Personality and Individual Differences 201 (2023) 111928

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

Temporary differences in pathogen disgust sensitivity and the perception of crowded spaces

Jeanine Ammann [a,*], Anne Berthold [b]

[a] Agroscope, Research Group Economic Modelling and Policy Analysis, Ettenhausen, Switzerland
[b] ETH Zurich, Department of Health Science and Technology (D-HEST), Consumer Behaviour, Zürich, Switzerland

ARTICLE INFO

Keywords:
COVID-19
Crisis
Crowded spaces
Longitudinal
Pathogen disgust
Physical distancing

ABSTRACT

Feelings of disgust, a disease avoidance emotion, vary among individuals. The present study investigated if individual differences in pathogen disgust sensitivity predict the level of disgust evoked by crowded places. Interested in the universality of this relationship, we studied it across countries (Study 1), and examined temporal differences in pathogen disgust sensitivity (Studies 2 and 3). Participants completed a pathogen disgust scale and rated the level of disgust evoked by two crowded situations. Data were collected in 2018 (before the COVID-19 pandemic), in 2020 (at the height of the pandemic) and in 2022 (later in the pandemic). Across studies and countries, individuals' pathogen disgust sensitivity predicted the disgust evoked by the situations. Moreover, the data revealed a significant increase in pathogen disgust from 2018 to 2020, most likely because of higher pathogen presence during the pandemic, before significantly decreasing in 2022 after the pandemic had progressed. This study captures a rare opportunity, investigating how these crises relate to pathogen disgust sensitivity and the perception of crowded spaces. Further, our longitudinal study is among the first showing changes in pathogen disgust sensitivity over time and monitoring the effect of the pandemic.

1. Introduction

Disgust is a basic human emotion (Ekman, 1992). As part of the behavioural immune system, it serves as a disease-avoidance response (Oaten, Stevenson, & Case, 2009; Terrizzi, Shook, & McDaniel, 2013). The behavioural immune system consists of psychological mechanisms that help detect pathogen cues, trigger suitable responses and thus facilitate behavioural avoidance of pathogen infection (Schaller, 2011; Schaller & Park, 2011). The reaction of the behavioural immune system can be either proactive or reactive (Ackerman, Hill, & Murray, 2018; Schaller, Murray, & Hofer, 2021). Reactive behavioural responses (e.g., hastening away) take place in cases of immediate threats, such as in the presence of a foul odor. Proactive responses, by contrast, aim to manage pathogen threats and disease risks that are not immediate. Therefore, they include habitual behaviours, such as hygiene behaviours (Ackerman et al., 2018). These behaviours (e.g., grooming or bathing) are performed by animals and humans to remove dirt and pathogens (Kelly, 2011) to prevent infections (Curtis, 2007).

Individuals differ in their tendency to experience disgust towards pathogens, which is called *pathogen disgust sensitivity*. Essentially, pathogen disgust sensitivity promotes avoidance behaviour and thus prevents pathogens from entering the body (Curtis, Aunger, & Rabie, 2004; Curtis & Biran, 2001; Tybur, Lieberman, & Griskevicius, 2009). Limiting pathogen exposure ultimately reduces infection-related morbidity and mortality (Schrock, Snodgrass, & Sugiyama, 2020). Individuals with higher pathogen disgust sensitivity are more sensitive when estimating pathogen threats (van Leeuwen & Jaeger, 2022) and contract fewer bacterial and viral infections (Cepon-Robins et al., 2021). However, this also comes with costs, as behaviours that increase pathogen risk are avoided. Thus, there is a trade-off between the health benefits of reducing pathogen contact and the costs related to this behaviour (Schrock et al., 2020). For social interactions, disgust can be a trade-off between the costs and benefits of interpersonal contact (Kupfer & Tybur, 2017) and helps regulate it (Oaten et al., 2009). Disgust cues are monitored; the resulting risks, costs and benefits of reducing pathogen exposure are calculated; and, ultimately, disgust sensitivity is calibrated (Curtis, de Barra, & Aunger, 2011).

One of these trade-offs is related to social contacts. With an increasing number of contacts comes a subsequent exposure to pathogens and increased risk of infection. Direct interpersonal contact and interpersonal transmission through aerosolised droplets are two of six proposed pathways of pathogen infection in humans (Curtis & de Barra,

* Corresponding author at: Agroscope, research division on Sustainability Assessment and Agricultural Management, Tänikon 1, 8356 Ettenhausen, Switzerland.
E-mail address: jeanine.ammann@alumni.ethz.ch (J. Ammann).

https://doi.org/10.1016/j.paid.2022.111928
Received 18 July 2022; Received in revised form 3 October 2022; Accepted 4 October 2022

2018). Not surprisingly, pathogen disgust sensitivity influences social interactions. For instance, individuals felt more comfortable approaching others who they perceived to be in good health than those who showed signs of illness and with higher pathogen disgust sensitivity. Further, facial blemishes were interpreted as a sign of poor health (van Leeuwen & Jaeger, 2022). In addition, individuals who express cues of sickness are less liked by others (Sarolidou et al., 2020). Disgust further impacts the size of personal space, that is, the preferred distance to other individuals during social interactions (Park, 2015).

