accidents, wars, or natural disasters together (Inhorn & Brown, 1990). The COVID-19 pandemic that the world is facing clearly illustrates (unfortunately) that pathogens still represent a great threat causing much hardship at both the individual and collective levels.

The Biological and the Behavioral Immune System

Humans are equipped with two defense systems that allow them to combat infectious agents (Miller & Maner, 2011). The biological immune system is the best-known system and combines innate and adaptive immune responses to detect and eliminate pathogens (Farmer et al., 1986; Richtel, 2019). This system helps us fight diseases but it is metabolically costly (Lochmiller & Deerenberg, 2000; Schaller & Duncan, 2007) and acts as a reactive line of defense (Allen & Wynn, 2011). Another system plays a crucial role in protecting us against pathogens: the Behavioral Immune System (BIS: Murray & Schaller, 2016; Schaller, 2006, 2011, 2016; Schaller & Duncan, 2007; Schaller & Park, 2011). The BIS consists of a set of psychological mechanisms whose ultimate function is to avoid potentially dangerous pathogens (Ackerman et al., 2018; Schaller & Park, 2011) or to expel them when ingested. Avoidance behaviors have also been

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observed in non-human animals such as mice, which avoid infected group members (Kavaliers et al., 2003), or tadpoles, which stay away from conspecifics infected by intestinal parasites (Kiesecker et al., 1999). Similarly, domestic ungulates prefer to graze in areas that are not contaminated by fecal matter (Brambilla et al., 2013).

Disgust: A Core Component of the BIS

Disgust is a primary emotion and a core component of the BIS that is involved in disease avoidance (Oaten et al., 2009). Disgust was originally described by Darwin [1809–1882] in his book written in 1872 as a sensation that *"refers to something revolting, primarily in relation to the sense of taste, as actually perceived or vividly imagined; and secondarily to anything which causes a similar feeling, through the sense of smell, touch, and even of eyesight."*(p. 253). Disgust is thought to have evolved to protect individuals from ingesting toxins (Curtis et al., 2004), and this is the reason why we feel disgusted by things that pose a risk of contamination. Attentional mechanisms have been shaped by disgust, with disgusting stimuli capturing more attention than neutral ones (e.g., Chapman, 2018; Chapman et al., 2013; Perone et al., 2021). Disgust also modulates memory. Photographs depicting disgusting things (e.g., injuries, rotten food) are remembered better than photographs depicting neutral things (e.g., a fork, a cup), and even better than photographs eliciting fear (e.g., a lion, a shark) (see Chapman, 2018; Chapman et al., 2013; Schienle et al., 2021). Importantly, disgusting stimuli are also potential vectors of contaminating agents. Related to the aim of the present research, certain studies have also shown that we have better memory for contaminated things in our environment, such as poisonous mushrooms (Fančovičová et al., 2020), toxic fruits (Prokop & Fančovičová, 2014), or objects touched by a contagious person (Bonin, Thiebaut, Prokop, et al., 2019; Fernandes et al., 2017, 2021; Gretz & Huff, 2019). Contamination effects in memory represent a relatively new line of evidence in favor of the adaptive view of memory.

