Pathogen disgust sensitivity changes according to the perceived harshness of the environment

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Much research has explored behaviours that are linked with disgust sensitivity. Few studies, however, have been devoted to understanding how fixed or variable disgust sensitivity is. We therefore aimed to examine whether disgust sensitivity can change with the environment by repeatedly testing university students whose environment was not changing as well as cadets undergoing intensive training at an army camp. We found that an increase in the perceived harshness of the environment was associated with a decrease in pathogen disgust sensitivity. Our results support the idea that disgust sensitivity is malleable depending on the environment. More specifically, we propose that in a harsh environment, where survival may be more difficult, pathogen disgust sensitivity may decrease to allow the consumption of available resources.

Keywords: disgust sensitivity; pathogen disgust; sexual disgust; moral disgust; environment

Introduction

Disgust is believed to be a basic human emotion (Ekman & Friesen, 1986; Mesquita & Frijda, 1992) that has evolved to aid human survival (Oaten, Stevenson, & Case, 2009). Studies have found that there is a universal facial expression for disgust (Ekman & Friesen, 2003). Actions associated with the emotion of disgust include wrinkling the nose and extruding the tongue, which decrease the inhalation of disgusting odours and expel any disgusting contents from the mouth (Rozin, Lowery, & Ebert, 1994). Moreover, the physiological responses of disgust, such as

vomiting (Rozin & Fallon, 1987) and increased salivation (Angyal, 1941), also function to avoid and/or expel disgust-arousing stimuli.

Research has found that there are three disgust domains (Tybur, Lieberman, & Griskevicius, 2009), the first being pathogen disgust. Across cultures there are certain animals that are found disgusting, such as cockroaches and rats (Davey et al., 1998). These animals often carry pathogens and therefore avoiding them would be adaptive. Similarly, disease-relevant stimuli are found to be more disgusting than disease-irrelevant stimuli (Curtis, Aunger, & Rabie, 2004). For instance, the same person is rated as more disgusting when sprayed with water to look feverish or the same towel is rated as more disgusting when it has a reddish-yellow stain (to represent blood and bodily secretions) rather than a blue stain (Curtis et al., 2004). Avoiding people (Olsson et al., 2014) and substances (Curtis et al., 2004) that may be carrying diseases would also be advantageous. Our level of sensitivity to these types of stimuli can be measured using pathogen disgust questions. These questions are able to measure our degree of pathogen avoidance by asking how disgusting certain statements are found, such as "Accidentally touching a person's bloody cut" (Tybur et al., 2009). These answers assess our "disgust sensitivity", which refers to our proneness for disgust to certain scenarios.

The second domain is sexual disgust, which helps avoid non-adaptive sexual partners. Sensitivity to these types of behaviours can be measured using sexual disgust questions, which ask how disgusting certain accounts are found, such as "Finding out that someone you don't like has sexual fantasies about you" (Tybur et al., 2009). These questions capture attitudes towards a general dimension of sexual aversion and certain items include more sex-specific costs or risk. For example, the question "A stranger of the opposite sex intentionally rubbing your thigh in an

elevator" may pose a threat of sexual coercion or aggression more so to women than men (Tybur, Bryan, Lieberman, Hooper, & Merriman, 2011).

The third domain is that of moral disgust, which is elicited by immoral behaviour. For instance, studies have shown that participants experience disgust when they are presented with descriptions of criminals (Jones & Fitness, 2008). Moral transgressors threaten the well-being of group members and therefore experiencing disgust towards them would be adaptive since it would encourage their ostracism from the group (Jones & Fitness, 2008). Our level of sensitivity to these types of behaviours can be measured using moral disgust questions. These questions measure our degree of moral misconduct evasion by asking how disgusting we find certain statements, such as "Stealing from a neighbour" (Tybur et al., 2009).

Much research has been carried out to explore behaviours that are linked with disgust sensitivity (e.g., DeBruine, Jones, Tybur, Lieberman, & Griskevicius, 2010; Smith, Oxley, Hibbing, Alford, & Hibbing, 2011; Thorpe, Patel, & Simonds, 2003) but only a few studies have been devoted to understanding how fixed or variable disgust sensitivity is. For example, Rozin (2008) found a significant reduction in disgust responses to death and body envelope violation elicitors in medical students after they had spent a few months dissecting a cadaver. Some studies also suggest that women's individual disgust sensitivity can vary in order to promote reproductive success. For instance, Fessler and Navarrete (2003) found that sexual disgust varies across the menstrual cycle, with an increase in disgust towards aberrant sexual behaviours when women's conception risk is high. In addition, when women are sexually aroused, they find certain sex related activities less disgusting (Borg & de Jong, 2012). Life events have also been linked to changes in disgust. For example, Prokop and Fančovičová (2016) showed that mothers demonstrated lower

disgust sensitivity than childless females and Azlan et al. (2017) showed that people with cancer are less disgust sensitive than age- and gender-matched controls without cancer.

