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Anxiety, disgust and negative emotions influence food intake in humans☆

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ABSTRACT

A growing body of research has shown that the emotion of disgust is adaptive since it protects humans from pathogens. The possible role of anxiety and other positive and negative emotions in pathogen avoidance remain less clear. We investigated individual food acceptance after a disgust-evoking experience (a trout dissection) in a real-life setting by assessing the taking of a portion of trout. The unique contribution is that both state and trait disgust influence the likelihood of taking food after being disgusted. Participants who were more anxious, disgust sensitive or predisposed to more negative emotions avoided food after dissection significantly more frequently than their more positively affected counterparts. Males tended to accept food more often than females. Overall, these results suggest that anxiety, disgust and additional negative emotions are important in human food avoidance and that both anxiety and emotions can be considered as adaptive from an evolutionary perspective.

Introduction

Pathogen stress favours individuals who are able to successfully combat diseases and successfully reproduce (Schaller and Duncan, 2007). Humans have developed a biological immune system (BIS) which is able to detect, distinguish and kill a variety of pathogens from viruses to macroparasites (Parham, 2009) and a behavioural immune system (BEH) which comprises cognitive, emotional and behavioural mechanisms that allow individuals to detect the potential presence of parasites in objects (or individuals) and act to prevent contact with those objects (or individuals) (Schaller and Duncan, 2007; Neuberg et al., 2011). Both BIS and BEH interact with one other (Schaller et al., 2010; Miller and Maner, 2011), although BIS is understood as a second line of defence, activated only after the disease could not be avoided. BEH is consequently the "cheaper" and more effective system working in the first line of defence against pathogens (Neuberg et al., 2011; Schaller and Park, 2011). Potential handicap effects by accepting poisonous food will not be discussed here because it has only been observed in non-human animals (see, e.g. Antczak et al., 2005).

To avoid disease, BEH is activated in the presence of disease-relevant cues (Kurzban and Leary, 2001) although it does not react to specific cues triggered by parasites because these may vary greatly. It instead responds in a hypersensitive way to the *perceived* presence of parasites in the sensory environment (Schaller and Duncan, 2007). It can also be compared to the 'smoke detector principle' (Nesse, 2005; Haselton and Nettle, 2006). A smoke detector is usually calibrated to be supersensitive to anything which (albeit superficially) resembles smoke in order to minimise the likelihood of failing to register the presence of real danger – a house fire – which would be an extremely costly false-negative error. In contrast, a false-positive error (e.g. detecting someone smoking in the toilet) is much cheaper than neglecting a dangerous fire.

Research suggests that there are individual differences in pathogen avoidance (Curtis et al., 2011) since the costs of disease transmission differ with respect to an individual's immune system (Stevenson et al., 2009; Prokop et al., 2010a, 2010b). There is actually growing evidence indicating that pathogen avoidance is manifested through changes in behavioural, emotional, cognitive and personality traits. People who think themselves vulnerable to disease transmission reveal a relatively greater level of aversive response to physically disabled individuals (Park et al., 2003), towards older adults (Duncan and Schaller, 2009), immigrants (Faulkner et al., 2004), toward obese people (Park et al.,

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2007) or toward disease transmitting animals (Prokop et al., 2010a, 2010b; Prokop and Fančovičová, 2010). These people pay increased attention to faces with even innocuous disfigurements (Miller and Maner, 2011) and evaluate themselves as less extroverted than less disease-sensitive people (Mortensen et al., 2010). Disease-sensitive people also engage more frequently in various anti-parasite behaviours such as increasing washing of hands (Porzig-Drummond et al., 2009), self-grooming behaviours (Thompson, 2010) or reducing physical contact with animals (Prokop and Fančovičová, 2011).

