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Activating the Biological and Behavioral Immune Systems

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Abstract

Psychology recognizes two distinct facets of the immune system: the biological immune system (BIO), covering all processes of the typical immune system, and the behavioral immune system (BEH), a set of cognitive, emotional, and behavioral responses to environmental stimuli. Research on this dual immune system indicates that each is capable of influencing the other (Schaller & Park, 2011). For example, perception of illness in others can activate the sympathetic nervous system (Schaller, Miller, Gervais, Yager, & Chen, 2010). Furthermore, evidence suggests that these two systems are capable of influencing moral judgment (Inbar, Pizarro, & Bloom, 2008). This study aims to further the overall understanding of the BEH and the manner in which it influences the BIO. Participants were recruited from college psychology courses in exchange for extra credit. These participants completed questionnaires regarding moral judgments and illness perception either before or after engaging in a visual stimulus task in which participants were prompted to select a face from a set of four using 32 different sets of photographs, each exposed for only 50 milliseconds. One face in each set of four appeared to be sick or engaged in sick behavior (coughing or sneezing). Saliva samples were taken from each participant before and after the questionnaire and visual stimulus task to measure and compare the levels of cortisol. Participants detected “sick” faces significantly above chance. Unfortunately, participants’ cortisol levels could not be analyzed due to error in the cortisol assay process. The face detection task did not affect moral judgments. Our primary results indicate that pathogen threat is salient even when the individual cannot completely process or analyze the stimulus. This research has many implications for medical treatment and decision making processes. More research is necessary to understand how the physiological activities of the BIO alone affect the processes of the BEH.

Activating the Biological and Behavioral Immune Systems

Plants, animals, and humans are subject to the threat of pathogens. In order to survive and pass genes on to the next generation, organisms must have mechanisms of avoidance to reduce exposure to harmful pathogens, mechanisms of defense to reduce likelihood of dangerous pathogens from gaining entry into vital systems, and mechanisms of attack that engage once a pathogen is detected within the body. In order to be effective, these mechanisms must be flexible enough to respond to new information within the external environment as well as a wide variety of ever-changing pathogens. This system would have to be almost infallible in processing and responding to stimuli even when there are signals that seem to indicate opposing conclusions. For example, environmental signals through vision may indicate that a particular food item is good to eat yet the food might also produce smells that signal to the brain that the item has spoiled. Finally, while the human lifestyle requires a system that is vigilant, adaptive, and infallible, these processes cannot constantly consume large amounts of energy if humans are also to support the cognitive power that they possess. This system would, therefore, also have to be incredibly complex to regulate so much while exerting little energy. The various processes, which together make up the immune system, are not enough alone to fulfill the requirements for human survival. Psychology has identified these adaptive behaviors collectively as the behavioral immune system (BEH) (Schaller & Park, 2011). While the function of the standard immune system--which will be referred to as the biological immune system (BIO)--is to destroy detected and potentially harmful pathogens within the human body, the BEH involves the behavioral avoidance of germs before contact is ever made. Research shows that the BEH includes mechanisms that allow the body to successfully avoid common pathogen threats while minimizing consumption of energy.

The adaptability of the BEH may be especially important in humans because their high rate of daily interpersonal exchanges increases the risk of contracting pathogens. The BEH is, perhaps, more active in the modern world than when it first began to evolve; humans are now capable of traveling large distances very quickly and carry pathogens with them. The complexity of the human immune system is not without reason: infectious disease is an incredibly dangerous threat to human life and the effects of deadly diseases are evident throughout history (Wolfe, Dunavan & Diamond, 2007). The ability to avoid contracting a terminal illness before reproducing and raising offspring would have been a vital skill for the survival of the human species as a whole. Therefore the complexity of the dual immune system and the amount of cognitive and physiological resources that are devoted to their function is evidence of the way in which the threat of disease and infection has altered the evolution of humankind (Oaten et al., 2009). Humans are also unique in their cognition; they are capable of recognizing powerful associations that other animal species cannot. This ability also means that the BEH may have the potential for producing consequences unrelated to pathogen avoidance, some of which may be very negative for the race as a whole. The BEH offers insight into the mechanisms that drive human behavior and cognition, as well as many human physiological processes.