For detecting and avoiding pathogen threats, disgust sensitivity is also related to prejudice towards outgroups, or even xenophobia (Faulkner, Schaller, Park, & Duncan, 2004; Karinen, Molho, Kupfer, & Tybur, 2019; Kusche & Barker, 2019; Zakrzewska, Olofsson, Lindholm, Blomkvist, & Liuzza, 2019). It seems that feelings of vulnerability to disease motivate negative reactions towards foreigners (Faulkner et al., 2004). Another study involving 980 individuals found that pathogen disgust sensitivity was associated with perceptions of interpersonal dissimilarity to strangers (Mentser & Nussinson, 2020).

All of these studies support the notion of disgust functioning as an avoidance mechanism (Shook, Thomas, & Ford, 2019) and regulator of social interactions. Following up on this, the present study used two crowded situations to assess the relationship between disgust evoked by the situations and individuals' pathogen disgust sensitivity. We hypothesised that a crowded situation would be a cue for higher pathogen presence and considered more disgusting, triggering higher pathogen disgust sensitivity.

Few studies have investigated how pathogen disgust sensitivity can change over time and whether disgust is related to actual infection risk in the environment. A recent study has addressed this gap in the literature and found that both perceived and objective pathogen risk explains variances in disgust levels (Hlay et al., 2021). Disease threat has clearly increased in light of the current COVID-19 pandemic, and various studies have replicated their correlational findings for disgust sensitivity and attitudinal variables (e.g., xenophobia) during the pandemic (Schaller et al., 2021). For instance, pathogen disgust sensitivity predicted physical distancing during the pandemic (Olivera-La Rosa, Chuquichambi, & Ingram, 2020), and pathogen avoidance was connected to COVID-19-preventive behaviours (Makhanova & Shepherd, 2020). Other researchers, however, reasoned that pandemics differ from common infectious diseases and should therefore be looked at more carefully (Ackerman, Tybur, & Blackwell, 2021).

Previous research has also shown that COVID-19 impacts interpersonal relationships (Fuochi, Boin, Voci, & Hewstone, 2021). Following up on this, the present study pursued two aims. First, using data from various countries, we aimed to investigate the relationship between pathogen disgust sensitivity and the perception of crowded spaces, expecting that individual differences regarding pathogen disgust sensitivity would predict a person's level of disgust experienced when confronted with crowded places (i.e., a crowded bus or concert). Second, we were interested in potential temporary differences in pathogen disgust sensitivity and in the perception of crowded spaces. Accordingly, we ran three studies at different points in time, in 2018, before the COVID-19 pandemic; during the pandemic in 2020, when public awareness of pathogens and infection risk were increased; and as the pandemic had progressed, in 2022, during the Russia–Ukraine conflict, when public attention was shifting away from topics like pathogens or infection risk. As the pandemic had a huge impact on people's awareness of pathogens, we expected to detect an increase in pathogen disgust sensitivity and in disgust evoked by crowded spaces at the height of the pandemic in 2020, and lower scores in 2018 (before the pandemic started) and 2022 (i.e., after the height of the pandemic).

2. Study 1

An online survey across 11 countries was conducted with the aim of investigating the relationship between pathogen disgust sensitivity and disgust perceptions associated with crowded spaces in different countries.

2.1. Method

2.1.1. Participants

Initial data for this study were collected in 2018 through an online survey of 11 countries, including Australia, China, England, France, Germany, Mexico, Spain, South Africa, Sweden, Switzerland and the United States of America. Participants for the Swiss sample were recruited from an internet panel obtained from a commercial, ISO-certified panel provider (Respondi AG). A total of 1122 Swiss participants completed the survey. Quotas were applied to the variable 'sex', to ensure equal numbers of male and female participants. The survey took around 15 min to complete; more detailed information about the whole project can be found elsewhere (Ammann, Siegrist, & Hartmann, 2019). Due to the short time they took to complete the survey, 34 participants were excluded, as they took less than half the median of the survey duration calculated for the whole sample to complete the survey. After excluding another 22 participants who failed to provide their age, the final sample consisted of 1066 participants (50 % females, age: $M = 49$, $SD = 16$).

Participants from the other ten countries were recruited through commercial providers of sampling services. Quotas were applied on the variables age and sex, to ensure an equal sociodemographic profile of participants across the countries. Sample characteristics are summarised in Table 1. More detailed information on this project can be found elsewhere (Egolf et al., 2019).

2.1.2. Questionnaire

Participants' sensitivity to physical distancing was assessed using two pictures, which were presented together with a short description. One picture depicted a crowded concert, while the other showed a bus with only a little standing room left (see Table 2). Participants rated the pictures for the level of disgust they evoked on a scale from 0 (*not disgusting at all*) to 100 (*extremely disgusting*). Across all countries tested, the two situations were significantly correlated (see Table 3).

Participants' pathogen disgust sensitivity was measured with the pathogen disgust items from the Three Domain Disgust Scale (TDDS, Tybur et al., 2009). The TDDS pathogen subscale ($TDDS_{pathogen}$) contained seven items that describe pathogen-related situations. Sample items are 'Accidentally touching a person's bloody cut' or 'Seeing some mould on old leftovers in your refrigerator'. Participants rated each item on a scale from 0 (*not disgusting at all*) to 6 (*extremely disgusting*). The scale had good reliability in all countries (see Table 3) and responses were similar to the values reported in previous studies (Mentser & Nussinson, 2020; Prokop & Fančovičová, 2016). Average scores were calculated across the 11 items.

Table 1
Overview on the sample characteristics across the 11 countries tested.