Adaptive Memory: Contamination and Memory

According to the adaptive memory view (Nairne, 2010, 2014, 2015, 2016), evolutionary pressures encountered in the distant past sculpted our memory systems to retain fitness-related information better than fitness-unrelated information. For instance, high-caloric food is localized better than low-caloric food (De Vries et al., 2020). More generally, items encoded in a survival context are remembered better than those encoded in a non-survival context (i.e., the survival processing advantage, e.g., Bonin, Thiebaut, Prokop, et al., 2019; Nairne et al., 2007, 2008). As mentioned above, recent evidence also suggests that contaminated things are remembered better than non-contaminated things (Bonin, Thiebaut, Witt, et al., 2019; Fernandes et al., 2017, 2021; Nairne, 2014). For example, objects presented with verbal descriptions referring to a potential source of contamination (e.g., person with a high fever, person with a runny nose) are remembered better than objects presented with neutral descriptions (e.g., person with green eyes) (Fernandes et al., 2017, 2021). Other studies have used photographs of faces showing signs of contamination (vs. "healthy faces") instead of verbal descriptions and have found the same results (Bonin, Thiebaut, Witt, et al., 2019; Fernandes et al., 2017, 2021). Contamination effects in memory have also been observed using videos depicting actors interacting with objects and described as "healthy" versus "cancer-sufferer" versus "diseased-contagious" (Gretz & Huff, 2019). More precisely, Gretz and Huff (2019) found that "touched items" were remembered better than "non-touched items" (in free recall) and, more importantly, that items touched by the actor with influenza were remembered better than items touched by the other "non-contaminated" actors.[1] It is important to stress that even though cancer was rated to be more emotional than influenza, the "cancer condition" did not produce a memory advantage compared to the healthy condition, perhaps because it is a noncontagious disease which does not activate the BIS (Gretz & Huff, 2019).

Previous research has used sources of contamination (e.g., objects associated with faces showing various signs of disease; hands covered with vomit or diarrhea) that were also disgusting (Bonin, Thiebaut, Witt, et al., 2019; Fernandes et al., 2021). Since disgust enhances memory (Chapman, 2018; Charash & McKay, 2002; Croucher et al., 2011; Schienle et al., 2021), one important issue related to contamination effects in memory is the question of whether contaminated things have to be disgusting in order for a memory boost to be observed. As stated by Al-Shawaf et al. (2016): "*The effects of disgust on memory are largely unknown* (…)" (p. 178). Indeed, the role of disgust as a proximal explanation of contamination effects in memory remains unsettled. In Fernandes et al. (2017), a contamination effect was found when everyday objects were presented next to sick compared to healthy faces (Study 2). In another study (Study 3), however, the same everyday objects were presented in proximity to fake sick faces, i.e., the sick faces were presented as those of actresses preparing to portray sick people in a TV show such as "Grey's Anatomy", and were compared to healthy faces, i.e., faces presented as belonging to viewers of this TV show. In this situation, where the potential for contamination was lacking, no memory benefit occurred for the objects paired with the (fake) sick faces.[2] The fear of being contaminated may therefore be necessary (for further evidence see Fernandes et al., 2021). This line of reasoning makes sense given that fear triggers memory formation and elicits various behavioral and physiological responses once learning has occurred (Johansen et al., 2011).

Aim of the Present Study

The aim of the present study was to investigate contamination effects in memory in relation to SARS-CoV-2. Beneficial adaptive behavior would appear to consist in remembering people who have been in contact with carriers or the surfaces they have touched because, according to the World Health Organization, the virus responsible for COVID-19 can be transmitted by droplets as well as by contaminated surfaces (Moore, 2020), in particular door handles, metro hand grips, or phone screens (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public).