Anxiety, defined as an organism′s preparatory response to contexts in which a threat may occur (Beck et al., 1985; Cisler et al., 2009), may be associated with the emotion of disgust (Cisler et al., 2007). Anxiety produces physiological responses such as an increased heart rate, stress hormone secretion, vigilance, fear of potentially dangerous environments and decreased feeding behaviour (Cohen et al., 1985, also see Bellisle et al., 1990 for different results regarding anxiety and feeding) which can be viewed as adaptive from an evolutionary perspective since it prepares the body for potential threat (Bateson et al., 2011). Reduced food intake induced by anxiety (Nordin et al., 2004) decreases the likelihood of being contaminated in environments with a high perceived threat. It is also associated with activation of the sympathetic division of the autonomic nervous system, which suppresses the parasympathetic division and consequently reduces feelings of hunger (McEwen, 2007).

Humans are omnivores (Ungar and Sponheimer, 2011) and a high variety of potential food is, on the one hand, beneficial since it heightens the probability of finding a potential food source, although it, on the other hand, generates the issue of selection of foods that do not contain deadly toxins (Pollan, 2006). Digestive infections are a major cause of morbidity and mortality (Kyne et al., 2002), thus evolutionary pressures toward selection of appropriate foods are expected.

In this study, we investigated whether anxiety, disgust and negative emotions are individual predictors of food avoidance. Specifically, we hypothesize that people with a higher disgust/anxiety sensitivity and those with a negative mood will avoid consumption. Unlike the majority of previously published studies, our data do not rely solely on self-reports. We instead made use of both paper-and-pencil tests and an actual elicitor of disgust (dissection) which stimulates visual, olfactory and tactile receptors, followed by behavioural observation of an individual′s willingness to eat food. This combined approach allowed for both validation of the paper-and-pencil tests (Rozin et al., 1999) and for more precise data from real-life situations.

Methods

Participants and data collection

The participants were students from the University of Education Heidelberg who routinely participate in a basic zoology course, which includes the dissection of a fish (trout; Randler et al., 2013). The dissection of the fish was rated as the most disgusting experience during the whole semester term (Randler et al., 2013). The trout was already dead before the dissection started. The semester course included living animals, such as earthworms, mice, woodlice and snails, as well as a trout dissection and some work with models of animals. In this study, disgust ratings were taken immediately after the respective lessons and the trout dissection was rated as most disgusting, compared to living animals (such as woodlice, earthworms and snails), as well as to lessons were no animals (dead or alive) were presented. Therefore, we consider the dissection of a trout as disgust evoking experience.

The age of the students ranged from approximately 22 to 23 years when they attend this course in the curriculum (Randler et al., 2013). The study followed the ethical guidelines of the “Forschungskommission” of the University of Education Heidelberg. The study did not need an additional ethical approval because it was linked with a regular course for teaching biology. The University of Education Heidelberg is regularly funding the dissection by special subsidies to enable the teachers to make the dissection experience possible. In contrast to pr)evious teaching a decade ago, the killing of animals has been strongly reduced (no frogs, mice, pigeons, etc. anymore, and the trout dissection is the only one dissection left.

The battery of questionnaires was applied on a voluntary, unpaid and anonymous basis, although the majority of the students participated in the study and the rejection rate was below 10%. All the students from the courses were invited to participate in this study. Prior to the dissection (one week before) we assessed if they ate fish or not. We excluded all persons from the statistical analyses who noted that they did not eat fish at all, but all persons participated in the dissection, the questionnaire study and the offering of trout portions. A total of 80 persons (all fish-eaters) were analyzed in the study (71 women, 5 men, 4 sex unspecified). A cross-validation check with actual observed behaviour confirmed that all persons stating that they did not eat fish indeed did not take any helping of fish ($p < 0.001$). One week in advance, we used a pre-test based on trait measurements (pre-trait). We used the German translation of the trait disgust scale (Petrowski et al., 2010). In addition, we asked for the number of dissections of fish and other animals or their organs. Immediately after the dissection we applied the following test: State anxiety (STAI-S), specific state disgust, and the positive and negative affect scale (PANAS; for details see the measurements). The students were consequently asked to deposit their questionnaire in a separate room. In this room, a number of small portions of trout had been prepared for eating (“finger food”). Researchers were present in this room and thanked the students for their participation, then offered the different fish portions and collected the questionnaires. Different types of helping had been prepared, all of them with rainbow trout, the same species that has been dissected before but not one of the actual animals that had been dissected due to hygiene and safety reasons. Different types of mayonnaise, horseradish, and portions with and without bread were provided. Students had the possibility to wash their hands prior to entering the room and moist towelettes (hygiene papers) were also offered. The room was far enough from the dissection room to not see or smell the remains after the dissection. The questionnaires were deposited in a closed box (urchin) but the researchers made a sign (“x”) on the blank backside of the questionnaire if the participant took one of the portions. The students were unknown to the researchers. There was some control over the knowledge of the researchers: PWA made the dissection course and sampled the questionnaires, while the researchers in the food room did not know the responses to the questions when they offered the portions.