		Age	Females
	n	*M (SD)*	%
Switzerland	1066	49 (16)	50.0
China	572	46 (13)	47.9
USA	630	45 (14)	50.5
South Africa	620	45 (14)	49.8
Spain	611	45 (14)	51.5
Australia	600	46 (14)	52.5
Mexico	629	44 (14)	50.6
Germany	617	45 (14)	51.1
Sweden	619	46 (14)	51.5
France	618	45 (14)	51.5
England	612	46 (14)	50.8

Note. Quotas were used for the variables age and sex.

Table 2
Overview on the two pathogen-related disgust stimuli (situations) and the descriptions presented with them.

Item	Picture
Concert: You are at a concert with many people. Everyone is standing close to together.	
Bus: You are taking a bus, which is so crowded that there is barely enough space to board.	

Note. Participants were asked to imagine the described situations and to rate them for how disgusting they think these are. Answers were provided on an interactive slider from 0 (*not disgusting at all*) to 100 (*extremely disgusting*). The midpoint of the slider was indicated (*neither*). Pictures were obtained from the website pixabay.com

2.1.3. Data analysis

Correlation analyses were used to investigate the relationship between the variables, and a multiple hierarchical regression analysis was used to analyse the influence of pathogen disgust sensitivity on the averaged disgust situations while controlling for age and sex. All data were analysed with the Statistical Package for the Social Sciences (SPSS) version 26 (IBM, New York, USA) for Windows.

2.2. Results and discussion

The crowded bus situation yielded higher disgust ratings than the concert across all 11 countries (see Table 3). The correlations between age, sex, pathogen disgust sensitivity and the situations are reported in Table 4. Pathogen disgust sensitivity was significantly positively associated with the situations in all seven countries. Correlation coefficients ranged from $r = 0.26$ to 0.41, which can be seen as medium- to large-sized effects (Funder & Ozer, 2019). Further, correlations between sex and pathogen disgust sensitivity were found for all seven countries: female participants always scored higher on disgust sensitivity. The results for age were less consistent. That is, small, significant positive correlations were registered for only four of the seven countries.

In Table 5, results of the final model of the multiple hierarchical regression analysis used to predict the disgust evoked by the two situations are reported for all seven countries. All models were statistically significant and explained between 7 and 11 % of the variances. In all countries, pathogen disgust sensitivity emerged as a significant predictor of the disgust evoked by the situation. As for food disgust sensitivity (Ammann, Egolf, Hartmann, & Siegrist, 2020; Egolf et al., 2019), the correlation patterns showed that the structure of pathogen disgust sensitivity seems to be similar across countries.

Table 4
Pearson's correlations for pathogen disgust sensitivity, disgust evoked by crowded situations (bus and concert), by age and sex.

		Pearson's correlations with $TDDS_{pathogen}$		
	N	Situations	Age	Sex
Switzerland	1066	0.38***	0.11*	0.14***
China	572	0.26***	0.11**	0.19***
USA	630	0.38***	0.07	0.18***
South Africa	620	0.34***	0.02	0.25***
Spain	611	0.29***	0.09*	0.21***
Australia	600	0.41***	0.03	0.24***
Mexico	629	0.32***	0.16***	0.28***
Germany	617	–	0.10*	0.24***
Sweden	619	–	0.01	0.16***
France	618	–	0.06	0.20***
England	612	–	0.05	0.20***

Note. Sex: 0 = males, 1 = females; $TDDS_{pathogen}$ = Three Domain Disgust Scale (TDDS, Tybur et al., 2009) pathogen subscale.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 3
Overview on the disgusting situations (bus and concert) and pathogen disgust sensitivity, mean values, standard deviations, Pearson's correlations between the two situations, mean values and Cronbach's alpha for pathogen disgust sensitivity and all 11 countries.

		Situations				$TDDS_{pathogen}$	
		Concert	Bus	Pearson's Correlation	*t*-test		
	N	*M (SD)*	*M (SD)*	*r*		*α*	*M (SD)*
Switzerland	1066	43.9 (29.7)	53.4 (30.5)	0.67***		0.81	4.06 (1.15)
China	572	44.2 (26.5)	45.0 (26.5)	0.56***	0.7 (ns)	0.80	4.24 (1.02)
USA	630	38.6 (29.3)	47.7 (30.1)	0.65***	9.1***	0.81	4.31 (1.06)
South Africa	620	44.3 (31.8)	55.5 (31.9)	0.56***	9.4***	0.80	4.42 (1.12)
Spain	611	36.3 (26.7)	46.1 (28.1)	0.61***	10.0***	0.79	4.13 (1.07)
Australia	600	45.3 (30.8)	53.3 (30.7)	0.62***	7.4***	0.82	4.10 (1.16)
Mexico	629	30.9 (30.2)	43.8 (33.5)	0.52***	10.2***	0.81	4.17 (1.24)
Germany[a]	617	–	–	–	–	0.77	3.88 (1.10)
Sweden[a]	619	–	–	–	–	0.81	3.89 (1.18)
France[a]	618	–	–	–	–	0.71	3.97 (1.00)
England[a]	612	–	–	–	–	0.78	4.08 (1.07)

Note. For the items *concert* and *bus*, participants were asked to imagine the described situations and to rate them for how disgusting they think these are. Answers were provided on an interactive slider from 0 (*not disgusting at all*) to 100 (*extremely disgusting*). The midpoint of the slider was indicated (*neither*). Both situations were presented as a written scenario together with a picture. Pictures were obtained from the website pixabay.com, $TDDS_{pathogen}$ = Three Domain Disgust Scale (TDDS, Tybur et al., 2009) pathogen subscale.
*** $p < .001$.
[a] The first study used an exploratory approach and was integrated as part of a larger international research project (see Egolf et al. (2019)). As a result, the situations were tested in only 7 out of the 11 countries.