The BEH: mechanisms and function

Schaller & Murray (2008) describe the functioning of the BEH as a cognitive detection of pathogens, an emotional experience of fear and disgust, and a behavioral reaction. The extent to which the BEH influences behavior on a conscious or subconscious level as well as the influence this system has on other processes--the effects on behavior, perception, and physiology to start--

is not so easily defined. Many human behaviors are instinctively and routinely pathogen avoidant by nature: maintaining personal hygiene, territorial behaviors, mate selection, and avoidance of certain foods (Curtis, 2007; Oaten, Stevenson, & Case, 2009). Such behaviors can be considered to be part of the BEH. The BEH also regulates much of human social interaction and some of these behaviors seem to be for the exclusive purpose of avoiding other individuals who are likely carriers of harmful germs (Schaller & Duncan, 2007). Nonetheless, the BEH must be adaptable to new stimuli, responding not only to variations in the level of pathogen threat but also to the source of that threat. The BEH is sensitive to perceptual cues indicating that pathogens may be present. When perceived, these cues of pathogen threat will trigger psychological responses that are adaptive for disease avoidance, which then facilitate avoidance of the threat. People feeling threatened by pathogen exposure are more conservative, have more prejudices, and are more likely to discriminate against others who are of a different race (Miller & Maner, 2011), or are different in other aspects (Schaller & Duncan, 2007). The custom of living in a group and maintaining close proximity to others increases human interaction and pathogen exposure; to compensate for this tendency, humans must adapt in behavior and signal detection (Park, Faulkner, & Schaller, 2003). The effect that the BEH has on personality traits is adaptive in reducing contact with contagious individuals. When pathogen threat is more prevalent, on a global scale or in an isolated situation, humans not only demonstrate more introversion but also show more signs of caution in personality type and disease avoidant behavior (Schaller & Duncan, 2007; Schaller & Murray, 2008). Introversion and cautious behavior also correlate with human populations that are more vulnerable to falling ill due to genetics, lack of nutrition, or pre-existing illnesses (Oaten et al., 2009). These behavioral responses help to limit interactions between people in groups more vulnerable to pathogen threat. For example, the need to protect the fetus makes pregnant women a particularly vulnerable group to pathogen threat and behavior responses that reduce their contact with potential carriers of illness or disease is beneficial. One study found that pregnant women tend to be more introverted and cautious of people who are of different races (Navarretea, Fessler, & Eng, 2007). This supports the possibility of BIO influence on the BEH. The research done by Schaller et al., (2010) demonstrating increases in BIO activity in response to mere perception of illness--assuming interpretation of these cues was done by the BEH--continues to be the most compelling evidence of communication between the two immune systems.

Many contagious diseases are indicated by physical or behavioral changes in the infected individual, such as lesions, skin discoloration, or coughing (Park, et al., 2003). Supporting research for this demonstrates that humans pay greater attention to faces that have physical abnormalities (Miller & Maner, 2011), which also supports the theory that the BEH uses an over-inclusive set of stimuli. This mechanism of avoidance is so effective, in fact, that there are negative repercussions for individuals who represent the source of the pathogen threat; individuals who are afflicted with skin conditions causing abnormalities expressed concern for being an outcast due to their diseased appearance (Benyamini, Goner-Shilo, & Lazarov, 2012). The interpretation of a signal as connoting a disease has clear and significant consequences for both individuals who detect pathogen threats and individuals who are detected as posing a threat.

What is more intriguing yet is the evidence that the two different immune systems interact and influence each other (Miller & Maner, 2011; Oaten et al., 2009; Schaller, Miller, Gervais, Yager, & Chen, 2010). Stressful events can facilitate immune responses such as the production of proinflammatory cytokines mediated through cortisol and norepinephrine (Webster, Tonelli, & Sternberg, 2002). This is clear evidence that perception and interpretation of the environment influence the BIO function. For example, seeing signs of illness in other individuals stimulates the BIO to be more active, increasing cytokine levels in the blood, though no actual foreign microbes have been detected (Schaller, et al., 2010). Visual perception of the symptoms implies one's own individual vulnerability. Such a phenomenon may reduce human exposure to infections and illness or pathogen survival after exposure.