Furthermore, while there is anecdotal evidence that at times of need disgust can be temporarily suspended in order to fulfil more immediate goals (e.g., drinking urine when facing acute thirst; Oaten et al., 2009), no study has investigated whether changes in the harshness of the environment can elicit changes in disgust sensitivity. We therefore aimed to examine whether disgust sensitivity temporarily changes with the environment. More specifically, we repeatedly tested pathogen, sexual, and moral disgust sensitivity in university students whose environment was not changing (as measured by questions concerning perceived harshness in the environment) as well as university student cadets undergoing intensive training at an army camp. Current research supports the idea that under certain circumstances, it is advantageous to suppress pathogen disgust (e.g., Case, Repacholi, & Stevenson, 2006) and we hypothesized that the same principle could be applied to sexual and moral disgust. We therefore predicted that sensitivity to all three domains of disgust would decrease with the training camp since desensitization would prove beneficial in a harsh environment where it would confer evolutionary benefits on the individual to eat what is available, mate with whom is available, and relax their moral principles to aid in their survival.

Methods

Participants and procedures

Ethical approval was received from the University of St Andrews Ethics Board and all participants provided consent. Both participants from the cadet sample and the student sample completed the study three separate times with time intervals of three days between each testing session. The student sample was collected at the University of St Andrews with students whose environment was not changing. Nine men (Mean age=26.89, SD=7.17) and eleven women (Mean age=22.45, SD=0.82) completed the study all three times and made up the student group. The cadet sample was collected at a military base where cadets who are part of the University Officer Training Corps were attending a ten day training camp. Session 1 was conducted on the first day of the camp before the training commenced and sessions 2 and 3 were conducted at three-day intervals during the remainder of the training camp. Twenty-three men (Mean age=19.48 SD=1.38) and eight women (Mean age=19.25, SD=1.04) completed the study all three times and made up the cadet group.

Participants were presented with a questionnaire that requested their sex, age, and a 21-item disgust questionnaire, which included subscales for pathogen, sexual, and moral disgust (Tybur et al., 2009). In order to measure perceived changes in the environment, questions intended to measure aspects that might differ between the normal university environment and the training camp environment were created and presented to the participants (on a scale from 1="not at all" to 10="very much"): "Currently, how tired are you?; Currently, how hungry are you?; Currently, how stressed are you?; How much physical strain have you been under in the past three days?; How much mental pressure have you been under in the past three days?; How much pain are you currently in?; How out of your comfort zone have you felt in the past three days?; How much have you been shouted at in the past three days?". Additionally, in order to examine whether face preferences change with the perceived harshness of the environment, participants were presented

with facial continua (that varied in adiposity and masculinity levels) and asked to click on the face when it was considered to be at its most attractive. The relationship between perceived environmental harshness and face preferences was examined in a separate paper (i.e., Batres & Perrett, 2017). This current paper aims to examine the relationship between perceived environmental harshness and disgust sensitivity.

Results

Changes in perceived environmental harshness

Independent samples t-tests for each perceived environmental harshness question during every testing session revealed that there were no significant sex differences except for the second session on the question of hunger. For all subsequent analyses, male and female participants were therefore aggregated. We then split the data by group and analysed it with repeated-measures ANOVAs where time (i.e. first, second, and third testing sessions) was the within-subjects variable in order to explore the differences between the student environment and the training camp environment. Greenhouse-Geisser corrections were used when the assumption of sphericity was violated.

The mean scores for the questions on tiredness and hunger were not significantly different in the student group across time nor in the cadet group across time (see Table 1). The mean scores for the questions on stress, physical strain, mental pressure, pain, out of comfort zone, and shouting were not significantly different in the student group across time but they were significantly different in the cadet group across time (see Table 1). In the cadet group, after the first testing

session, participants reported higher levels of stress, physical strain, mental pressure, pain, being more out of their comfort zone, and being shouted at more.