Table 5
Final model for the multiple hierarchical regression analysis predicting the level of disgust evoked by the disgust situations (bus and concert), by age, sex and pathogen disgust sensitivity.

	Switzerland		China		USA		South Africa		Spain		Australia		Mexico	
	$N = 1066$		$N = 572$		$N = 630$		$N = 620$		$N = 611$		$N = 600$		$N = 629$	
Variable	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE
Constant	2.34	3.67	14.86**	4.94	0.89	5.07	11.04*	5.45	17.52***	4.736	2.97	4.95	11.30*	4.63
Sex	5.96***	1.62	−0.05	1.93	1.26	2.02	−2.72	2.20	0.78	1.951	−2.38	2.13	1.09	2.19
Age	0.19***	0.05	0.12	0.07	0.01	0.07	−0.02	0.08	−0.10	0.071	0.15*	0.07	−0.11	0.08
$TDDS_{pathogen}$	8.38***	0.69	5.78***	0.95	9.55***	0.96	8.94***	0.98	6.69***	0.914	9.89***	0.91	7.28***	0.89
R^2	0.16		0.07		0.15		0.12		0.09		0.18		0.11	
F	67.28***		14.17***		35.36***		28.00***		19.31***		42.01***		25.01***	

Note. Sex: 0 = males, 1 = females; $TDDS_{pathogen}$ = Three Domain Disgust Scale (TDDS, Tybur et al., 2009) pathogen subscale.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

3. Study 2

Study 1 showed that there is a connection between pathogen disgust sensitivity and the perception of crowded spaces. As data for Study 1 were collected before the COVID-19 pandemic, the aim of Study 2 was to test whether pathogen disgust sensitivity had changed because of the pandemic. We expected that, with the pandemic and the recommendations for increased hygiene and physical distancing, people would be more sensitised regarding pathogens and more reluctant to be present in crowded places.

3.1. Method

3.1.1. Participants

Data for this study were collected through an online survey in April 2020, shortly after the outbreak of the COVID-19 pandemic, in Germany. Around this time, the 7-day average of deaths per day peaked at almost 300.[1] Participants were recruited from an internet panel obtained from a commercial, ISO-certified panel provider (Respondi AG). Quotas were applied to the variable 'sex' to ensure equal numbers of males and females in the sample. The survey took roughly 10 to 15 min to complete. Participants who needed less than half the median of the survey duration calculated for the whole sample were excluded from the analysis. The final sample contained 519 participants (50 % females). Participants were aged between 21 and 71 years ($M = 50$, $SD = 13$). More detailed information on this project can be found elsewhere (Ammann & Casagrande, 2021).

3.1.2. Questionnaire

The questions were the same as in Study 1. Reliability of the pathogen disgust scale was good (7 items, $\alpha = 0.80$). As in Study 1, participants indicated for the same two disgust-invoking situations (i.e., bus, concert) how disgusting they perceived them to be. The bus situation yielded slightly higher disgust ratings than the concert ($M_{bus} = 65.99$, $SD = 30.14$ and $M_{concert} = 49.45$, $SD = 32.04$). The two items were highly correlated ($r = 0.66$, $p < .001$) and therefore taken together to form an average ($M = 57.72$, $SD = 28.29$).

3.1.3. Data analysis

Identical methods and procedures were used as described for Study 1.

3.2. Results and discussion

Table reports the correlations between age, sex, pathogen disgust sensitivity and the averaged disgust ratings of the crowded situations. Pathogen disgust sensitivity was significantly positively associated with the situations ($r = 0.40$, $p < .001$) (Table 6).

Table 6
Pearson's correlations pathogen disgust evoked by crowded situations (bus and concert), by age and sex, $N = 519$.

	1	2	3	4	M	SD
1. $TDDS_{pathogen}$	1				4.44	1.12
2. Situation	0.40***	1			57.72	28.29
3. Age	0.12**	0.20***	1			
4. Sex	0.17***	0.15**	0.09*	1		

Note. Sex: 0 = males, 1 = females; $TDDS_{pathogen}$ = Three Domain Disgust Scale (TDDS, Tybur et al., 2009) pathogen subscale.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 7 lists the results of the multiple hierarchical regression analysis used to predict the disgust evoked by the two situations. The model was statistically significant and explained 19 % of the variance. As in Study 1, pathogen disgust sensitivity emerged as a significant predictor of the disgust evoked by the situations.

4. Study 3

To follow up on the results of Study 1, which provided cross-cultural evidence for the relationship between pathogen disgust sensitivity and the perception of crowded spaces, as well as Study 2 from 2020, which showed that, in Germany, the relationship remained similar during the pandemic, Study 3 aimed to investigate this relationship while another crisis, one unrelated to pathogens, dominated the daily news feeds. For this, data were collected in Germany in the spring of 2022, two years after the start of the pandemic and during the Ukraine–Russia conflict.

4.1. Method

4.1.1. Participants

Data for this final study were collected in March and April 2022 during the war between Russia and Ukraine. Around this time, the 7-day average of deaths per day due to COVID-19 was around 300,[2] which happens to be a similar level as reported during data collection of Study 2. Data were collected through an online survey in Germany. Participants were recruited through a variety of mailing lists and various social media channels (e.g., Facebook, Twitter, Reddit). The survey took roughly 10 to 15 min to complete. Four participants who did not reveal

[1] https://github.com/CSSEGISandData/COVID-19

[2] https://github.com/CSSEGISandData/COVID-19

Table 7
Final model for the multiple hierarchical regression analysis predicting the level of disgust evoked by the disgust situations (bus and concert), by age, sex and pathogen disgust sensitivity, $N = 519$.

