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The Effect of Affective State on Tactile Sensitivity

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Abstract Page

Infection from pathogens are the remaining threat that controls the human population and, evolutionarily speaking, the reproductive success of human beings. Past research demonstrates that disease avoidance encompasses not only a physiological response, but also that of a behavioural and psychological nature. There is bountiful research relating to disease avoidance behaviours being induced through indirect and direct exposure to disease salient stimuli and how the skin behaves as a barrier protecting the body. Jack Cotter (2011), attempted to identify a link hypothesizing that tactile sensitivity would increase, but did not gain significant results when testing disgust and two-point discrimination threshold using an aesthesiometer. The present study sought to modify and repeat Cotter's study. Forty participants completed the study consisting of exposure to neutral stimuli, a tactile sensitivity test, a distraction task, exposure to fear or disgust-related stimuli and then another tactile sensitivity test. T-tests and an ANOVA identified a significant change in tactile sensitivity with those induced in to pathogen disgust, as opposed to those induced in to fear. Slight gender differences identified were not concluded to be statistically significant. Repetition of the study with a larger sample could amend the short comings of this experiment, clarify the ambiguity still surrounding gender differences and distinction between fear and disgust-related stimuli, it may also increase the reliability of these results and equipment used.

Key Words	Pathogen	Disgust	Fear	Tactile	Sensitivity

1.) Introduction
1.1. Role of disgust

It was Ekman and Friesen (1974), who recognised and outlined 6 primary emotions that lead to the basic behavioural response tendencies such as "fight or flight" (Becker-Asano, Kopp, Pfeiffer-Leßmann, & Wachsmuth, 2008). The 6 primary emotions outlined are as follows: happiness, sadness, surprise, fear, anger and disgust. Theories behind the function of disgust traditionally focused on the oral rejection of harmful substances (Ekman & Friesen, 1975; Rozin & Fallon, 1987; Tomkins, 1963). Darwin (1872/1965) defined disgust as *"something revolting primarily in relation to the sense of taste, as actually perceived or vividly imagined; and secondarily to anything that causes a similar feeling, through sense of smell, touch and even of eyesight"*. Today's psychological definition states disgust is a homogeneous emotion elicited in response to a variety of acts and substances ranging from faeces, to incest and pornography, to lying and stealing (Tybur, Lieberman, Griskevicus, 2009). In Tybur's 2009 paper, he states difficulty in outlining the specific function of disgust due to its varied nature. Previous models have recognised that disgust applies to objects and acts as well as the "something revolting" Darwin defined, and therefore suggested that disgust encourages avoidance or protecting one's self (Miller, 2004). Tybur identified this as a mere general function of the emotion, and so expanded on this idea by dividing the emotion in to three functionally specialised domains; moral, sexual and pathogen. Moral disgust motivates the avoidance of violating social norms, sexual disgust motivates the avoidance of sexual behaviours that will jeopardise long term reproductive success and pathogen disgust motivates the avoidance of infectious microorganisms.

Historically and prehistorically, infection and disease have progressed at a competitive rate with human beings and have posed adaptive challenges for us (Terrizzi, Shook, & McDaniel, 2013). Infectious microorganisms were a recurring feature to humans in their ancestral environments and posed a constant threat to health and therefore survival and reproduction, (Maynard Smith, 1978; Tooby, 1982). Therefore pathogen disgust is elicited by objects perceived to have to contain infectious agents including rotten food, bodily fluids and even dead bodies. It is also elicited by stimuli that emits such agents but are not actually infectious, be they visual, olfactory, auditory or tactile cues (Rozin et al., 1986). Interestingly a disease avoidant response can be triggered through stimuli that isn't infectious but is conceptualised as so, e.g. a dog with a physical deformity (Haselton & Nettle, 2006; Kurzban & Leary, 2001; Park, Faulkner, & Schaller, 2003; Schaller & Duncan, 2007). There are so many independent categories that come under the emotion title of disgust, Tybur's use of the three domains means that these categories can be more parsimoniously explained within a broader domain such as pathogen disgust. The present experiment is focused on just how far pathogen can be manipulated with an individual.

1.2. The Behavioural and Biological Immune System

In addition to the body's robust and complex physiological immune system which uses cell based intervention to engulf and destroy invading pathogens, being in a state of disgust activates the behavioural immune system. The behavioural immune system is an evolved mechanism that aids avoidance of parasites and pathogens through activating a variety of physiological, behavioural and psychological responses (Neuberg, Kenrick, & Schaller, 2011; Oaten, Stevenson, & Case, 2009; Schaller and Park, 2011). Schaller and Duncan, (2007) outlined examples of such responses, including prevention of contact and ingestion of pathogens. A major role of the behavioural immune system is to act as a first line of defence (Schaller, 2006), immunologically speaking the true first line of defence is the skin. Having this behavioural mechanism increases the likelihood of disease avoidance and also reduces the burden on the last line of defence, the biological immune system which has a function that is energetically costly (Brown, 2003). Unlike the biological immune system that specifically reacts to the invasion of pathogens in the body, the behavioural immune system is hypersensitive in its response, it not only responds to specific cues but to the perceived presence of parasites in one's sensory environment before it has invaded the body (Prokop & Fančovičová, 2010).