Disgust and the BEH

The experience of disgust toward a specific stimulus or a set of stimuli not only supports the parameters of the BEH but also offers insight from an evolutionary perspective into the development of this dual immune system. Disgust is a combination of the cognitive awareness of what the stimulus is, an emotional component of aversion toward stimulus, and the avoidant behavior that is often a result (Oaten et al., 2009). This definition of disgust aligns well with the cognitive, behavioral, and emotional facets that form the BEH providing further evidence to support disgust as a function of the BEH. The correlation that is present between the cues that connote disease and those that elicit disgust demonstrates a cognitive understanding of a pathogen threat and supports the connection between disgust and disease avoidance (Curtis, Aunger, & Rabie, 2004; Curtis, 2007). Such cues that are clearly indicative of a threat of pathogens also evoke disgust consistently worldwide (Oaten et al., 2009). Additionally, the disgust response is regulated physiologically from sympathetic fibers in various organs which release neuropeptides and neurotransmitters to modulate the immune system (Curtis, 2007) which agrees with previous research on the BEH and demonstrates the connection between perception of disease-connoting signals and influence on the BIO. Disgust is not only a mechanism of the BEH but also an important clue to understanding how the BEH functions and interacts with the BIO.

Humans are sensitive to the possibility of contamination; contact with a disgust-eliciting stimulus will allow disgusting qualities to spread (Oaten et al., 2009; Rozin & Royzman, 2001). Allowing raw meat to come into contact with other food that is safe to eat could be dangerous for a human. This idea of contamination demonstrates the adaptive nature of the BEH to support the unique division of energy in the human body.

These examples of the human disgust response illustrate an entirely new cognitive division of labor altogether, allowing humans to spend less time worrying about whether there is a potential pathogen threat or not. Humans can therefore spend less time focusing on survival and more time on higher order thought processes. Humans delegate the majority of pathogen threat detection work to the BEH freeing up more cognitive processing space. In order for this design to be successful there cannot be any error in which a threat is not detected but is present. Such an error in processing stimuli for the individual will result in, at best, illness or potentially death. High frequency in false negative errors across the population would not allow humanity as a whole to survive (Schaller & Duncan, 2007). The human disgust response uses a set of stimuli that is overly inclusive, resulting in a very high rate of false positive detections of pathogen threat (Oaten et al., 2009). Disgust is a compelling emotion and experiencing disgust can cause humans to feel an irrefutable need to avoid the elicitor even when the individual is cognitively aware that the threat is no longer or was never present (Oaten et al., 2009). Furthermore, research suggests that humans believe that contamination of negative qualities, especially those that are disgust evoking, are much stronger influences of behavior and typically outweigh any positive contamination that an object might have received (Rozin & Royzman, 2001). This fulfills the highly vigilant system that would have been adaptive as humans evolved; this behavior agrees with the reality that the dangers of pathogen exposure outweigh nutritional benefits in most situations.

Disgust is not only responsible for causing avoidance behavior toward a stimulus. Disgust is capable of influencing personality traits and moral judgments. Disgust-evoking smells have a significant correlation with more negative attitudes toward homosexual individuals in questionnaire data (Inbar, Pizarro, & Bloom, 2012). Additionally, high disgust sensitivity in general correlates with negative views about same sex relationships (Inbar, Pizarro, Knobe, & Bloom, 2009) as well as greater moral conservatism overall (Inbar, Pizarro, & Bloom, 2008), though whether one factor influences the other is still unclear. Even reminders of human vulnerability to pathogens, such as a sign reminding individuals to wash their hands, influence individuals to respond to questions in a more conservative manor (Helzer & Pizarro, 2011). The idea of contamination is powerful and affects human views and opinions, decreasing individual acceptance of other races and cultures (Rozin & Royzman, 2001). The influence of the BEH is not limited to the individual but also on the development of the human race as a whole.

While the disgust response represents a product of evolutionary fitness and insight into the BEH, it does not, in itself, offer further evidence of interactions between the dual immune systems. Even the behavioral and moral judgment changes that occur as a result of eliciting disgust or simply suggesting vulnerability do not implicate involvement of the BIO or communication with it. In order to claim that such communication does exist there must be evidence that perception alone causes a physiological response as well as the reverse, that mere physiological processes of the BIO cause behavioral responses. While there is research to offer evidence of the former, there has been less research on the latter.