Changes in disgust sensitivity

For all the analyses, average pathogen, sexual, and moral disgust scores were calculated. Data for pathogen disgust were normally distributed. Sexual disgust scores showed slight negative skew, distribution was normalised with a natural log transform. Moral disgust scores showed positive skew, distribution was normalised with a natural log transform of 8 minus moral disgust scores. Independent-samples t-tests for disgust sensitivity at baseline (i.e., Session 1) revealed that there were no significant differences between the student group and the cadet group for pathogen ($t(49)=-1.26$, $p=0.214$), sexual ($t(42.7)=-0.63$, $p=0.535$), or moral disgust ($t(49)=-0.11$, $p=0.916$).

We then ran repeated-measures ANOVAS where time (i.e. first, second, and third testing sessions) was the within-subjects variable and group (i.e., student versus cadet) and participant sex were the between-subjects variables in order to examine the interactions. A significant interaction between time and group was found for pathogen disgust ($F(1.5,70.0)=4.28$, $p=0.027$), but not for sexual ($F(1.3,61.3)=3.00$, $p=0.078$) and moral disgust ($F(1.5,69.5)=0.89$, $p=0.388$).

To further investigate the significant interaction between time and group for pathogen disgust, we split the data by group (i.e., student versus cadet) and analysed it with repeated-measures ANOVAs where time (i.e. first, second, and third testing sessions) was the within-subjects variable (see Table 1, Figure 1). The mean scores for pathogen disgust were not significantly different in the student group across time but they were significantly different in the cadet group across time. Bonferroni-corrected post-hoc tests showed significant differences in

pathogen disgust in the cadet group between all the testing sessions except between sessions 2 and 3.

Lastly, we computed changes in perceived environmental harshness (i.e., the mean level between Sessions 2 and 3 minus the level at Session 1) and changes in disgust sensitivity (i.e., the mean level between Sessions 2 and 3 minus the level at Session 1) for all participants. To avoid false positives from multiple comparisons, change in perceived environmental harshness measures were factor analysed. Tiredness and hunger were excluded as these had not shown to change with time. Factor analysis without rotation revealed 2 factors (see Appendix A), each with a normal distribution. The first factor, accounting for 47% of the variance, loaded highly on all change measures positively ($r>0.67$), but more weakly on stress change ($r=0.38$) and was significantly higher in the cadet group ($t(47)=6.42$, $p<0.001$). The second factor, accounting for 17% of the variance, loaded positively on stress change ($r=0.76$), negatively on physical strain change ($r=-0.58$), and did not differ between groups ($t(47)=-1.05$, $p=0.298$). The factor analysis thus suggests that the self-reports reflect a singular change in perceived hardship as a result of the training. This change in the perceived hardship factor correlated with pathogen disgust change ($r(49)=-0.32$, $p=0.027$), but not with sexual disgust change ($r(49)=0.16$, $p=0.266$) or moral disgust change ($r(49)=0.17$, $p=0.231$) for all participants[1].

Discussion

[1] The same pattern of results was found if stress was excluded from the factor analysis, which then produced a single change in perceived hardship factor loading on all change measures >0.69. This single factor continued to correlate with pathogen disgust change but not with sexual disgust change or moral disgust change.

Our results showed that the participants in the student group did not experience a change in the perceived harshness of their environment. More specifically, the student participants reported the same levels of stress, physical strain, mental pressure, pain, feeling out of their comfort zone, and being shouted at across the three testing sessions. On the other hand, our results showed that the participants in the cadet group faced an increase in the perceived harshness of their environment during the training camp. More specifically, the cadets reported having higher levels of stress, experiencing more physical strain, mental pressure, pain, feeling more out of their comfort zone, and being shouted at more during the training (i.e., Sessions 2 and 3) than before commencing the training (i.e., Session 1).

Our results also showed that the cadets' pathogen disgust sensitivity levels changed throughout the testing sessions. Pathogen disgust sensitivity decreased from the start of the training camp and then remained constant at the lower level for the duration of the training camp. This suggests there may be an association between pathogen sensitivity levels and perceived environmental harshness. Decreasing pathogen disgust in a harsher environment would be a way to increase survival since it would allow individuals to consume what is available when resources are scarce.