Despite hypersensitivity meaning that the system will be more efficient in making sure no potential threats are missed, it does mean that it can be triggered by cues that present little threat, and therefore are not infectious and will not cause potential harm to the body- false positives (Schaller & Park, 2011). False positives can be problematic given the variety of short-term physiological and psychological changes that can occur in an individual. Such changes include, nausea, changes in respiratory output (Ritz, Thons, Fahrenkrug & Dahme, 2005), changes in cardiac output (Rohrmann & Hopp, 2008), and increase in cortisol (the hormone that releases in reaction to stress) concentration in saliva (Rohrmann, Hopp, Schienle, & Hodapp, 2009). Most of these physiological responses were found and therefore manipulated through indirect exposure to disgust evoking stimuli; Mortenson et al., 2010 found that after being primed in to a state of disgust, subjects were found to exhibit more avoidant behaviours included those previously stated, providing evidence about what was theorised about pathogen disgust and its effect on the behavioural immune system. As problematic a response to a false-positive can be, the behavioural immune system's hypersensitivity is by no means to be considered as over responsiveness, Nesse, 2006 described over responsiveness of defence mechanisms as an illusion. The defences appear to be over responsive because they are inexpensive compared to the consequences of reacting to a false negative (e.g. getting sick from not interpreting a disease cue as disgusting).

1.3. The Skin

As stated before, Schaller, 2006 outlined the behavioural immune system as an informal first line of defence in avoiding invasion by pathogens, the true first line of defence is the skin, the largest organ in the human body. The skin acts as a physical barrier, protecting the body from harmful contagions, temperature and chemicals. The skin is innervated by a variety of sensory neurones designed to detect a variety of forms of sensory input. Touch is the main way for potentially harmful entities to come in to contact with the body. The specialised sensory neurones within the skin are sensitive to different forms of touch such as pressure, temperature, and vibration. Sensory input activates mechanoreceptors; peripheral nerves which enable us to detect sensory information, and monitor the position of our muscles, bones and joints. There are two types of mechanoreceptor, pacinian corpuscles and muscle spindles. Pacinian corpuscles are pressure receptors, a mechanism relevant to the present experiment; they are located in the skin and also in some vital organs such as the bladder, each is connected to a sensory neurone. When pressure is applied to the corpuscle, volleys of electrical impulses are initiated in to its coinciding sensory neurone. Muscle spindles are associated with muscle stretch and knee jerk reflex. Touch receptors usually reside near hair follicles, so if the skin is not directly touched, the movement in the nearby hair is detected. Therefore touch receptors are not distributed evenly all over the body, the finger tips and tongue have approximately 100 receptors per cm^2, and areas like the back of the hand have approximately less than 10 per cm^2. This can be proved using two point discrimination threshold tests, using a two or three point discriminator or aesthesiometer.

Despite playing such a huge role in defending the body there has been limited focus in investigating the relationship between disease avoidance and the skin. Touch is very much underrated when it comes to reaction to disgust; psychological interest favours behaviours that aid in the aversion of contaminants after invasion in to the body, when the skin's defences are passed the point to come to the body's aid. The skin is not just a protective layer of tissue that acts as a physical barrier against harmful disease, (Madison, 2003) is also has complex mechanisms that work towards the body's advantage. It secretes antibodies to engulf and destroy harmful pathogens on the skin's surface, (Hosoi, 2006).

1.4. Emotion and tactile sensitivity

Emotional state can modulate an individual's sensory processing, a number of studies have suggested that affective state can manipulate pain perception. Disgusting and fear invoking images have been found to have this effect, (Meagher, Arnau and Rhudy, 2001). Meagher et al, 2001 found that the viewing of fearful and disgusting images decreased pain and unpleasantness thresholds, something which would be to a human's benefit when faced with a potential "fight or flight" scenario as any unwanted contact with the threat will be detected quickly so it can be imminently followed by a form of aversion. A key example to explain this is the research demonstrating that affective mood states can modulate the thresholds of the central nervous system in chronic pain patients, (Montoya et al., 2005). Therefore it is fair to assume that those who are sensitive to disgusting stimuli have a temporary increased sensory sensitivity under disease salient conditions, therefore an increase in tactile sensitivity. All individuals seem to demonstrate focused attention with disgust-related stimuli, which is positively correlated with disgust sensitivity scores (Charash & McKay, 2002). The evolutionary explanation for this is that disgust acts as a cognitive and evolutionary alarm signal, so the attention is directly focused on the stimuli that are potentially dangerous or harmful. Such hypervigilance is a behaviour that is typical with those who suffer conditions involving persistent pain, a quality which conforms with Montoya's research. The individual will pay excessive attention to seek out their symptoms; it would be fair to say they almost continually scan their bodies for the threat that is their condition (Van Damme, Legrain, Vogt and Crombez, 2010). The same can be suggested for individuals who are in conditions of increased disease-salience, they too scan their bodies in a similar way in order to quickly detect potential threat. This focused attention could potentially result in heightened tactile sensitivity (Cotter, 2011).

An experiment project run by Cotter., (2011) attempted to investigate the effect of disease-salient stimuli on tactile sensitivity. He anticipated finding a significant difference between the changes in two-point discrimination thresholds between those exposed to disgust-related stimuli, fear-related stimuli and affectively neutral stimuli. He also predicted that disgust sensitivity scores through a questionnaire may be correlated with baseline two-point discrimination thresholds. Using thirty participants, each assigned to one of three conditions, a three-point discriminatory aesthesiometer, a tool commonly used in research towards tactile functioning, was used to test baseline discrimination threshold. Afterwards participants were given a disgust sensitivity questionnaire to fill out, followed by watching a series of images, either neutral, disgust or fear-related. Afterwards a final discrimination threshold test was conducted. Cotter revealed that those who reported lower sensitivity to the disgusting stimuli had a larger threshold to the discrimination test, meaning their accuracy in detecting the two points on the discriminator was poorer than those who reported high sensitivity (a negative correlation). However, the effect of image content on threshold found no significant change in two-point discrimination thresholds on all areas of the body that were tested (palm ascending, palm descending, forearm ascending and forearm descending). This may have been due to practise effects, the participant being used to the test and therefore having a decrease in sensitivity, the skin being habituated to the stimuli regardless of how the participant was primed.