	Situation		
Variable	B	SE	ß
Constant	−2.40	6.01	
Sex	4.15	2.28	0.07
Age	0.32***	0.09	0.15
$TDDS_{pathogen}$	9.47***	1.03	0.37
R^2	0.19		
F	40.24***		

Note. Sex: 0 = males, 1 = females; $TDDS_{pathogen}$ = Three Domain Disgust Scale (TDDS, Tybur et al., 2009) pathogen subscale.
*** $p < .001$.

their sex or indicated that they did not fit with the binary groups were excluded, to ensure equal sample sizes across all analyses. The final sample contained 218 participants (79 % females). Participants were aged between 19 and 69 years ($M = 31.5$, $SD = 11.5$).

4.1.2. Questionnaire

The questions were the same as those used for the Swiss sample in Study 1. The reliability of the pathogen disgust sensitivity scale was good (7 items, $\alpha = 0.70$). As in the previous studies, participants evaluated the two disgust-invoking situations depicting a crowded concert and bus. The bus situation again yielded slightly higher disgust ratings than the concert ($M_{bus} = 52.47$, $SD = 29.22$ and $M_{concert} = 39.17$, $SD = 26.93$, $t(217) = 8.00$, $p < .001$). As in the previous studies, the two items were highly correlated ($r = 0.62$, $p < .001$) and therefore taken together to form an average ($M = 45.82$, $SD = 25.27$).

4.1.3. Data analysis

The same methods and procedures were used as described for Study 1.

4.2. Results and discussion

Table 8 reports the correlations between age, sex, pathogen disgust sensitivity and the situations. Pathogen disgust sensitivity was significantly positively correlated with the situations ($r = 0.27$, $p < .001$).

The results of the multiple hierarchical regression analysis used to predict the disgust evoked by the two averaged situations are shown in Table 9. The model was statistically significant and explained 7 % of the variances. As in the previous studies, pathogen disgust sensitivity emerged as a significant predictor of the disgust evoked by the crowded situations.

4.2.1. Synthesis of the three studies

Having collected data for pathogen disgust sensitivity using the TDDS in Germany over the three time points allows us to make temporal comparisons. We found that, in 2018, before the pandemic, individuals' pathogen disgust sensitivity was significantly lower than it was two years later, after the pandemic had started (see Fig. 1). Similarly, a comparison between 2020 and 2022 revealed that, after two years of pandemic living and after the onset of another pathogen-unrelated crisis, pathogen disgust sensitivity had decreased significantly.

Table 8
Pearson's correlations of pathogen disgust sensitivity and disgust evoked by crowded situations (bus and concert), by age and sex, $N = 218$.

	1	2	3	4	M	SD
1. $TDDS_{pathogen}$	1				3.64	0.98
2. Situations	0.27***	1			45.82	25.27
3. Age	0.18**	0.02	1		31.55	11.52
4. Sex	0.14*	0.08	−0.03	1		

Note. Sex: 0 = males, 1 = females; $TDDS_{pathogen}$ = Three Domain Disgust Scale (TDDS, Tybur et al., 2009) pathogen subscale.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 9
Final model for the multiple hierarchical regression analysis predicting the level of disgust evoked by the situations (bus and concert), by age, sex, and pathogen disgust sensitivity, $N = 218$.

	Situation		
Variable	*B*	*SE*	*β*
Constant	20.78**	7.76	
Sex	2.63	4.14	0.04
Age	−0.07	0.15	−0.03
$TDDS_{pathogen}$	6.89***	1.75	0.27
R^2	0.07		
F	5.69**		

Note. Sex: 0 = males, 1 = females; $TDDS_{pathogen}$ = Three Domain Disgust Scale (TDDS, Tybur et al., 2009) pathogen subscale.
** $p < .01$.
*** $p < .001$.

5. Overall discussion

The three studies presented herein aimed to investigate the relationship between pathogen disgust sensitivity and people's perceptions of crowded spaces. We found similar result patterns regarding pathogen disgust sensitivity and the evaluation of crowded situations across 11 countries (Study 1) and three time points (Studies 1–3). With higher individual levels of pathogen disgust sensitivity, the more disgusting individuals evaluated the crowded spaces. We further found an increase in overall pathogen disgust sensitivity during the COVID-19 pandemic and an increased disgust response regarding crowded spaces (Study 2). During the Russia–Ukraine conflict in 2022 (Study 3), however, we found overall pathogen disgust sensitivity that was at a similar level as before the pandemic (Study 1).

5.1. Pathogen disgust sensitivity as an important predictor for disgust evoked by crowded spaces

Given the avoidance nature of disgust, it is not surprising that pathogen disgust sensitivity was significantly correlated with both situations depicting crowded spaces in our study. Across three studies, pathogen disgust sensitivity emerged as a significant predictor for the perception of two crowded spaces. The behavioural immune system tends to be hypersensitive to perceptual disease cues (Schaller & Park, 2011); therefore, participants with high levels of pathogen disgust sensitivity in our studies reacted more strongly to the crowded situations. Similarly, recent research, which was also conducted during the pandemic, has found that pathogen disgust sensitivity predicted lower judgments of trustworthiness and lower social desirability (Olivera-La Rosa et al., 2020), and that food disgust sensitivity predicted disease-preventive behaviours (Ammann & Casagrande, 2021).