Measurements

Trait disgust

Disgust was measured as a trait measurement with 37 items one week prior to the intervention and dissection. Trait disgust consist of three domains: core disgust (15 items), animal reminder disgust (9 items) and contamination disgust (13 items). All items are five-point Likert scaled. We used the German version of the scale, which has solid psychometric properties (Petrowski et al., 2010). The reliabilities (Cronbach′s α) of the present sample are core disgust: 0.73, animal reminder disgust: 0.79, and contamination disgust: 0.70.

Specific state disgust (trout)

Specific state disgust was measured with a scale (7 items) related to the dissection of the rainbow trout (see Randler et al., 2012). Example items are “If I were served an entire trout (including the head and eyes) in a restaurant, I would not be able to eat a thing.”, “Trouts are disgusting.”, “I would rather leave the room when we dissect a trout.”, “During trout dissection, I would rather use a nose clip to avoid the smell." or "I don't mind touching a trout. (reverse coded)". The items were rated on five-point Likert scales and 2 of the 7 items were reverse coded. Cronbach's α was 0.73. As shown earlier, this specific disgust measurement is state-dependent and thus sensitive to intra-individual changes (Randler et al., 2012). The specific state disgust was measured immediately after the dissection in the lab room.

State anxiety (STAI-S)

State anxiety was measured with a scale (20 items) which is sensitive to changes (STAI-S; Laux, Glanzmann, Schaffner, & Spielberger, 1981). The items are four-point Likert scaled with 10 items being positive and 10 items being negative coded. The reliability of the state anxiety was high in the present sample (α=0.88). State anxiety was measured immediately after the dissection within the lab room.

Positive and negative affect schedule/PANAS

PANAS was used in the German translation (Krohne et al., 1996). We used the state versions which inquire as to how one feels at the moment. The scale consists of 10 positive and 10 negative aspects rated on the 5-point Likert scale. Cronbach's α of the PA was 0.89 and of the NA was 0.76. PANAS was measured immediately after the dissection.

Additional variables

As exclusion criterion we asked whether the participants eat fish or not. The total number of dissections of fish and other animals or their organs was also assessed as covariate. In addition, we asked our students three weeks later in retrospect in an open question format if they ate the helping and if not why, and only 6 indicated it was due to the absence of hunger.

Data handling and statistical analysis

Correlation analysis was used and the multivariate analyses are based on a discriminant function (DF) because we had only continuous variables. SPSS 20 was used (German version, SPSS Munich). We did not apply Bonferroni or other adjustments to the correlational Table 2 because the intention of the correlational table is to show how the different independent variables are related with each other.