1.5. Gender Differences

Men and women differ in their emotional perception of the world, it has been consistently reported that women score higher in measures that are related to emotional experience (e.g. Kring & Gordon, 1998) and are generally more expressive of their emotions than males. Research has also consistently shown that women systematically score higher than males on disgust sensitivity scales (Haidt et al., 1994; Casera et al., 2007). Interestingly, it was found from a variety of research that there was a significant increase in female disgust sensitivity with certain anxiety disorders such as contamination-related OCD (Woody & Tolin, 2002), and blood injury related phobias (Davey, 1994; De Jong et al. 2000; Matchett and Davey 1991; Mulkens et al. 1996; Olatunji et al. 2006; Sawchuk et al. 2000). Despite findings in gender difference in regard to disgust and how it is experienced, this difference is not accompanied by corresponding physiological changes the body undergoes in a state of disgust, there appears to be no gender difference as far as physical reaction goes. According to Rohrmann, Hopp & Quirin, 2008, these physiological changes remain largely ambiguous. The use of neural imaging has also failed to establish a physical response difference in gender when it comes to disgust sensitivity (Caseras et al., 2007).

Nevertheless, using a manipulation check, the Three-Domain Disgust Scale which is a 21-item Likert scale based measure made to provide scores relating to disgust sensitivity within the three domains outlined by Tybur, Lieberman and Griskevicius, 2009, Cotter attempted to identify a gender difference in disgust sensitivity. He found a negative correlation between female disgust sensitivity score in regard to sexual disgust and baseline forearm-ascending two-point discrimination threshold. An explanation for this is that there is a fitness cost administered to an individual overcome by a sexually disgusting cue, which reduces the female's opportunities to reproduce. In theory, natural selection through viruses alone (a biological selector) might cause a reduced relationship between heritability of a strong immune system and reproductive success, making the animal unable to carry to full term or produce healthy offspring. Such qualities would reduce the chance of conspecifics choosing the individual as a mate, completely eradicating any reproductive success within the organism, (Banzhaf & Eeckman, 1995). Therefore reason or face validity would suggest that females may be more sensitive to pathogen disgust-related stimuli.

1.6. Monofilaments

The two-point discrimination aesthesiometer is the current popular method for testing tactile threshold. Somewhat similar to a caliper, the aesthesiometer uses two adjustable points used to determine how short a distance between two impressions on the skin can be detected. A new method to measure pressure-related tactile sensitivity is Semmes-Weinstein Monofilaments, plastic rods holding fibres of different gauges. A video demonstration conducted by Schreuders, Sliiper, Selles, (2010) showed the monofilaments being used repeatedly on different areas of the palm and the participant had to voice when they could feel it. The demonstration provided a clear protocol for how to use the filaments with equal pressure on the skin, the filament fibre is meant to be pressed on to the skin until the nylon bends to form a C shaped curve. By changing the position of the nylon on different parts of the body and by changing the gauges of the fibres, the degree to how pressure sensitive that area of the body is can be measured. Evaluation of the equipment found the use of monofilaments to be carried out with ease and produce application forces that are repeatable within a predictable range, (Bell-Krotoski, & Tomancik, 1987).

1.7. Hypothesis

The present experiment aims to put Cotter's idea to the test with some adjustments to the methodology. The aim is to investigate whether priming in to a state of pathogen disgust has an effect on pressure-related tactile sensitivity, and therefore to test whether the behavioural immune system is truly triggered by a perceived threat of contagions. By testing pressure-related tactile sensitivity using monofilaments this not provides insight in to a specific area of tactile functioning that reinforces the skin's role as a physical barrier, but also introduces the novel idea of using such equipment to test an evolutionary hypothesis. Breaking/fissures of the skin is a key direct way for pathogens or harmful substances to enter the body as well as exposed orifices, such injuries are more or less caused by increased pressure on the skin. Therefore the testing of pressure sensitivity is an appropriate area tactile functioning to investigate, being visually invoked in to disgust may encourage an influence on primary tactile sensation (Kennett, Taylor-Clarke and Haggard, 2001).

By comparing the change in pressure-related tactile sensitivity between those who are manipulated through affectively neutral and then either fear or disgust related stimuli, it will not only further the research in to tactile processing when faced with an infectious threat but also support and expand on Cotter's recently non-significant results.

Despite previous theoretical and empirical research in to the matter, the present study is still very novel, so the outcome is still considerably difficult to predict. Cotter's focus on two-point discrimination may be too complex a form of tactile functioning for such a under-researched idea. Change in pressure sensitivity may be a lot simpler and a more theoretically appropriate dependent variable due to breakage of the skin causing an increase in infection. It is anticipated that those primed in to pathogen disgust would exhibit a greater increase in tactile sensitivity than those exposed to fear. Pressure-related sensitivity is expected to increase as like persistent pain patients, (Van Damme et al, 2010), the individual attempts to scan their bodies for the sensation of contamination by a contagion or exposed areas such as wounds where the contagion can enter the bloodstream. An increase however is not entirely unexpected in the fear condition, when faced with a physical threat; tactile sensitivity may increase in order to detect potential wounds that the threat may administer. With the research in to pain threshold (Van Damme, Legrain, Vogt & Crombez, 2010), those in the fear condition may exhibit decreased tactile sensitivity, as the body prepares for a "fight or flight" response pain threshold decrease in the anticipation of damage from the threat. Despite the debate, the fear condition is acting as a control; it is the effects of evoked pathogen disgust that are of interest.

Cotter failed to find a gender difference, in disgust and discrimination threshold. Nevertheless the research finding female's increased sensitivity to disgust (something Cotter did find) combined with that related to tactile processing and the behavioural immune system, it all allows one to surmise in the present experiment that female participants may experience a greater increase in pressure-related sensitivity than males when exposed to disease salient stimuli.