Sexual and moral disgust sensitivity did not change across the testing sessions. We had predicted that in a harsh environment, where mating opportunities may be limited and life expectancy may be reduced, it might be beneficial to lower sexual disgust in order to maximize mating possibilities. We had also predicted that a relaxation of moral principles would be beneficial in a harsh environment. However, we did not find a significant interaction between time and group for sexual and moral disgust. One possibility for these results is that while our pathogen disgust scores fell within the expected range (Tybur et al., 2009), the sexual and moral disgust

scores were quite a bit lower than expected. Such low values may have made it difficult to detect any changes in sexual and moral disgust sensitivity over time.

Our null sexual and moral disgust results could also be attributed to the fact that the type of harshness the cadets were experiencing (i.e., military training) is a very specific type of harshness. For instance, much of army training enforces following rules, so while harshness may be changing, cadets are still expected to act a certain way. Army personnel have a strict code of acceptable behaviours and morals. It would therefore be interesting to examine changes in sexual and moral disgust sensitivity in individuals who face a harsher environment without the influence of the codes of conduct enforced by the army (akin to Golding's (2003) literary speculation of the morality breakdown in "Lord of the Flies").

Further research would thus benefit from a different way of changing perceived environmental harshness. Army training is supposed to increase thresholds for fear, pain, and disgust and as a result, any changes in disgust sensitivity may reflect this training, rather than harshness of the environment. Additionally, the effects of training may be more permanent (akin to medical training; Rozin, 2008) and therefore using different or additional measures of harshness would also allow for the investigation of whether disgust changes temporarily to correspond to the current environment or whether changes in disgust sensitivity are long-term once established.

At baseline, the student sample and the cadet sample did not differ in pathogen, sexual, or moral disgust sensitivity. This suggests that those who self-select for the Officer Training Corps do not have different dispositional disgust sensitivities. However, there may be several other systematic differences between those who choose to go to the Officer Training Corps and those that do not, so there could be additional unobserved differences between the groups driving our observed effects. Thus, while our study provides interesting preliminary evidence for pathogen

disgust being malleable depending on the environment, further exploration (particularly with a sample where there is not such strong self-selection) is needed to determine causality. Additionally, the cadet and student samples were unmatched in terms of gender and age.

Future studies with larger samples are particularly needed. It was quite difficult getting permission/access to the army sample and thus our sample size was small, particularly for women. Thus, although our results suggest that pathogen disgust sensitivity changes with the environment, follow-up studies with larger samples are needed to confirm such an effect. More specifically, large enough samples where age and gender can be further examined are needed.

Another limitation from our study is that our measures of perceived environmental harshness were relative and self-reported (e.g., "Currently, how tired are you?"; "Currently, how hungry are you?"). Thus, there could be unwanted reporting effects. For instance, being in an army environment may create the expectation to answer questions a certain way and this could bias responses. It would have therefore been useful to also measure more objective external environmental factors, such as how many hours of sleep the participants got and the quality/quantity of food they consumed. Directly measuring certain aspects of the external environment would have allowed for a better examination of which aspects of the environment have a greater impact on disgust sensitivity and therefore future research would benefit from including observational measures alongside self-report measures.

In addition, our study did not measure other emotions. Emotions other than disgust may have also temporarily changed as a result of the training camp. If so, the decreases we found in pathogen disgust in the cadet group could be a result of negative emotions more generally being impacted under such an environment. As a result, future research is needed to determine whether

such increases in environmental harshness change other emotions or whether that change is restricted to the emotion of disgust.

In conclusion, we found that disgust sensitivity appears to change depending on the environment. More specifically, we found that an increase in the perceived harshness of the environment was associated with a decrease in pathogen disgust sensitivity. Lowering pathogen disgust sensitivity would be beneficial since it would facilitate the consumption of available resources. Future work is still needed to determine if in times of hardship disgust becomes less sensitive in order to serve more basic goals of survival but our study provides a meaningful first step in understanding the malleability of disgust sensitivity and its relationship with environmental harshness.

Declaration of interest statement

The authors report no conflicts of interest.