At the time of writing of this paper, the world is still being ravaged by SARS-CoV-2, and more specifically by the disease it causes: COVID-19. One formidable problem in the case of the COVID-19 pandemic relates to asymptomatic carriers (Dezecache et al., 2020). As clearly stated by Seitz et al. (2020): "*Motivations to physically distance and to cleanse after contact with potentially contaminated surfaces are native to the contact disgust system but are strongest when there are clear signs of disease—blood, guts, bodily fluids, yellow eyes, pale skin, lesions, or a runny nose. In the COVID-19 pandemic, this is not what most people see. Family, friends, coworkers, and strangers look healthy—as they can be asymptomatic for days, not knowing they are infected.*" (p. 27,769). These individuals cannot therefore be identified as potential threats. Indeed, SARS-CoV-2 has an incubation period of about 14 days. During that time, people who are infected do not show signs of infection. Thus, an individual who is infected can transmit the disease before becoming sick and exhibiting signs of sickness such as fever, fatigue, cough, or loss of smell (Moore, 2020). More importantly, most people who are infected by SARS-CoV-2 do not display visible signs on the face that may trigger disgust. Thus, one key issue investigated in the current study was whether contamination effects in memory can be obtained when there are *no visible disgust-inducing signs.* Given the central role of disgust in the BIS (Oaten et al., 2009), this system may not be suited to dealing with such a modern disease (Ackerman et al., 2021). Thus memory—a cognitive component of the BIS that is sensitive to disgust (Chapman, 2018; Oaten et al., 2009)—may not be activated in this novel disease context and, therefore, a contamination effect may not be observed. One theoretical implication would be that the BIS was shaped mostly for the detection and avoidance of diseases eliciting visible signs of disgust. The fact that people who have contracted COVID-19 do not exhibit disgusting facial or bodily signs stands in sharp contrast to the case of other diseases. Indeed, of the 25 deadliest diseases in history, 23 come with facial stigma (Wolfe et al., 2007) which result in social rejection (Crandall & Moriarty, 1995). For example, people who contract leprosy—an infectious disease that still exists (e.g., in India)—have a ridged and thick skin as well as a wider nose. However, "contamination-without-disease-cues effects" do not necessarily have to be processed via an emotional path through disgust or fear. People may infer possible pathogen contamination from certain relevant environmental details such as the presence of unfamiliar crowds (Wang & Ackerman, 2019) or unfamiliar (vs. familiar) individuals (Bressan, 2020; De Vries & Lee, in press; Faulkner et al., 2004; Schlager & Whillans, 2022), or the knowledge that some individuals have more interpersonal interactions than others (e.g., extraverts) and are therefore more prone to contracting the virus and then transmitting it (Rolón et al., 2021). Individuals also know that going to specific places (e.g., a restaurant) during an acute phase of the COVID pandemic may put them at risk (De Vries & Lee, in press). People may also use information provided by the media about COVID-19 to infer the risk of being infected (e.g., number of cases). Indeed, it is quite adaptive to use the available knowledge about a disease, especially when it produces no visible symptoms, and remember the circumstances surrounding it. (However, it is worth mentioning that the perception of the risk of personally experiencing an adverse life event is generally underestimated relative to the perceived risk of other people experiencing such events [Sharot, 2011] and it has been found that the perceived risk of contracting COVID is no exception to this optimism bias [Wise et al., 2020].) Interestingly, as far as the specific roles of knowledge about COVID-19 and of COVID-related affects in disease avoidance are concerned, a recent study has shown that social-physical distancing in students was (positively) predicted by affect (feeling threatened by COVID-19), whereas for members of the wider community (an older and a more diverse population), distancing was predicted by both affect (e.g., how concerned they were about catching COVID-19) and knowledge (e.g., number of days officially recommended for self-quarantining) (Choi et al., in press).

To test the existence of a contamination-without-disease-cues effect in memory, we used photographs designed by Fernandes et al. (2019). Front-on photographs of everyday objects were shown in clean hands (see Figure 1 in Fernandes et al., 2019 for examples). Two groups of participants took part in this study. In one of the groups, the participants were told that the objects were held in the hands of an individual who was infected by SARS-CoV-2, whereas the participants in the other group were told that the objects were held in the hands of an individual who was in excellent health. For each presented object, the participants had to rate (on 5-point Likert scales) the extent to which they found this object useful in everyday life. A surprise memory task took place after short distraction tasks. It is important to stress that memory for *exactly the same objects* being held by *clean hands* was tested, but the *fitness-relevance of the context* (presence or absence of disease) varied between groups.