The evidence of interactions within the dual immune system is clear; yet, processes such as experiencing disgust do not seem to require the BIO at all. Why is it that certain stimuli can be processed completely by the BEH alone while others seem to require communication and intervention from the BIO? As previously stated, humans are incredibly social creatures. People are capable of avoiding objects that evoke disgust or pose a threat to physical health, and humans even seem to be capable of avoiding other humans with diseases. However humans cannot possibly avoid every individual who falls ill nor would doing so be beneficial. The BIO is capable of increasing defenses against pathogens when an individual detects signs of illness in others (Schaller et al., 2010). The acuity with which the BEH is capable of processing such signals and accurately relaying them to the BIO is still unclear.

Humans process visual stimuli that may be life threatening very quickly (Ogawa & Suzuki, 2004). The way in which humans visually process, detect, and focus on other faces also takes place faster than non-faces (Di Giorgio, Leo, Pascalis, & Simion, 2012). Information about genetics, physical fitness, recognition, and mood all appear in the face (Milders, Sahraie, Logan, Donnellon, 2006). For example, humans will respond more quickly and accurately to faces showing disgust, surprise, and happiness over other emotions (Calvo & Nummenmaa, 2008); however, other studies in this area present mixed results. Though detection of certain expressions may not always be faster or more accurate over others, it is worth noting that the facial expression of disgust can be recognized across the world (Milders et al. 2006). Furthermore, reaction time decreases for detecting faces with negative emotion rather than neutral or positive emotion (Milders, Sahraie, Logan, Donnellon, 2006). Viewing faces with emotional significance activates emotion processing areas in the brain and causes changes in behavior and performance on subsequent tasks. Additionally, emotional faces cause physiological responses (Milders et al.

2006). Therefore, while humans may not be able to avoid all other individuals who might be ill on a given day, detection of illness in others using visual stimuli, such as facial cues, is important; behavioral and biological intervention measures could potentially reduce the spread of illness.

While many of these phenomena in face detection are not related to the BEH, this does not mean that the BEH does not utilize this mechanism. For example, evidence shows that humans more quickly detect faces that are of a race different from his or her own race (Lipp et al., 2009). Research already indicates that there is a connection between the BEH and the detection of and behavior toward other races (Miller & Maner, 2011).

The BEH clearly utilizes face detection mechanisms to process information about others that could indicate pathogen threat. However the implications of this method in modern society go far beyond implementing behaviors and biological processes to avoid catching a cold; there are important byproducts resulting from human fear of contamination and human perception of others. More than avoidance, humans are, often rejecting of individuals of other races (Faulkner et al, 2004). However humans are also less likely to recognize the faces of people living in low socioeconomic conditions (Shriver et el., 2008). This indicates an avoidance response meant to reduce affiliation with such individuals.

The prevalent roles of the BIO and BEH in human interactions are clear; however, the threshold at which these processes begin to interact is still unknown. Cues of disease and illness that appear in the face, in particular, may also play a key role in BEH function. More research is required to better understand mechanisms of the BEH and the communication between the dual immune systems. The three goals of this study are to determine 1) whether sick and diseased appearing faces are salient over healthy appearing faces; 2) if viewing sick and diseased faces at near subliminal durations significantly alters moral values in various social situations on a questionnaire; and 3) the effects of the perception of sick and diseased appearing faces of the BEH on physiological processes of the BIO by analyzing the cortisol content in participants' saliva before and after viewing sick or diseased faces at near subliminal durations. The stress hormone, cortisol, found in saliva, will be used to measure physiological changes due and possible BIO activation because of its involvement in inflammation (Rosenkranz et al., 2013). It is hypothesized that sick and diseased faces will be noticed more frequently than healthy appearing faces when shown for nearly subliminal exposures. Furthermore, it is hypothesized that viewing sick and diseased appearing faces for very short durations will cause scores on a social questionnaire to be more conservative. Lastly, It is expected that the amount of cortisol present in saliva will increase after viewing sick and diseased faces at near subliminal times.

Method

Participants

Participants were college students (26 women, 7 men, M_{age} = 20 years, SD = 2 age range:18-27 years) recruited from Psychology courses at Hamline University in exchange for extra credit in a psychology course. IRB was obtained andS all participants signed a form indicating their informed consent before participating in this study.

Materials and Procedure

Upon arrival a random number generator assigned each participant to a control group or experimental group. Each participant completed three questionnaires and participated in a face detection task on a computer. Additionally, two saliva samples were collected from each participant in order to measure any changes in their cortisol level; the pre-saliva sample was collected before the face detection task and the post saliva sample was collected afterwards. The control group completed Questionnaire #2 before participating in the face detection task; the experimental group participated in the face detection task first before completing Questionnaire #2 (the order of tasks given to each group is presented in Table 1).