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Appendix A. Factor loading for the perceived environmental harshness questions

Change Item	*'Perceived Hardship Change' Factor Loading*	*'Perceived Stress Change' Factor Loading*
Stress	0.38	0.76
Physical Strain	0.67	-0.58
Mental Pressure	0.77	0.16
Pain	0.69	-0.24
Out of Comfort Zone	0.71	0.22
Being Shouted At	0.80	-0.02

Table 1. Means and standard deviations across testing sessions as well as a summary of the repeated-measures ANOVAs

	Student Group									*Cadet Group*								
	M_1	SD_1	M_2	SD_2	M_3	SD_3	df	F	Sig	M_1	SD_1	M_2	SD_2	M_3	SD_3	df	F	Sig
Tiredness	5.80	2.80	5.60	1.98	5.05	2.31	2,38	0.84	0.438	5.69	2.07	6.24	2.56	6.97	2.43	2,56	3.01	0.057
Hunger	2.75	2.22	3.50	2.74	2.70	1.95	1.5,28.1	0.82	0.419	4.41	2.26	3.69	2.29	3.34	2.78	2,56	1.83	0.170
Stress	4.53	2.04	5.47	2.22	4.68	2.38	2,36	2.61	0.087	3.53	2.00	4.93	2.49	4.20	2.75	1.6,46.7	3.66	0.042
Physical Strain	4.79	2.32	4.53	2.25	4.32	2.21	2,36	0.43	0.655	3.94	1.53	6.48	2.00	5.19	2.29	2,60	19.03	<0.001
Mental Pressure	5.50	1.95	5.61	1.94	5.33	2.20	2,34	0.17	0.845	3.84	1.77	6.42	1.73	6.87	1.80	2,60	50.76	<0.001
Pain	2.21	1.55	2.00	1.49	2.26	1.66	2,36	0.19	0.830	2.00	1.46	3.81	2.20	3.97	2.48	2,60	13.27	<0.001
Out of Comfort Zone	3.21	2.12	2.84	1.61	3.63	1.98	2,36	1.38	0.265	4.07	2.10	6.03	2.31	5.62	2.04	2,56	12.85	<0.001
Being Shouted At	1.25	0.64	1.35	0.81	1.20	0.70	2,38	0.36	0.702	2.68	1.78	5.29	2.30	4.77	2.36	2,60	23.86	<0.001
Pathogen Disgust	4.09	1.20	4.04	1.13	4.03	1.19	1.4,26.6	0.24	0.706	3.68	1.12	3.24	1.13	3.20	1.20	1.5,46.0	10.52	0.001

There were 3 testing sessions, with time intervals of 3 days between each testings session

N=20 for the student group; N=31 for the cadet group

Greenhouse-Geisser df were used when the assumption of sphericity was violated

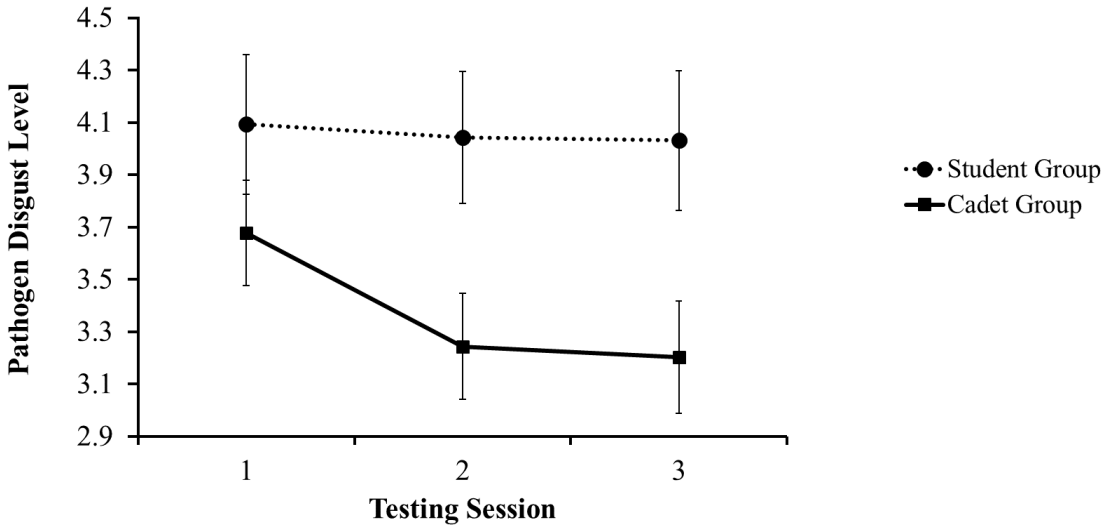

Figure 1. Comparison of pathogen disgust sensitivity across time for both the student group and the cadet group. Session 1 was conducted on the first day of the army camp before the training commenced and sessions 2 and 3 were conducted during the remainder of the army training camp.