Method

Participants

Eighty-two adults (M = 20.42 years; SD = 2.08; 68 females) took part. Most of them (77) were psychology students at the University of Bourgogne Franche-Comté. They were tested individually and received course credits for their participation. The participants were all native speakers of French and none of them were taking medication that could affect their memory. Two participants were excluded: One participant was excluded because she had already taken part in a similar experiment and another participant because she was dyslexic. Half of the participants were randomly assigned to the “healthy” condition and the remaining half to the “COVID-19” condition. Thanks to the availability of the data from the Fernandes et al. (2021) Study 2 and Study 3 (disease context)—which are the two studies most comparable with the current research—we were able to compute an estimation of Cohen’s d with a between-subjects design using 40 participants per condition. The estimation of $d = .57$[3] leads to an *a priori* power of .71 in a bilateral test and of .81 in a unilateral test at the alpha level of .05. Since the direction of the contamination effect in memory is predicted, a one-tailed test is more appropriate here (see, for instance, Roelofs & Piai [2017] for this type of application). Written informed consent was obtained from all of the participants before the beginning of the study. All the study procedures were approved by the Statutory Ethics Committee of the University Clermont Auvergne.

Stimuli

We chose 30 photographs of objects presented in clean hands from the Objects-on-Hands Picture Database (Fernandes et al., 2019). All of the selected photographs had high name agreement (M = 95.39%, SD = 15.13) in French[4] and were front-on views of everyday objects. The list of the object names is available in the Supplemental Material.

Apparatus

The different experimental scripts were run on an Apple computer using Psyscope software (Cohen et al., 1993) which controlled the randomization of the photographs.

Procedure

The participants first gave informed consent and were then randomly assigned to one of the two encoding conditions (healthy vs. COVID-19). First of all, demographic information was collected (age, gender, use of neuroleptics, level of study, native language). In the healthy condition, the instructions stated: “In this task, you will see objects presented in the hands of a perfectly healthy person. Indeed, a medical check-up showed that she is in really excellent health.” In the COVID-19 condition, the instructions were as follows: “In this task, you will see objects presented in the hands of a sick person. She is infected by coronavirus and is extremely contagious.” During encoding, the participants had to rate, on a 5-point Likert scale, the extent to which they found each of the objects presented in the photographs useful in everyday life. The photographs were randomly presented in the center of the screen. The times taken to give the ratings were collected. During a retention interval of 3-min, the participants had to perform the ‘X-O’ letter comparison task (Salthouse et al., 1997) and the ‘plus-minus’ task from Jersild (1927) and Spector and Biederman (1976). The free recall task then followed and the participants had to write down the names of all the objects they remembered on a sheet of paper. They were given five minutes to do this.

At the end of the recall period, the participants completed the Perceived Vulnerability to Disease (PVD) questionnaire (Duncan et al., 2009) and the Three Domain Disgust Scale (TDDS) (Tybur et al., 2009). The PVD questionnaire (Duncan et al., 2009) consists of two subscales. The first subscale, “perceived infectability”, includes 7 items such as “If an illness is going around, I will get it”, “In general, I am very susceptible to colds, flu, and other infectious diseases”. The second subscale is “germ aversion”. It is made up of 8 items such as “I prefer to wash my hands pretty soon after shaking someone’s hand”, “I don’t like to write with a pencil someone else has obviously chewed on”. For each statement, participants are required to indicate their agreement using 7-point Likert scales (1 = strongly disagree vs. 7 = strongly agree). The TDDS comprises 21 items relating to moral disgust (e.g., “shoplifting a candy bar from a convenience store”), sexual disgust (e.g., “hearing two strangers having sex”), or pathogen disgust (e.g., “seeing some mold on old leftovers in your refrigerator”). Participants indicate their level of agreement with each statement on a 7-point Likert scale (0: “not at all disgusting”, 6: “extremely disgusting”).

Results

Free Recall

A significant mnemonic advantage was obtained for “contaminated” objects ($M = .64$, $SD = .09$) compared to “healthy” objects ($M = .55$, $SD = .15$), $t(78) = 3.31$, $p < .01$, $d = .74$. The number of extralist intrusions ($M = .32$, $SD = .56$) was low.

Perceived Utility

The perceived utility of objects held in the hands of a person infected by coronavirus ($M = 2.99$, $SD = .55$) did not differ from that of objects held in the hands of a healthy person ($M = 3.04$, $SD = .44$), $t(78) = -.44$, $p = .66$, $d = -.098$. There was no correlation between perceived utility of the objects and recall rates ($r = -.009$, $p = .93$).