While our study is well aligned with the theory of the behavioural immune system, we want to acknowledge, however, that other studies have critically discussed whether the behavioural immune system can be applied to pandemics (Ackerman et al., 2021; Schaller et al., 2021). The main argument was that pandemics take place in globalised civilisations, which is something that has developed recently. It is therefore unlikely that pandemic-specific mechanisms have been shaped through selection starting in small-scale ancestral societies (Ackerman et al., 2021). We therefore conclude that our study adds yet another important piece of information in the quest to understand the psychological mechanisms behind the behavioural immune system.

Across all three studies, the situation with the bus was rated as

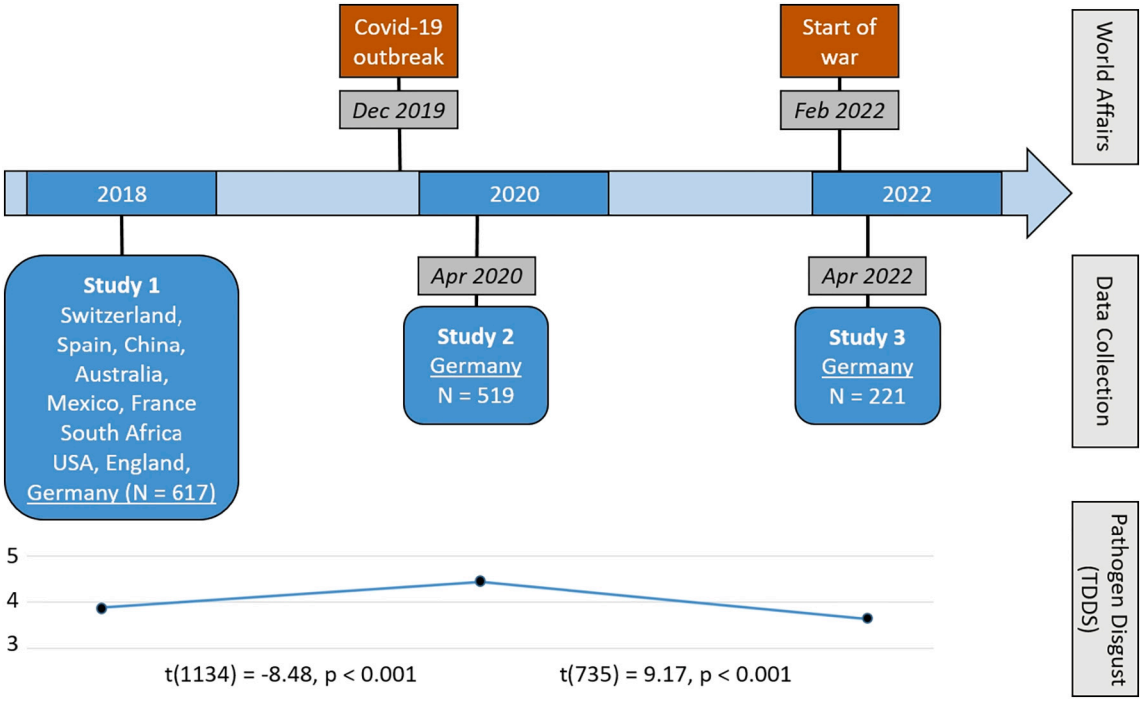

Fig. 1. Overview of the three studies, with a focus on Germany.

consistently more disgusting than the concert. Given that both pictures show the same disgust elicitor (i.e., other people), a possible interpretation is that a concert is primarily attended for fun and voluntarily, while a bus might be the necessary means of transport when travelling or commuting from one place to another. Another possible, however speculative, explanation can be drawn from the connection between disgust and xenophobia, causing aversive reactions towards foreigners (Schaller, 2011). Individuals attending a concert share a common interest (e.g., liking the same band), which could make them subjectively less 'foreign', compared to individuals commuting on the same bus. Finally, it is important to note that a bus is a small, enclosed space, which can provoke anxiety.

5.2. Temporary changes in pathogen disgust sensitivity

We found that pathogen disgust sensitivity increased significantly between 2018 and 2020. Later, when the Russia–Ukraine conflict emerged, we found that pathogen disgust sensitivity decreased significantly as the pandemic progressed and was partly contained by the introduction of various measures against its spread. Further, from 2020 to 2022 the European public's attention shifted from the pandemic towards the war in Ukraine.

To the best of our knowledge, this is the first work to provide evidence on these temporary differences in pathogen disgust sensitivity. Though there are stable individual differences, we aim to argue that an individual's pathogen disgust sensitivity is not static, but can adapt according to the current pathogen pressure in the environment. With that in mind, our results are in line with Hlay et al. (2021), who proposed that disgust may be a leading emotional shift triggered by pathogen presence in the environment.

5.3. Limitations and outlook

Our research is one among a few that provide longitudinal data on pathogen disgust sensitivity. Future research should add to the evidence by providing longitudinal data and look more deeply into the ontology of disgust (Rottman, DeJesus, & Greenebaum, 2019). Further, it should test additional situations to investigate situational, conceptual and individual differences in pathogen disgust sensitivity.