Each participant filled out Questionnaire #1 (see Appendix A) in order to give each an acclimation period to decrease stress before the pre-saliva sample was collected. Items on this questionnaire ask for basic background information. Data from questionnaire #1 was not analyzed. Pre-saliva samples were placed directly into a freezer after being collected.

Questionnaire #2 (see Appendix B) was obtained from a study done by Helzer & Pizarro (2011)--item #3 was not obtained from this study and was included as a test scenario for detecting individuals who are potential outliers. This questionnaire measured differences in moral judgment in individuals who were either exposed to sick appearing faces at near subliminal times (experimental group) or not (control group). During Questionnaire #2 participants read a series of scenarios and rated how comfortable he/she was with each on a scale from 1-7, 1 being "not at all comfortable" and 7 being "completely comfortable." Each participant then received an average score on the overall questionnaire. Each scenario was from one of three classifications: contamination, sexual deviance, and social deviance. For the interests of this study many of the questions in the social deviance category from the original questionnaire were removed. Therefore Questionnaire #2 was only analyzed as a whole, or by individual items and not as groups of items fitting into these categories.

The post saliva sample was collected immediately following the face detection task and placed into the freezer. Immediately afterwards participants in the experimental group filled out Questionnaire #2 and then Questionnaire #3, participants in the control filled out Questionnaire #3. Questionnaire # 3 was written to obtain simple feedback about participants' chronic stress, recent illness, and recent injury. No statistical analysis was run on Questionnaire #3 and this questionnaire was not included in the appendices.

During saliva sample collection, participants kept a cotton swab under their tongues for two minutes during both the pre-saliva sample collection and the post-saliva sample collection. After collection, all samples were in a locked and secure laboratory freezer. At the conclusion of the data collection period, saliva samples were tested using a Salimetrics Salivary Cortisol Enzyme Immunoassay kit over the period of eight days. Saliva samples were thawed, centrifuged at room temperature and pipetted into microcentrifuge tubes and refrozen. On the day of the assay samples were thawed, vortexed, and centrifuged beforehand.

Face Detection Task

During the face detection task, participants saw 32 matrices of four faces each. Each face set contained three healthy appearing faces and one behaviorally sick face (e.g. coughing, sneezing; see Figure 1i and ii) or one physically diseased face (e.g. red, blotchy, misshapen; see Figure 1 iii and iv). Target faces appeared randomly in the four cells of the quadrant. Each face set was shown for 50 milliseconds with 7 seconds between each set. Two pilot groups, one with 10 participants and the second pilot group with 5 participants, were used to confirm that these times were appropriate. 50 milliseconds was found to be enough time for the participant to detect that some faces appeared to be ill, but only if their attention to the task is vigilant. The 7 seconds between each exposure was found to be enough time for each participant to recover and prepare for the next image without losing focus. Participants were asked to point to the face that stood out the most in each set after it appeared and their responses were recorded by an observer sitting behind them. To control for the effects of race, gender, and age on perception, each target face (the behaviorally sick or physically diseased appearing face) was grouped with control faces of similar race (categories of racial backgrounds included Asian, European, Latin American, and African), same gender, and similar age. Each photo was also controlled as well as possible for hair color and light exposure. Several different order versions of the face sets were created using a Latin Square method so that each face set appears in a different order and surrounded by different face sets in every version. Participants were randomly assigned to one of these versions upon arrival. These different orders control for any effects that position of a face set might have on participants' detection of the target faces as well as any priming effects due to order of the face sets.

Results

A z-test for proportions was used to analyze the results from the face detection task to determine if the target face was detected above chance (25%). Sick appearing faces were noticed 41.9% in 34 trials ($z = 2.27$, $p < 0.01$; Fig. 2). Rate of detection of behaviorally sick appearing faces was significant 46.5% ($z = 2.89$, $p < 0.01$) while rate of detection of physically diseased appearing faces was not significant at 37.2% ($z = 1.65$, $p = 0.10$). Analysis of individual face sets revealed 13 sets that were not significant. Of these, the results for one face set revealed that that the target face was noticed significantly less than chance as shown by $z = -2.14$, $p < 0.01$. Additionally, three other face sets also obtained z-scores that are less than zero however these were not significant. Of the 13 face sets in which the target face was not noticed significantly above 25%, nine of those were in the physically diseased appearing category as well as all of the face sets which received z-scores that are less than zero.