Rating Times

The time taken to rate the perceived utility of the objects held in the hands of a person infected by SARS-CoV-2 ($M = 2{,}104$ ms, $SD = 669$) was no longer than the time taken to rate the utility of objects seen in the hands of a healthy person ($M = 2{,}314$, $SD = 1{,}044$), $t(78) = -1.07$, $p = .29$, $d = -.23$.

Individual Differences

As can be seen from Table 1, there were no significant differences on the scores obtained with the two PVD subscales or on the scores obtained in the TDDS. In addition, none of the

Table 1. Mean Scores (and Standard Deviations) on the PVD and TDDS Scales.

	Healthy condition	Covid-19 condition	*P* value
Perceived infectability	21.6 (8.15)	24.6 (9.54)	.138
Germ aversion	33.6 (7.85)	32 (9.31)	.401
Moral disgust	27.2 (8.24)	24.8 (9.94)	.248
Sexual disgust	19.2 (8.54)	21.9 (10.8)	.227
Pathogen disgust	26.9 (6.96)	26 (6.34)	.536

correlations between these scores and the recall rates reached significance either within the individual conditions ($Max|r| = .195$; all $ps > .227$) or when all participants were considered together ($Max|r| = .145$; all $ps > .2$).

Discussion

By deploying a set of proactive mechanisms whose ultimate function is to guide organisms to inhibit contact with pathogens, the BIS is a first line of defense against pathogens. Although this system is distinct from the biological immune system, the two are complementary and interact in a complex way (Troisi, 2020). The BIS is an adaptation designed to preemptively detect, and subsequently avoid, potential sources of contamination (Ackerman et al., 2018; Murray & Schaller, 2016; Schaller, 2006, 2011, 2016; Schaller & Park, 2011). However, this view is still the subject of theoretical development and debate (e.g., Lieberman et al., 2018; Lieberman & Patrick, 2018; Murray & Schaller, 2016). There is some disagreement regarding the relationship between the BIS and disgust and whether the BIS should be viewed as synonymous with "disgust" (Hlay et al., 2021) or not (e.g., Schaller, 2006, 2011, 2016; Schaller & Park, 2011). In our view, if an organism is to avoid different sources of contamination efficiently, it must learn and remember what the sources of contamination are, where they are located, etc. In humans, social learning is also very important in order to avoid sources of contamination. For instance, to eat mushrooms safely, it is necessary to learn whether or not they are toxic (Fančovičová et al., 2020) and the same holds true for various plants (Wertz, 2019). Thus, the BIS involves memory. Until now, however, there have only been very few "BIS studies" investigating the involvement of memory. Indeed, the majority of studies that have explored the cognitive aspects of the BIS have focused on perceptual or attentional processes (Axelsson, Sundelin, Lasselin, et al., 2018; Axelsson, Sundelin, Olsson, et al., 2018; Sundelin et al., 2015). As reviewed in the Introduction, several studies have found that contaminated things are remembered better than non-contaminated things (Bonin, Thiebaut, Witt, et al., 2019; Fernandes et al., 2017, 2021; Gretz & Huff, 2019). However, these studies are relatively recent additions to the adaptive memory literature.

In the present research, we investigated contamination effects in memory in relation to COVID-19, a newly emerged infectious disease. One critical issue that was addressed was whether a contamination effect would emerge when contaminated stimuli do not show visible signs eliciting disgust. Indeed, being infected by SARS-CoV-2 does not produce visible facial signs in most individuals. It is worth remembering that certain researchers have therefore claimed that the BIS may not be fine-tuned to detect such a modern disease (Ackerman et al., 2021). However, our findings suggest otherwise. In effect, we found that objects presented in the hands of an individual infected by coronavirus (SARS-CoV-2) were remembered better than the same objects presented in the hands of someone healthy. The finding that a disease context was able to boost memory of objects touched by an individual is consistent with previous studies (Bonin, Thiebaut, Witt, et al., 2019; Fernandes et al., 2017, 2021; Gretz & Huff, 2019). However, and importantly, a contamination effect in memory was obtained for the first time with a new disease when the hands or the objects showed no visible signs that could elicit disgust. Our findings thus indicate that sources of contamination do not have to be visually disgusting in order to bring about a memory boost.