To conclude, it is expected that those primed in to pathogen disgust will experience an increase in tactile sensitivity, the fear condition is up for debate but should tactile sensitivity increase in this condition too, it is expected that the increase will be greater in the disgust condition and that females will display a greater increase in sensitivity than males.

2.) Method

2.1. Sample

Forty participants took part in the experiment (24 females, 16 males) with ages ranging from 18-25 years (*M*= 19.9, *SD*= 1.61), three of which were left handed and the remaining 37 were all right handed. All participants were students at the University of Portsmouth, mostly first year Psychology Undergraduates. The participants were recruited on a voluntary basis; an advert for the study was posted on the university participant pool and on social networks, where people could sign up for time slots. There was an inclusion criteria in order to take part in the study, participants must not have contagious skin conditions such as Impetigo or have damaged their sensory nerves via the spinal cord to the point they have limited sensation in their extremities. Participants also had to arrive to the experiment wearing a top that either had no sleeves or sleeves that could be easily rolled up, so their forearms were easily accessible. Participants were asked questions on arrival about their medical history and current conditions to ensure that the inclusion criteria were met.

2.2. Materials/ Apparatus

2.21. Tactile Sensitivity Apparatus:

Tactile sensitivity evaluation was measured using Baseline Evaluation Instruments (monofilaments) from Fabrications Enterprises (*see appendix A)*. The monofilaments consisted of plastic rods holding nylon fibres gradually increasing in grams force (from 0.008g force, to 300g force), they are designed to apply pressure on the participant's skin measuring their pressure perception. This form of equipment is currently used in medical practice, research with diabetic patients found that monofilaments were a more reliable method in screening for foot ulceration, a symptom that can lead to amputation if not detected in time (Kumar, Fernando, Veves, Knowles, Young and Boulton, 1991). According to research by Bell-Krotoski et al, (1995) a monofilament of 2.83 level (0.07 grams force) is a good predictor of normal tactile sensitivity for the hand, leg and arm- the part of the body which was used in the present experiment. The arm is an area that is a major component for actions such as reaching, eating and drinking, all outlets for coming in to contact with pathogens and contagions. Interestingly the arm is also a frequent site for compulsive washing behaviours which is done in an attempt to remove and prevent contamination (Cisler, Olatunji, & Lohr, 2009; Lewis, 1997; Mckay, 2006; Thorpe, Patel, & Simonds, 2003). Practise attempts using the equipment supported Bell-Krotoski's findings to some degree; no participants in a neutral setting had a pressure sensitivity level more than a couple of monofilaments above or below the 2.83 level.

2.22. Stimulus Images:

Participants were randomly assigned to one of the two conditions; they were exposed to a series of affectively neutral images and then either a series pathogen disgust-related or fear inducing images taken from the International Affective Picture System (CSEA, 1995) an archive of emotionally affective images which are used in a variety of psychological research. The images were presented using separate timed PowerPoint presentations on a computer; the images for each PowerPoint were shown on the screen for 6 seconds. Each PowerPoint consisted of 20 images. The images in the neutral PowerPoint consisted of everyday household items such as furniture and household appliances, none of which would invoke a specific emotion in the participant. The fear PowerPoint consisted of 7 images of dangerous weapons such as knives and guns, 6 images of dangerous animals such as dogs and sharks and 5 images of dangerous scenarios such as plane crashes, fires and extreme weather. The disgust PowerPoint consisted of 10 images involving damage to the skin, 6 images of human and non-human cadavers, 3 images of faeces/vomit, and one image involving drawing of blood from the arm.

2.23. Standard Apparatus:

Other apparatus includes the computer which was used to make note of each participants' details and their results, as well as an outlet on which the PowerPoint presentations were shown. A ruler was also used to measure an approximate quarter of the participant's forearm, during the practise runs with the monofilaments, Bell-Krotoski, 1987 identified value of "normal" tactile sensitivity was best detected approximately a quarter of the arm's length away from the hand, further up the arm showed a decrease in sensitivity. The ruler ensured the same part of each participant's arm was tested on. In order to ensure that participants could not see when the monofilaments were being used on their skin, a visual block was used. This piece of equipment comprised of a cardboard box with a large hole through it, the experimenter's end of the box had a hood to make sure the participant was unable to see (*see appendix B)*. This ensured that the participant could only know what was happening by being able to feel the monofilament. In order to decrease the risk of practise bias which may have occurred in Cotter's study, a distraction task was administered between the two sensitivity tests; the experimenter paired with another dissertation experimenter and had participants fill in a questionnaire (*see appendix C*) on an unrelated topic (Rejection and Loneliness). Therefore the questionnaire used for that study was included in the apparatus required for the present experiment.

2.3. Design/ Procedure

The planned procedure of the experiment was outlined and ethically approved by the ethics committee at the University of Portsmouth, Department of Psychology. The study was advertised via social network threads and the university participant pool, designed for level 4 Psychology Undergraduates to gain credits through taking part in dissertation projects. The study was titled, 'The Effect of Affective State on Tactile Sensitivity", offering 30 minutes timeslots for which the participant would be awarded a whole credit for their participation. Those willing to participate either contacted the researcher or reserved one of the available time slots on the participant pool. All participants were tested individually on the university grounds; the experiment was conducted in a small well-lit research cubicle in King Henry Building, this is where the Psychology department is based. Upon entering the cubicle, participants were given informed consent to sign (*see appendix C*) and were asked for demographic information relating to age, gender, ethnicity, handedness, whether they have broken the arm they do not write with, current blood pressure status, skin conditions and whether they had any damage to their sensory nerves. All participants completed the experiment in the following order: (1) viewing of neutral visual stimuli (2) a tactile sensitivity test using the monofilaments; (3) a distraction task using a Likert scale based questionnaire from another dissertation project researching rejection and loneliness; (4) viewing of the emotionally affective stimuli (fear/disgust); (5) the second tactile sensitivity test using the monofilaments. Participants were randomly assigned to one of the two images conditions and the experimenter left the room when the stimuli were being shown to participants.