In results for Questionnaire #2 (see Fig. 4), an independent samples t-test revealed no significant difference between participants who filled out the questionnaire before engaging in the face detection task and participants who filled out the questionnaire afterwards.

While the overall results for Questionnaire #2 had no significant differences between groups, item number one was significant; participants taking Questionnaire #2 before the face detection task (N=16) scored an average of $M = 2.56$, $SD = 1.26$, while those taking Questionnaire #2 afterwards (N=18) scored an average of $M = 1.67$, $SD = 1.08$ as shown by $t(32) = 2.225$, $p = .03$ (Appendix B see Fig. 5). Additionally item number three on the questionnaire approaches significance shown by $t(32) = 1.65$, $p = .108$.

Statistical analysis on cortisol results was not able to be run due to problems in the chemical testing of the saliva samples.

Discussion

Measurements of detection of sick appearing faces were compared to the detection of healthy appearing faces at near subliminal durations. Additionally, the influence of exposure to sick appearing faces on moral judgment was also measured. Salivary cortisol before and after exposure to sick appearing faces was also assessed but could not be analyzed.

Detection of sick and diseased appearing faces was significantly greater than chance. There is clear evidence that attention is drawn to sickness over healthy appearing stimuli, indicating that the detection of sickness is evolutionarily significant. These results agree with my hypothesis and are supported by previous research demonstrating that people react to sick appearing faces even though they are not consciously aware (Schaller et al., 2010). These results indicate that sick appearing faces draws upon subconscious focus. Detection of sick appearing faces may also be the result of theses target faces appearing to be different from the healthy appearing faces. Determining if a single healthy appearing face in a group of sick appearing faces is detected significantly less than 25% of the time would demonstrate more fully how individuals are processing pathogen related stimuli. Additionally, the marginal difference in detection of the target face between the behaviorally sick appearing photos and physically sick appearing photos was likely due to the quality of the photos used for each set; the behaviorally sick appearing photographs were of better quality than the physically diseased appearing photographs. Creating a set of stimuli that has more controls would decrease the likelihood that detection of faces is due other aspects of the photo that are not related to sickness.

There was no significant difference between comfort level in the social questionnaire which does not support my expectations. Previous research on the influence of disgust on morals also does not support these results (Helzer & Pizarro, 2011). This result is not supported by previous research indicating that the feeling of vulnerability to pathogens does affect moral judgment (Helzer & Pizarro, 2011). The significance of item number one may indicate that more sensitive measures, or increasing exposure to sick appearing faces may better demonstrate the influence of the BEH on moral judgment. Increasing the number of questions on the social questionnaire may also demonstrate what aspects of moral judgment may be influenced by the BEH. Including more mild situations would also better demonstrate if the BEH is able to affect morals as readily as previous research seems to suggest. A larger sample size would better demonstrate target face detection as a whole as well as items on a social questionnaire show differences between the control and experimental group.

Exposure to illness cues, even those that are hardly noticeable by the conscious mind in daily life, still draw on the attention of subconscious processes. While the resulting moral judgments are not largely influenced, there may still be slight changes. Additionally, while there is still no data testing the effects of subliminal perception of illness on physiological response, previous research supports a correlation between conscious perception of illness and increased activity of the BIO (Schaller et al., 2010) proving that these two systems interact. These findings on the BEH have implications for treatment of illness. Whether the vigilance of the BEH is effective in illness prevention and recovery or, due to medical advances, is simply depleting the body's energy resources is unclear. There are additional social implications; though minimal perception of illness has limited effects on moral judgment, previous research indicates that the effects of disgust evoking cues are still significant (Helzer & Pizarro, 2011). The significant difference between groups on item number one and the near significant differences between groups on item number three of Questionnaire #2 indicates that the use of more mild situations may provide a more sensitive measure of response to near subliminal stimuli. Interacting regularly with illness may still provide ample opportunity for disgust response activation to have influence on moral judgments. Furthermore, the duration of these physiological and social alterations after exposure to pathogen threat or disgust evoking stimuli is also unknown.