What, then, are the proximate mechanisms underpinning contamination effects in memory? Fernandes et al.'s (2021) findings led the authors to question whether arousal and disgust constitute potential explanations of the recall advantage observed for contamination. Our findings concerning individual differences in the PVD and TDDS and their relation to memory performance also do not fit well with the idea that disgust is involved in the contamination effect found here. First of all, we did not find that participants in the COVID-19 condition had higher levels of germ aversion, perceived infectability or (pathogen) disgust. We cannot exclude the possibility that this was due to the measures used, which are not reliably able to capture situational fluctuations in pathogen avoidance. Indeed, as pointed out by Makhanova et al. (2021): "*The PVD and the TDD are widely used and have greatly facilitated the development of the literature on pathogen avoidance. Nevertheless, both scales reflect trait pathogen avoidance and are typically not affected by experimental manipulations of pathogen avoidance motives*." (p. 23). Second, none of the correlations between PVD, TDDS scores and recall rates reached significance in either condition. However, since we did not directly measure the emotion of disgust during encoding, we think that it is premature to rule out the involvement of this emotion in contamination effects in memory. The precise role of disgust in memory is still unknown (Al-Shawaf et al., 2016), and its relation to memory processes therefore remains to be investigated more thoroughly. Future studies could investigate the role of disgust in memory, for instance by using electromyography (Chapman et al., 2009; De Jong et al., 2011) or recordings of physiological parameters such as heart rate (Rohrmann & Hopp, 2008; Stark et al., 2005) or skin conductance (Stark et al., 2005). Another possibility is that the emotion of fear (of contamination) is responsible, at least in part, for the contamination effect in memory reported here because, as claimed by Troisi (2020): "*fear of infection is deeply rooted in our emotional brain.*" (p.73). However, since we did not measure the emotion of fear directly, our findings tell us nothing about the role it may play. One way to explore this possibility more directly would be to use psychophysiological factors related to threat and to the emotion of fear. For example, to investigate the involvement of fear in the survival advantage in memory, Fiacconi et al. (2015) used measures of heart rate to index the presence of fear bradycardia, which is a marker of the defensive freezing response. Fiacconi et al. (2015) were able to show that when words are rated for their relevance within a survival scenario (e.g., "truck" in the context of finding food/water or protecting oneself against predators when stranded in wild grasslands), heart rate slows down more than when words are rated for their relevance within a house-moving scenario (e.g., "truck" to move your belongings to a new apartment/house). Another candidate proximate mechanism is attention. Contaminated objects capture more attention than non-contaminated objects (Perone et al., 2021; van Hooff et al., 2013). A line discrimination task such as the one used by Chapman et al. (2013), for example, could be used to clarify the role of attention. Finally, as set out in the Introduction, it also is also possible that people infer the potential for pathogen contamination from certain relevant environmental details (e.g., presence of unfamiliar crowds, Wang & Ackerman, 2019). Thus, future studies should aim to better characterize proximate explanations of the contamination effect reported here.