Participants were given an activity sheet (*see appendix D*) to fill out for each slideshow; for the neutral images, they had to state whether there was a red dot present with each image, in the fear and disgust slideshow participants were required to rate each image (1- not at all, 5-extremely) on how frightening or disgusting they found them (*see Appendix E & F*). The red dot activity ensured full attentions was paid to the slide show, so the experimenter could be assured that the participants were truly manipulated in to a neutral mindset.

To carry out the tactile sensitivity test using the monofilaments, the participants were seated with their arm they do not write with held straight, resting palm side up (supinated position) on the table. Unlike Cotter's research; the experimenter did not use the participant's dominant arm, individuals are more likely to use their dominant arm for everyday activities, and will be less likely to be habituated to minute sensations on the skin which the monofilaments administer if detected. The other arm will be more sensitive to such and will therefore give more insight in to unbiased tactile sensitivity. An approximate quarter of the forearm was measured and marked once informed consent was given. A visual block was used to conceal the participant's view of what the experimenter was doing. The experimenter started with the thinnest monofilament with the lowest gram force (0.008g) and asked the participant to verbally report whether they could feel it on their arm or not. The monofilament was held at the base of the rod, to ensure the experimenter's hand did not come in to contact with the participant and potentially causing tactile disorientation. If the participant could not feel the monofilament the experimenter moved on to the next one until the participant could detect it; the level value detected was noted down when this happened. The first round of this test gave the experimenter the participant's pressure related sensitivity in the neutral mindset which acted as their assumed normal level of tactile sensitivity. The second round of the test took a second sensitivity level reading to show how the participant's sensitivity has changed in reaction to the stimuli they were shown. Participants were not given feedback when the experiment was over, but they were fully debriefed (*See Appendix G*) and rewarded with a credit. They were also given the opportunity to contact the experimenter if they wished to find out more about the experiment.

3.) Results

The sample (*N* = 20) was equally divided between the two independent experimental conditions (*N* = 20). The neutral/disgust condition contained 9 males and 11 females and the neutral/fear condition contained 8 males and 12 females. The change in tactile sensitivity in each condition via monofilaments was investigated using SPSS 19.

3.1. Bar chart representation of results (*see figure 1 & 2)*

Two bar charts were developed on SPSS to visualise the difference in tactile sensitivity scores between participants before and after priming in to fear or disgust through appropriate images.

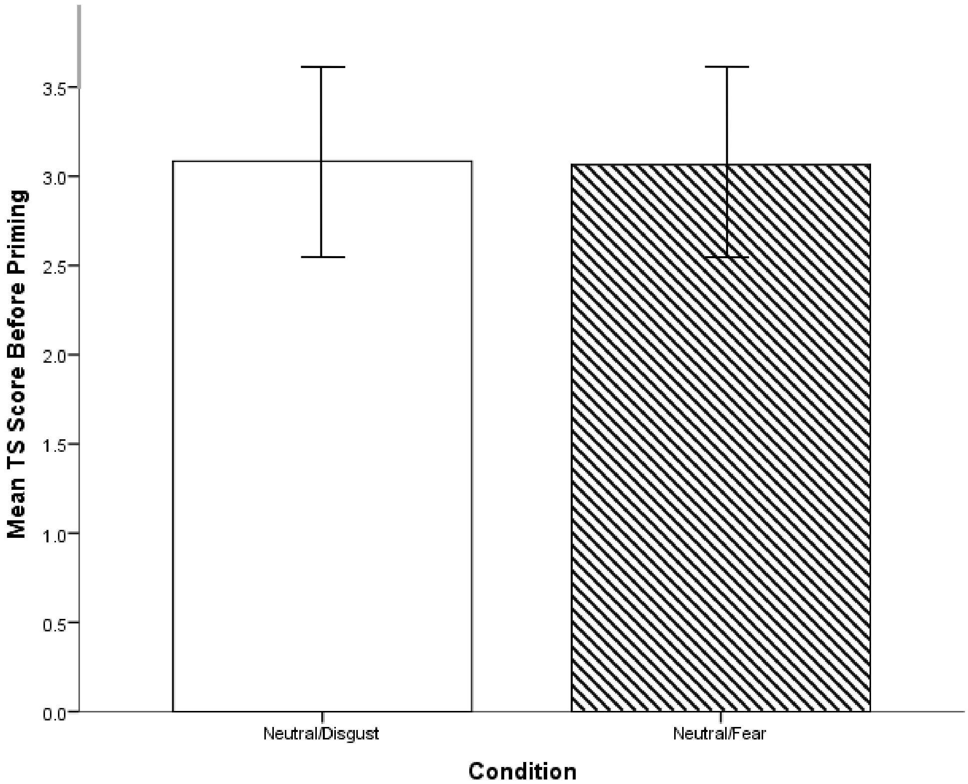

Figure 1. A bar chart showing the mean tactile sensitivity scores of both conditions after view affectively neutral images but before emotional priming (TS= Tactile sensitivity).