5.4. Conclusion

A major strength of the present study its longitudinal nature, presenting data that were collected over three points in time. With world affairs developing into several major crises during the studies' data collection periods, we had the rare opportunity to investigate the influence of these crises on the relationship between pathogen disgust sensitivity and the perception of crowded spaces. Moreover, given that one crisis was directly related to pathogens while the other was not, more depth has been added to our analyses. Across 11 countries, we have shown that the construct of pathogen disgust sensitivity was similar, that is, higher levels of sensitivity were related to more disgust evoked by the crowded situations. Further, across three points in time, we found an increase in pathogen disgust sensitivity during the pandemic, which was most likely caused by a higher expected pathogen presence during that time. Through the course of the pandemic, the overall level of pathogen disgust sensitivity decreased again, probably because of a habituation effect and because the pandemic was partially contained with protective measures and vaccinations. Moreover, the public's attention has shifted towards a new crisis – the Russia–Ukraine conflict.

CRediT authorship contribution statement

Jeanine Ammann: Conceptualization, Methodology, Data collection for studies 1 and 2, Data curation and analysis, Writing- Original draft preparation, Visualization, Investigation. **Anne Berthold:** Writing-Reviewing and Editing, Data collection for study 3, Data analysis.

Funding and acknowledgements

The research for Study 1 was financially supported by the Swiss National Science Foundation (project number 165630). The research for Study 2 and Study 3 did not receive any specific grant from funding

agencies in the public, commercial, or not-for-profit sectors. The rearchers thank Dr. Aisha Egolf (Study 1) and Meret Casagrande (Study 2) for their support in data collection. Finally, we thank Prof. Dr. Michael Siegrist for his feedback on the questionnaires (Study 1 and Study 2).

Data availability

Data will be made available on request.

References

Ackerman, J. M., Hill, S. E., & Murray, D. R. (2018). The behavioral immune system: Current concerns and future directions. *Social and Personality Psychology Compass, 12*(2). https://doi.org/10.1111/spc3.12371

Ackerman, J. M., Tybur, J. M., & Blackwell, A. D. (2021). What role does pathogen-avoidance psychology play in Pandemics? *Trends in Cognitive Sciences, 25*(3), 177–186. https://doi.org/10.1016/j.tics.2020.11.008

Ammann, J., & Casagrande, M. (2021). Food disgust sensitivity predicts disease-preventing behaviour beyond the food domain in the COVID-19 pandemic in Germany. *PLoS One, 16*(7), Article e0254648. https://doi.org/10.1371/journal.pone.0254648

Ammann, J., Egolf, A., Hartmann, C., & Siegrist, M. (2020). Cross-national comparison of the food disgust picture scale between Switzerland and China using confirmatory factor analysis. *Food Quality and Preference, 79*. https://doi.org/10.1016/j.foodqual.2019.103756

Ammann, J., Siegrist, M., & Hartmann, C. (2019). The influence of disgust sensitivity on self-reported food hygiene behaviour. *Food Control, 102*, 131–138. https://doi.org/10.1016/j.foodcont.2019.03.023

Cepon-Robins, T. J., Blackwell, A. D., Gildner, T. E., Liebert, M. A., Urlacher, S. S., Madimenos, F. C., & Sugiyama, L. S. (2021). Pathogen disgust sensitivity protects against infection in a high pathogen environment. *Proceedings of the National Academy of Sciences of the United States of America, 118*(8). https://doi.org/10.1073/pnas.2018552118

Curtis, V. (2007). Dirt, disgust and disease: A natural history of hygiene. *Journal of Epidemiology and Community Health, 61*(8), 660–664. https://doi.org/10.1136/jech.2007.062308

Curtis, V., Aunger, R., & Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease. *Proceedings of the Biological Sciences, 271*(Suppl. 4), S131–S133. https://doi.org/10.1098/rsbl.2003.0144

Curtis, V., & Biran, A. (2001). Dirt, disgust, and disease - is hygiene in our genes? *Perspectives in Biology and Medicine, 44*(1), 17–31. https://doi.org/10.1353/pbm.2001.0001

Curtis, V., & de Barra, M. (2018). The structure and function of pathogen disgust. *Philosophical Transactions of the Royal Society B-Biological Sciences, 373*(1751). https://doi.org/10.1098/rstb.2017.0208

Curtis, V., de Barra, M., & Aunger, R. (2011). Disgust as an adaptive system for disease avoidance behaviour. *Philosophical Transactions of the Royal Society B-Biological Sciences, 366*(1563), 389–401. https://doi.org/10.1098/rstb.2010.0117

Egolf, A., Siegrist, M., Ammann, J., Pacheco-Lopez, G., Etale, A., & Hartmann, C. (2019). Cross-cultural validation of the short version of the food disgust scale in ten countries. *Appetite, 143*, Article 104420. https://doi.org/10.1016/j.appet.2019.104420

Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion, 6*(3–4), 169–200. https://doi.org/10.1080/02699939208411068

Faulkner, J., Schaller, M., Park, J. H., & Duncan, L. A. (2004). Evolved disease-avoidance mechanisms and contemporary xenophobic attitudes. *Group Processes & Intergroup Relations, 7*(4), 333–353. https://doi.org/10.1177/1368430204046142

Funder, D. C., & Ozer, D. J. (2019). Evaluating effect size in psychological research: sense and nonsense. *Advances in Methods and Practices in Psychological Science, 2*(2), 156–168. https://doi.org/10.1177/2515245919847202

Fuochi, G., Boin, J., Voci, A., & Hewstone, M. (2021). COVID-19 threat and perceptions of common belonging with outgroups: The roles of prejudice-related individual differences and intergroup contact. *Personality and Individual Differences, 175*. https://doi.org/10.1016/j.paid.2021.110700

Hlay, J. K., Albert, G., Batres, C., Richardson, G., Placek, C., Arnocky, S., & Hodges-Simeon, C. R. (2021). The evolution of disgust for pathogen detection and avoidance. *Scientific Reports, 11*(1), 13468. https://doi.org/10.1038/s41598-021-91712-3

Karinen, A. K., Molho, C., Kupfer, T. R., & Tybur, J. M. (2019). Disgust sensitivity and opposition to immigration: Does contact avoidance or resistance to foreign norms explain the relationship? *Journal of Experimental Social Psychology, 84*. https://doi.org/10.1016/j.jesp.2019.103817

Kelly, D. (2011). *Yuck! The nature and moral significance of disgust.* Cambridge, Mass.: MIT Press.