Since we are curious about the emotions that surround the "coronavirus disease", a newly emerged pandemic which has brought about a wide range of outcomes at both individual and societal levels (Seitz et al., 2020), we decided to use online questionnaires to explore the involvement of the emotions of fear and disgust that are aroused when thinking about this disease (see Supplemental Material for details). It must be stressed that since these ratings were collected independently of the memory experiment, any information they provide about the involvement of these emotions in the contamination effect in memory reported in the present research is purely indirect and must therefore be treated with care. Caution is thus warranted and we should not extrapolate in an attempt to find a ready account for this novel contamination effect in memory. Fifty participants had to use 6-point Likert scales to evaluate the levels of fear and disgust (but also sadness and anger, see Supplemental Material B) they felt when thinking about the disease caused by SARS-CoV-2. Four questions were then randomly presented to the participants and they responded on the same Likert scales: (1) Are you afraid of being infected by coronavirus because of the risk it could represent for you? (2) Are you disgusted by the idea of being infected by coronavirus? (3) Would you be afraid to touch an object that a person infected by coronavirus has touched? (4) Are you disgusted by the idea of touching an object that a person infected by coronavirus has touched? To summarize the findings, we found that when the participants were asked to think about COVID-19, their level of fear was reliably higher than their level of disgust. Moreover, the scores given in response to the more specific questions confirmed this observation. The participants expressed more fear than disgust at the idea of being infected. In addition, the level of fear at the thought of touching an object previously in contact with a person infected by SARS-CoV-2 was higher than the level of disgust induced by the thought of touching the same object. (The detailed results are provided in the Supplemental Material.)

It is important to acknowledge some limitations of the present work in order to help and guide future research. To begin with, our sample of participants consisted overwhelmingly of females. Previous studies have shown sex differences in disgust sensitivity and germ aversion. Indeed, females express greater levels of (pathogen) disgust (Al-Shawaf et al., 2018) and germ aversion than men (Duncan et al., 2009). It would be interesting in future research to investigate whether the findings reported here are moderated by sex. Fernandes et al. (2021) pointed out that if disgust were the key emotion underpinning contamination effects in memory, a larger effect should be observed in females than in males, but found no such results in their studies, both males and females remembered contaminated things better than non-contaminated things.[5] Second, in the present study, the majority of participants were young and we know that young adults are not particularly at risk of having health issues as a result of contracting the virus. Instead, the disease is more lethal for very old individuals, and especially those with comorbidities (Bartleson et al., 2021). It would be interesting to test different types of people at risk for their memory of objects touched by people infected with SARS-CoV-2. Another interesting avenue of investigation would be to test medical staff such as doctors or nurses who are more familiar with pathogens.

Conclusion

The ultimate function of the BIS is to prevent us from entering into contact with pathogenic agents and memory is a critical component of this system. However, research into the BIS has only more recently focused on its cognitive aspects. In the present work, we investigated memory in relation to contamination with SARS-CoV-2. In line with previous studies (Bonin, Thiebaut, Witt, et al., 2019; Fernandes et al., 2017, 2021; Gretz & Huff, 2019), we found that contaminated objects were recalled better than non-contaminated objects, even when the objects were presented in hands showing no visible signs electing disgust.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

Notes

1. These studies illustrate what has been called the "law of contagion" (Rozin & Fallon, 1987). This describes to situations where properties (e.g., disgust, disease) are transferred between stimuli through contact. For example, a neutral object touched by a contagious person becomes contaminated by mere contact.

2. Another possible explanation is that the fake sick faces did not activate disgust to a sufficient level to trigger memory processes. Unfortunately, Fernandes et al.'s study (2017) did not assess the level of disgust induced by the "fake sick faces" meaning that it is not possible to compare this with the levels induced by the "real sick faces" in their experiments.

3. The average effect size in these two studies was $M(dz) = .47$, and the mean of the correlations between recall in the healthy and sick conditions was $M(r) = .26$. The estimation of d was then computed using the relationship between dz obtained for related samples and the d-value based on independent samples (e.g., Brysbaert, 2019, p. 12).

4. Name agreement was collected from an independent group of 50 psychology students (M = 20.1 years; SD = 2.14). The photographs of the objects were presented on a white screen with their names translated into French (the English names were taken from Fernandes et al., 2019), and the participants had to estimate, on a 5-point Likert scale, the extent to which they agreed with each presented object referred to with the object name given.

5. As pointed out by an anonymous reviewer, it could be that the females were already at or near ceiling effects.

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