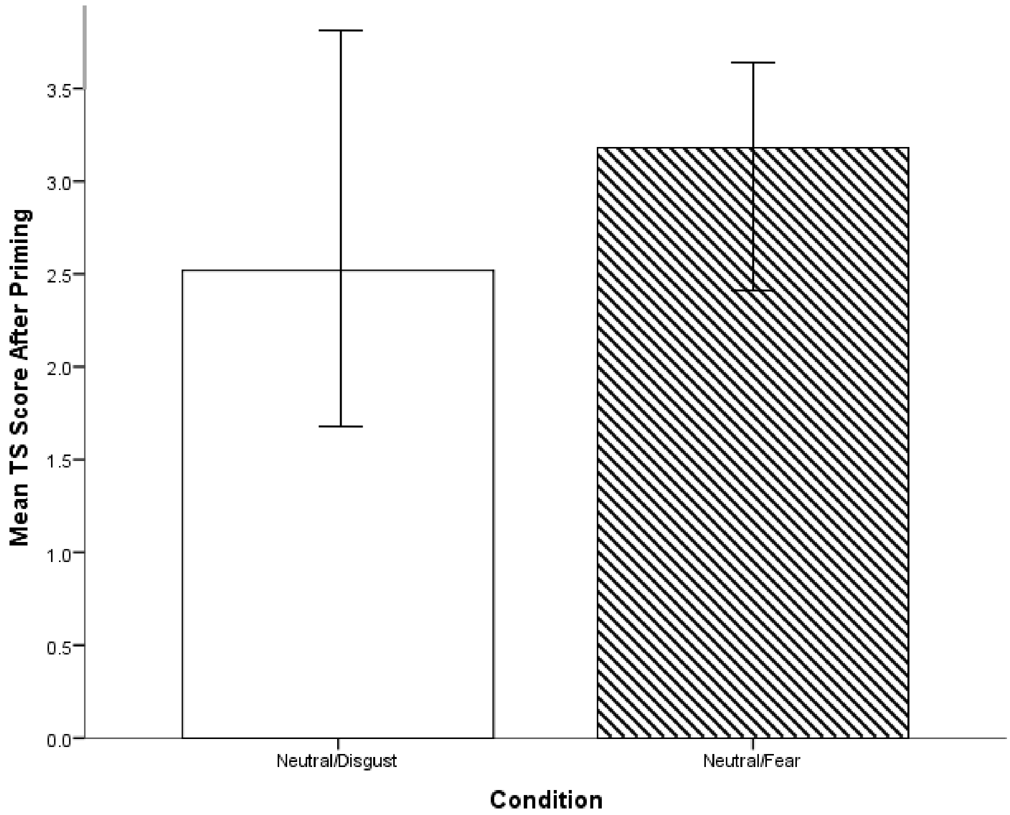

Figure 2. A bar chart representing the mean tactile sensitivity scores in participants after priming in to either fear or pathogen disgust (T.S = Tactile sensitivity).

3.2. Statistical Analysis

Table 1. Means (*M*), standard deviations (*SD*) and standard mean errors (2 d.p) of the mean percent change in pressure-related tactile sensitivity level measurements after participants viewed affectively neutral and then either fear or disgust inducing visual stimuli.

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Percent change	Neutral/Disgust	20	-.19	.23	.05
	Neutral/Fear	20	.05	.14	.03

3.21. Independent groups T-test investigating the effect of image content on pressure related tactile sensitivity

An independent-samples t-test was conducted to compare the change in pressure-related tactile sensitivity between participants exposed to disgust eliciting and fear eliciting stimuli. Percent change in tactile sensitivity was calculated for each participant and was the values used as the dependent variable for analysis. A significant difference was found in the mean change in pressure-related tactile sensitivity in those who were primed in to pathogen related disgust through seeing disgust related images (*M*= -0.19, *SD*= 0.23, *95% CI* [-0.36, -0.11]) compared to those primed in to a fear though fear eliciting images (*M*= 0.05, *SD*= 0.14, *95% CI* [-3.36, -1.11]) with a greater increase in pressure-related tactile sensitivity found in those primed in to pathogen disgust; *t*(38)= 3.905, p< 0.01 (2-tailed), *d*= 1.27. This suggests that being in a state of disgust causes an increase in pressure-related tactile sensitivity, a change that is greater and more statistically significant than the tactile effect from being in a state of fear (*see figure 1 & 2).*

3.22. Pair-samples T-tests comparing the significance of the effect of disease salient and fear images on pressure-related tactile sensitivity percent change before and after priming

A paired samples t-test was conducted to compare the mean tactile sensitivity scores participants achieved before and after exposure to disease salient images. The test revealed there was a statistically significant difference between tactile sensitivity scores before and after being exposed to the images, *t*(19)= 3.573, *p*= .002 (2-tailed), *d*= 0.9. The mean tactile sensitivity score participants received after exposure (*M*= 2.52, *SD*= 0.83) was smaller than the mean tactile sensitivity scores before exposure to the stimuli (*M*=3.08, *SD*= 0.42) meaning that disgust salient images had a significant effect on tactile sensitivity.

A paired-samples t-test was conducted to compare the mean tactile sensitivity scores participants received before (*M*= 3.06, *SD*= .41) and after (*M*= 3.18, SD= .40) exposure to fear-inducing images. The t-test revealed there was not a statistically significant difference between tactile sensitivity scores before and after exposure; *t*(19)= 1.371, *p*= .186 n.s. (2-tailed), *d*= 0.29. Therefore fear-inducing images did not have a significant effect on tactile sensitivity.

3.23. One way independent groups ANOVA investigating the gender variance of stimuli effect on tactile sensitivity

A one way independent groups ANOVA was used to test for gender differences in tactile sensitivity in males and females that were shown either fear or disgust inducing stimuli. Tactile sensitivity measurements differed significantly depending on nature of stimuli, *F*(3, 36)= 5.579, *p*= 0.003, $\eta^2 p$= 0.317. Bonferroni pair-wise comparisons of the genders within the two conditions indicated there were gender differences between participants who were exposed to stimuli eliciting disgust, but the comparison was not significant. Despite this, there was a slightly larger percent change (.0045 increase) in tactile sensitivity, between females (*M*= -0.189*, SD*= 0.226, *95% CI* [-0.340, -0.037]) and males (*M*= -0.184, *SD*= 0.243, *95% CI* [-0.371, 0.003]), n.s. at the *p*< 0.05 level, suggesting that females were more disgust sensitive than males, but as stated it wasn't a statistically significant difference. There was also no significant difference between genders in those exposed to fear inducing stimuli, with males showing a larger percent change in tactile sensitivity, (*M*= -0.114, *SD*= 0.180, *95% CI* [-0.036, 0.265]), than females (*M*= -0.003, *SD*= 0.095, *95% CI* [-0.057, 0.063]), n.s. at the *p*<0.05 level. The data suggests males appear to be more fear sensitive than females as a larger mean percentage but not at a statistically significant level.