Results

The descriptive statistics of the variables are presented in Table 1. Of the 80 persons who indicated that they are fish eaters, 37 ate a helping after the dissection. Table 2 indicates the inter-correlation of the psychological measures. We used a discriminant function to assess which variables exerted the strongest influence on the behaviour to eat a trout helping. Table 3 presents the structure matrix of the full model according to the size of the factors. The model produced one function with an Eigen-value of 0.548 and a canonical correlation of 0.595 (Wilk's λ=0.65, x2=25.14, df=9, p=0.003). Structure matrix correlation coefficients less than 0.30 are typically not interpreted because the square of the structure matrix coefficient reveals that such discriminators account for less than 10% of the variability in the function (Brown and Wicker, 2000). A total of 73.8% of the cases were classified correctly. The choice of a person to eat a small trout helping was predicted by the high positive affect after the dissection, by low specific-state disgust, low contamination disgust (as a trait disgust measure) and low state anxiety after the dissection. State disgust was the most important predictor, followed by positive affect, trait disgust (contamination disgust) and state anxiety. Trait and state variables of disgust consequently contributed to the discriminant function. When adding our post-hoc measure of hunger, the model changed minimally, but hunger emerged as an additional factor, that is people reporting that they were not hungry did not eat a helping (Table 3). The model produced one function with an Eigen-value of 0.805 and a canonical correlation of 0.668 (Wilk's λ=0.55, x^2=33.65, df=10, $p < 0.001$). A total of 73.8% of the cases were classified correctly as in the previous model.

Table 1
Descriptive statistics of the variables.# of previous dissections refers to the previous number of dissection carried out by the participants.

	Minimum	Maximum	Mean	SD
Specific State Disgust	1.00	4.00	1.89	0.70
Core Disgust	2.20	4.73	3.68	0.49
Animal Reminder Disgust	1.00	4.56	2.49	0.71
Contamination Disgust	1.54	4.54	3.17	0.53
STAI State Anxiety	1.10	2.85	1.71	0.40
Positive Affect	1.00	4.90	3.42	0.81
Negative Affect	1.00	3.00	1.33	0.43
# previous dissections	1.00	4.00	1.55	0.52

Discussion

The main goal of this study was to assess the influence of disgust and affect on feeding behaviour in humans in a real life situation. Disgust as a "protective emotion" (Curtis et al., 2004; Rozin et al., 1999; Tybur et al., 2009, 2013) was significantly associated with food avoidance. Specifically, participants who rated themselves as more disgust-sensitive, avoided small trout portions more than their less disgust-sensitive counterparts. This finding is in line with Rozin et al. (1999) who found that a participant's willingness to touch and/or consume several disgust-relevant objects such as cockroaches, mealworms or dog food negatively correlated with disgust sensitivity. Here, we demonstrated that a smoked trout, a clear example of common food, was rejected more often by disgust-sensitive participants. Trout rejection was mostly associated with the contamination disgust domain of trait disgust scale which suggests that the conditions in our study which represent a risk of *potential* contamination yielded more sensitive participants to avoid trout helpings. An association between hunger level and participant's willingness to eat trout portions can be explained by lowering the threshold for food intake induced by food deprivation (Hoefling et al., 2009). In previous work, we showed that the dissection of a trout elicited the highest disgust in our students, higher than living woodlice, snails or earthworms (Randler et al., 2013). These results provide real-life support for the idea that perceived disgust reduces food intake. This finding is corroborated by Nordin et al. (2004) who found a positive correlation between disgust sensitivity and food neophobia (rejection of novel or unknown foods).

One might ask why certain participants were unwilling to consume a safe food that would increase caloric intake and survival in an evolutionary sense? The answer lies in over-perception of the risk of contamination. Responding to a *potentially* contaminated food by a false positive error (Nesse, 2005; Haselton and Nettle, 2006) is usually much "cheaper" than to digest a toxic food. More disgust sensitive, and hence perhaps more immunologically compromised participants (Stevenson et al., 2009; Miller & Maner, 2011; Mortensen et al., 2010), would benefit from stricter food selection in order to avoid physical contamination.

More anxious participants avoided trout portions more than less anxious participants. This suggests that anxiety, as a preparatory response to potential threat (Beck et al., 1985; Cisler et al., 2009), may reduce food intake and re-direct energy to vigilance and preparedness in a dangerous, or at least in an unpredictable, environment. In our view, anxiety plays a protective role similarly to the emotion of disgust; these two variables are correlated (Cisler et al., 2007). This result contradicts one previous report on humans, where opposite or no relationships (Bellisle et al., 1990) between anxiety and food intake were found.