Kupfer, T. R., & Tybur, J. M. (2017). Pathogen disgust and interpersonal personality. *Personality and Individual Differences, 116*, 379–384. https://doi.org/10.1016/j.paid.2017.05.024

Kusche, I., & Barker, J. L. (2019). Pathogens and immigrants: A critical appraisal of the behavioral immune system as an explanation of prejudice against ethnic outgroups. *Frontiers in Psychology, 10*, 2412. https://doi.org/10.3389/fpsyg.2019.02412

Makhanova, A., & Shepherd, M. A. (2020). Behavioral immune system linked to responses to the threat of COVID-19. *Pers Individ Dif, 167*, Article 110221. https://doi.org/10.1016/j.paid.2020.110221

Mentser, S., & Nussinson, R. (2020). We're not of the same feather: Disgust sensitivity and reduced perceived similarity to unknown others. *Personality and Individual Differences, 163*. https://doi.org/10.1016/j.paid.2020.110039

Oaten, M., Stevenson, R. J., & Case, T. I. (2009). Disgust as a disease-avoidance mechanism. *Psychological Bulletin, 135*(2), 303–321. https://doi.org/10.1037/a0014823

Olivera-La Rosa, A., Chuquichambi, E. G., & Ingram, G. P. D. (2020). Keep your (social) distance: Pathogen concerns and social perception in the time of COVID-19. *Pers Individ Dif, 166*, Article 110200. https://doi.org/10.1016/j.paid.2020.110200

Park, J. H. (2015). Introversion and human-contaminant disgust sensitivity predict personal space. *Personality and Individual Differences, 82*, 185–187. https://doi.org/10.1016/j.paid.2015.03.030

Prokop, P., & Fančovičová, J. (2016). Mothers are less disgust sensitive than childless females. *Personality and Individual Differences, 96*, 65–69. https://doi.org/10.1016/j.paid.2016.02.064

Rottman, J., DeJesus, J., & Greenebaum, H. (2019). Developing disgust: Theory, measurement, and application. In V. LoBue, K. Pérez-Edgar, & K. Buss (Eds.), *Handbook of emotional development.* Cham: Springer.

Sarolidou, G., Axelsson, J., Kimball, B. A., Sundelin, T., Regenbogen, C., Lundstrom, J. N., & Olsson, M. J. (2020). People expressing olfactory and visual cues of disease are less liked. *Philosophical Transactions of the Royal Society B-Biological Sciences, 375*(1800). https://doi.org/10.1098/rstb.2019.0272

Schaller, M. (2011). The behavioural immune system and the psychology of human sociality. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 366*(1583), 3418–3426. https://doi.org/10.1098/rstb.2011.0029

Schaller, M., Murray, D. R., & Hofer, M. K. (2021). The behavioural immune system and pandemic psychology: The evolved psychology of disease-avoidance and its implications for attitudes, behaviour, and public health during epidemic outbreaks. *European Review of Social Psychology, 1–37*. https://doi.org/10.1080/10463283.2021.1988404

Schaller, M., & Park, J. H. (2011). The behavioral immune system (and why it matters). *Current Directions in Psychological Science, 20*(2), 99–103. https://doi.org/10.1177/0963721411402596

Schrock, J. M., Snodgrass, J. J., & Sugiyama, L. S. (2020). Lassitude: The emotion of being sick. *Evolution and Human Behavior, 41*(1), 44–57. https://doi.org/10.1016/j.evolhumbehav.2019.09.002

Shook, N. J., Thomas, R., & Ford, C. G. (2019). Testing the relation between disgust and general avoidance behavior. *Personality and Individual Differences, 150*. https://doi.org/10.1016/j.paid.2019.05.063

Terrizzi, J. A., Shook, N. J., & McDaniel, M. A. (2013). The behavioral immune system and social conservatism: A meta-analysis. *Evolution and Human Behavior, 34*(2), 99–108. https://doi.org/10.1016/j.evolhumbehav.2012.10.003

Tybur, J. M., Lieberman, D., & Griskevicius, V. (2009). Microbes, mating, and morality: Individual differences in three functional domains of disgust. *Journal of Personality and Social Psychology, 97*(1), 103–122. https://doi.org/10.1037/a0015474

van Leeuwen, F., & Jaeger, B. (2022). Pathogen disgust sensitivity: Individual differences in pathogen perception or pathogen avoidance? *Motivation and Emotion, 46*(3), 394–403. https://doi.org/10.1007/s11031-022-09937-2

Zakrzewska, M., Olofsson, J. K., Lindholm, T., Blomkvist, A., & Liuzza, M. T. (2019). Body odor disgust sensitivity is associated with prejudice towards a fictive group of immigrants. *Physiology & Behavior, 201*, 221–227. https://doi.org/10.1016/j.physbeh.2019.01.006