4.) Discussion

4.1. Outline of findings

The present study sought to determine whether the viewing of disgust-inducing visual stimuli resulted in significant changes to tactile sensitivity compared to the viewing of fear-inducing visual stimuli. The results demonstrate that there was indeed a significant percentage change in pressure-related tactile sensitivity for those exposed to disgust inducing stimuli therefore conforming to the previously stated experimental hypothesis. Those primed in to disgust had an increase in tactile sensitivity on their forearm palm-ascending when tested with the monofilaments designed to test pressure related tactile sensitivity. There was no significant gender difference within each condition but the results of the ANOVA did show a greater change in tactile sensitivity in females than males when induced in to disgust, this does indicate females could be more sensitive to disgusting stimuli belonging to the pathogen domain as well as the sexual domain found by Cotter, 2011 but due to the data being not statistically significant, the results of the present study can only partially support this assumption.

4.2. Testing pressure related tactile sensitivity

Due to the novelty of the equipment it was difficult to judge the best area of the body in which to test. The forearm palm-raising was judged the best part of the body to test due to it being easily accessible, and the theoretic reasoning behind using the arm. Palm-ascending position was chosen as this area is generally not as hairy as the back of the forearm, so it can be assured that it is purely the skin's pressure sensitivity (therefore pacinian corpuscle function) that is being tested and not indirect tactile stimulation via the hair. The forearm is also an easily accessible area; providing the participants followed the clothing inclusion criteria, the practical application of the sensitivity test was very straightforward as the participant merely had to roll up their sleeve, remove any jewellery and rest their arm in a supine position on the table through the view block. The present study's protocol follows in a similar fashion to the standardised protocol used for diabetic patients but on a much simpler scale. The present experiment tested the approximate same one area of each participant's arm instead of gathering readings of the sensitivity of different areas of the arm like the monofilaments are used on diabetic patients pre-amputation. The chosen protocol did ensure that sensitivity levels were reliably taken from the same area on each participant but it does not dictate that the sensitivity level they detected would be the same around the whole body. Unlike Cotter's experiment, the participants were not blindfolded, Cotter's reasoning for doing so was so the participants could not see whether he was using one or two points of the aesthesiometer. This was because the experimenter did not want the sensation of wearing a blindfold to distract the participants. Being subjected to blindness causes other senses such as hearing and touch to become heightened (Legge et al, 2008). However the application of a blindfold can be disorientating, it can be a possible source of stress from sensory deprivation which can affect one's tactile processing and underestimate the potential of sense of touch, (Heller & Gentaz, 2013, Kennett, Taylor-Clarke & Haggard, 2001). On the other hand Heller and Gentaz offered the idea that it is equally disorientating to deny visual access to the hand as we normally employ vision to guide touch (Heller, 1989). Despite this, the methodology for the present study attempted to meet some middle ground with this dilemma, the participant was unable to see their arm which may have caused some disorientation but no extra disorientation and sensory input was administered to the participant via the use of a tight blindfold.

The effectiveness of monofilaments has been criticised to be less specific than current methodologies to investigate sensitivity in diabetic patients such as biothesiometer, (Kumar, Fernando, Veves, Knowles, Young & Boulton, 1991) but they were identified to be a lot more sensitive than the biothesiometer and very easy to use. The sensitivity level readings taken when the participants were in a neutral state did not deviate more than a couple of monofilaments above or below the stated norm for the arm that Bell-Krotoski, 1987 outlined.

4.3. Possible explanations of findings in disgust condition

The present experiment achieved what Cotter's research failed to do, which was finding a significant difference in sensitivity when induced in to disgust. These findings open the door to adding the breadth of research in to the psychological and physiological changes, such as change in respiratory and cardiac output, that occur during a state of disgust, triggered by both direct and indirect stimuli. The increase in pressure-related tactile sensitivity conforms with the behaviour and characteristics of the behavioural immune system which is designed to aid disease avoidance. When confronted with situations exhibiting contagious entities, one will strive to minimise physical contact (Mortensen et al., 2010), therefore when primed in to disgust via a staged threat, it appears to be no different. Yet not tested, it would be fair to apply Van Damme's theory about hypervigilance to the increased sensitivity found in the present study, like chronic pain sufferers, those in a state of disgust mate scan their bodies in order to detect the sensation of contaminating substances on the skin, therefore making the skin more sensitive to sensation such as pressure.

On the other hand, the present findings in the disgust condition did not conform with the findings from Meagher et al, 2001, if the exposure to disgusting stimuli decreases pain threshold which holds skin sensitivity as a large component, then reason dictates that tactile sensitivity would decrease with it. This was not found in the present study, which raises question whether pain threshold is truly affected through disgust, or whether the participants were truly in a state of disgust. It is worth making a point of this as not all participants expressed an increase in sensitivity, some appeared to show a decrease despite being shown the same visual stimuli and the rest of the participants in the condition. Despite this the majority of the participants showed an increase in pressure-related sensitivity, creating the significant difference. In order to investigate the conflicting results, repetition of the experiment with a larger sample of participants would be needed.