As predicted, positive emotions were associated with trout accep-

Table 2
Correlations between the predictor variables trait disgust, state disgust, state-anxiety (STAI), and positive/negative affect. The data presented here are to show the intercorrelation of the variables, therefore we did not correct for multiple testing.

		core disgust	animal reminder disgust	contamination disgust	STAI	Positive Affect	Negative Affect
specific state disgust	r	0.232*	0.401**	0.097	0.614**	−0.311**	0.359**
	P	0.039	< 0.001	0.391	< 0.001	0.005	0.001
core disgust	r		0.500**	0.679**	0.179	−0.164	0.031
	P		< 0.001	< 0.001	0.111	0.146	0.785
animal reminder disgust	r			0.523**	0.199	−0.207	0.024
	P			< 0.001	0.077	0.065	0.836
contamination disgust	r				0.135	−0.107	0.020
	P				0.234	0.343	0.863
STAI state anxiety	r					−0.399**	0.592**
	P					< 0.001	< 0.001
Positive Affect	r						−0.069
	P						0.542

Table 3
Coefficients of loading of the variables on the discriminant function to separate eaters from non-eaters. Negative signs show a negative influence (non-eaters), positive values indicate that the variable was linked to the consumption of a trout helping. In bold are the loadings higher than 0.3.

	Function 1 N=80	Function 1 N=80 (with hunger variable)
Specific state disgust	**−0.530**	**−0.437**
Positive Affect (PANAS)	**0.506**	**0.418**
Contamination disgust	**−0.465**	**−0.384**
STAI state anxiety	**−0.401**	**−0.331**
Animal reminder disgust	−0.290	−0.239
Negative Affect (PANAS)	−0.217	−0.179
Gender	0.199	0.164
Core disgust	−0.102	−0.084
# previous dissections	0.050	0.041
Hunger	–	**−0.353**

tance. As the measure of affect was given immediately after the trout dissection, it may simply reflect individual differences in the affective consequences of the dissection which would likely carry over to the acceptance of trout to eat but not necessarily generalize to food selection overall. Edwards et al. (2013) and Evers et al. (2013) recently discovered that negative emotions lowered food acceptability and positive emotions increased food acceptability, although their investigations were not based on experimental manipulation with food which could be perceived as potentially contaminated. According to evolutionary theory, it can be expected, however, that within species variability in terms of food preference is to be expected favouring individuals who are able to select nutritious and edible food (Pollan, 2006). Positive emotions would be, on one hand, associated with less selective (and, thus, riskier) food acceptability. On the other hand, positive emotions are associated, with better health and lower mortality rates (reviewed by Cohen and Pressman, 2006, Kok et al., 2013).

One may argue that the responses to the food offering might be influenced by the state disgust measure, but the participants were unaware of the offering of food (the food was not mentioned during the dissection and the questionnaire application and was offered in separate room). Further, it is unlikely that the participants showed a social desirable behaviour and it is unlikely that the food offering may have been seen as an opportunity for the participants to show that their responses were accurate for two reasons. First, researchers were different in the trout dissection experiment, and second, researchers in the room where the portions were offered were 'blind' to the students' previous behaviour and their responses on the questionnaire.

In addition, it would be useful to add a specific measure of hunger after the dissection and prior to the offering of the portions to assess situational specific hunger in more detail compared to our raw measure.

Future studies might include a control group in the research design, but then, the effect of treatment would be the important variable to measure and the emotions should be less relevant. In addition, other food that trout portions could be used to generalize the results. As another important aspect, we consider to assess food preferences during different times of day because there seem to be circadian fluctuations (Haynes et al., 2016). However, our study sample was too small to assess these effects.

Conclusion

To conclude, we demonstrated that individual differences in affective state after a dissection influenced the participants' food choice. Adults who were female, more anxious, more disgust sensitive and who perceived themselves as more predisposed to negative emotions avoided eating smoked trout more than others. We would like to call for further research examining the costs and benefits from engaging in risky behaviour such as eating potentially contaminated foods in humans.

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