Despite being the control condition, the results from the fear condition sparked some interest as well, the majority of the participants showed no changed in tactile sensitivity, which too deviates from the idea Meagher had theorised. Some did show a decrease in tactile sensitivity; this conforms with the idea that induction in to fear can trigger the body to go in to a "fight or flight" response where the sympathetic nervous system is activated and blood is pumped to the heart and lungs to allow the body to fight or flee from a perceived threat. Therefore areas like extremities will have less blood pumped to them which explains the decrease in pain and therefore pressure-related threshold. Interestingly one participant in the fear condition

expressed an increase in tactile sensitivity perhaps because of a crippling fear of dogs, something that featured a number of times in the PowerPoint presentation used to elicit a fear response. Research by Sawchuck et al, (2000) found arachnophobia was correlated with disgust sensitivity; despite spiders/insects being partially related to pathogen disgust, it is not the fear of contamination that sparks the arachnophobic individual's avoidance behaviours but the threat itself. Despite the established grey area, pictures of spiders and snakes were not used in the fear condition to avoid a dual activation of both fear and disgust; something of which has been demonstrated in previous research (Gerdes, Uhl and Alpers, 2009; Mulkens, de Jong and Merckelnack, 1996; Olatunji and Deacon, 2008). An increase in tactile sensitivity may aid in the prevention of coming in to contact with the perceived threat which could be the explanation for why the participant in question received the results they did. According to Woody and Teachman, 2000 fear and disgust can co-occur and encompass a compatible emotion with disgust. The two are distinguishable, in terms of brain activity and neural firing (Alvarez, Chen, Bodurka, Kaplan and Grillon, 2011) but there is debate whether they are distinguishable by the physiological changes they cause. Possibly with further research the present experiment may open the door making a clear distinction between the two. Like disgust, to gain a greater and more reliable understanding of the effect fear has on tactile sensitivity, repeating with a greater sample of participants would be necessary.

4.4. Gender differences

The results from the present experiment did express a gender difference, the results show a larger mean percent change in tactile sensitivity in females in the disgust condition, this change was specifically an increase in sensitivity as females scored lower levels in the tactile sensitivity test following the viewing of disgusting stimuli. Results from the ANOVA revealed this difference to be not statistically significant. Despite this, what little was found does conform with the previous research regarding females being more disgust sensitive (Haidt et al, 1994; Caseras et al, 2007). Previous research has only found this gender difference through ratings of disgusting stimuli and questionnaire responses, no physiological changes have been identified. The increase in tactile sensitivity in females suggests there may be a physiological gender difference, but due to the lack in significant results and small sample, repetition of the study and use of a larger sample would shed light on whether there truly is a difference in physiological reaction to disgust between sexes. Also testing for other physiological changes such as respiratory output, heart rate and even cortisol levels in participants may increase understanding in reactions to disgust, and also establish further understanding in to the possibility of a gender difference.

It was males that showed the greatest percentage change in the fear condition, it has been well documented that the amygdala has been identified to be involved when processing a threat-related stimuli (e.g. Adolphs, 2002). Males have a lot more testosterone than females; studies have led to the assumption that testosterone levels are associated with amygdala activity, when administering a dose of testosterone in to females (Hermans et al. 2008). Derntl et al, 2009 furthered this association by demonstrating that testosterone levels affect amygdala activation and also behavioural responses to threat-related emotions such as fear in males. The study was more focused on facial expression and recognition but these behavioural responses could potentially include tactile processing or avoidance behaviours which would explain the gender difference in the fear condition. As previously stated, repetition with a larger sample will clarify the ambiguity surrounding this gender difference.

4.5. Potential amendments

No experiment is without its short comings, despite the promising results from the present study, there are always improvements that can be made. The increase in tactile sensitivity could be attributed to a practise bias, the participants may have gained a level of understanding undergoing the first tactile sensitivity test and therefore increases their hypervigilance, scanning their bodies for tactile stimulation when being tested for the second time. Repeating the experiment with a larger sample and carrying out the procedure in reverse order would shed light on which is more likely to be having the effect, practise bias or a disgust response. This amendment will increase understanding in the physiological response to fear also and begin to clarify the ambiguity surrounding how disgust and fear can be individually distinguished.

There is ambiguity as to whether blindfolding or restricting the vision of participants is the best procedure, by repeating the experiment comparing sensitivity and possibly discrimination threshold using the aesthesiometer, light can be shed on how the different levels of disorientation caused by denying vision (Heller & Gentaz, 2013, Kennett, Taylor-Clarke & Houggard, 2001) affect tactile processing. This will also provide a critical evaluation of the two different methodologies. Since Cotter used piloting in his experiment, it is more than likely that participants experienced a practise bias leading to his lack in significant results. Repeating his experiment without the use of piloting will effectively test the reliability of using a two-point aesthesiometer to test discrimination threshold. Also by testing multiple areas of the body it can be investigated whether the identified change in pressure-related tactile sensitivity occurs throughout the body when elicited in to a state of disgust and not just the arm.

4.6. Conclusion

The current study utilised a relatively novel methodology to explore what Cotter, (2011) identified as an *"overlooked gap in the increasingly expanding literature on disgust and the body's behavioural and biological immune system".* It also attempted to investigate the supposed link between disgust and tactile processing using Cotter's lack in significant changes as a rationale. A significant change in pressure-related tactile sensitivity was identified, reinforcing that Cotter's research was not all for nothing and increasing insight in to the physiological changes that occur when the behavioural immune system is activated through the indirect presence of contagions. Further research is required to increase the reliability of these results and clarify the ambiguity surrounding the link between fear and disgust and the gender differences in tactile sensitivity that occur in these emotional states. Other ideas for further research which are currently being proposed, involve looking at pathogen disgust's effect on components in saliva, blood and tactile sensitivity when the mouth is open during stimuli exposure and also its effect on olfactory sensitivity.

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