While illness proves to be an evolutionarily significant stimulus, the threshold at which perception of illness is salient and at which it correlates with changes in human moral judgments and physiology is still unclear. The use of more sensitive measures to investigate the effects that perception has on various processes in human cognition and physiology may provide more detailed information, not only about the BEH, but also how the BEH and the BIO interact with each other. Further, research is also necessary to understand the sensitivity of the BIO to perceptions made by the BEH. Additionally, further comparison of differences in evolutionary significance among different types of sick appearing human stimuli, including behaviorally sick appearing and physically diseased appearing, is necessary to a greater understanding the BEH and the signals to which it is sensitive

Research has only just begun to unravel the complexity and intricacies of the dual immune systems. Whether or not the processes of the BEH are still adaptive in the present are also unclear. Human perception of illness is incredibly prevalent due to the media and the consequences of chronic stress. The almost constant energy cost of the BEH processes in comparison to their success in maintaining health requires further investigation. As information of these processes increases the overall medical and social advancements that are possible are significant.

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Tables

Table 1

Control	Experimental
Questionnaire #1 (assimilation period)	Questionnaire #1 (assimilation period)
Pre-saliva sample	Pre-saliva sample
Questionnaire #2 (social questionnaire)	Face detection task
Face detection task	Post saliva sample
Post saliva sample	Questionnaire #2 (social questionnaire)
Questionnaire #3 (stress/illness questionnaire)	Questionnaire #3 (stress/illness questionnaire)

Figures

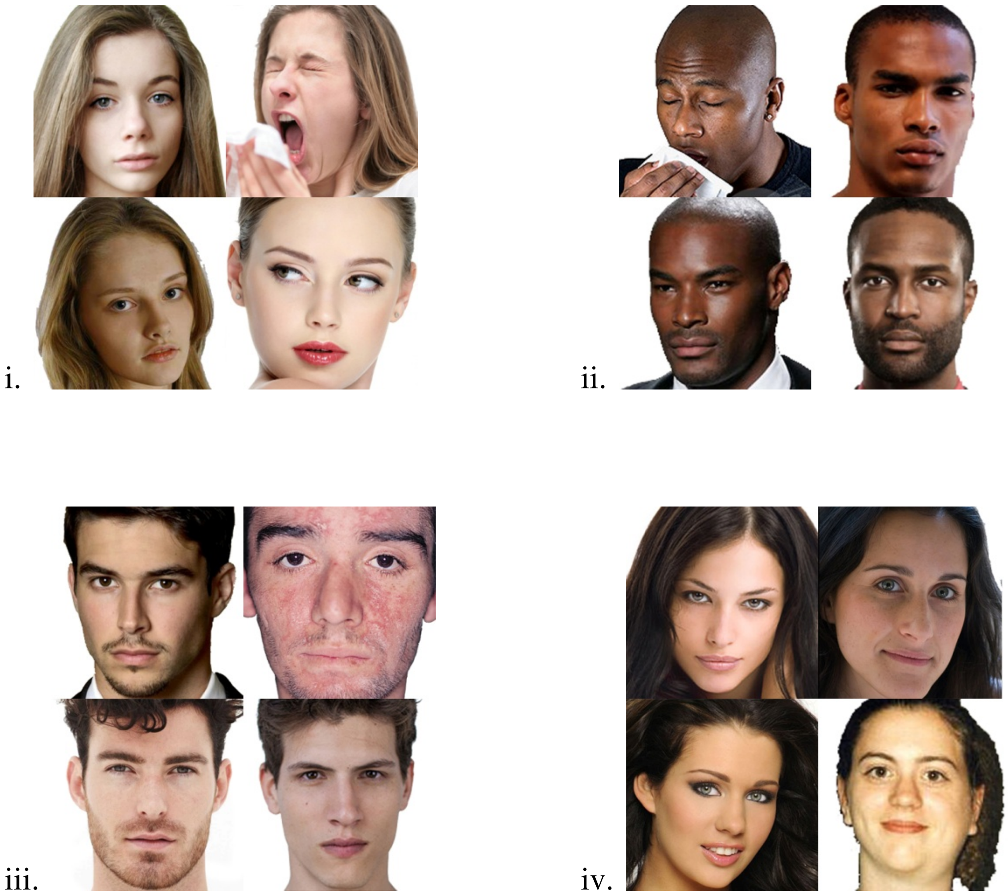

Figure 1.

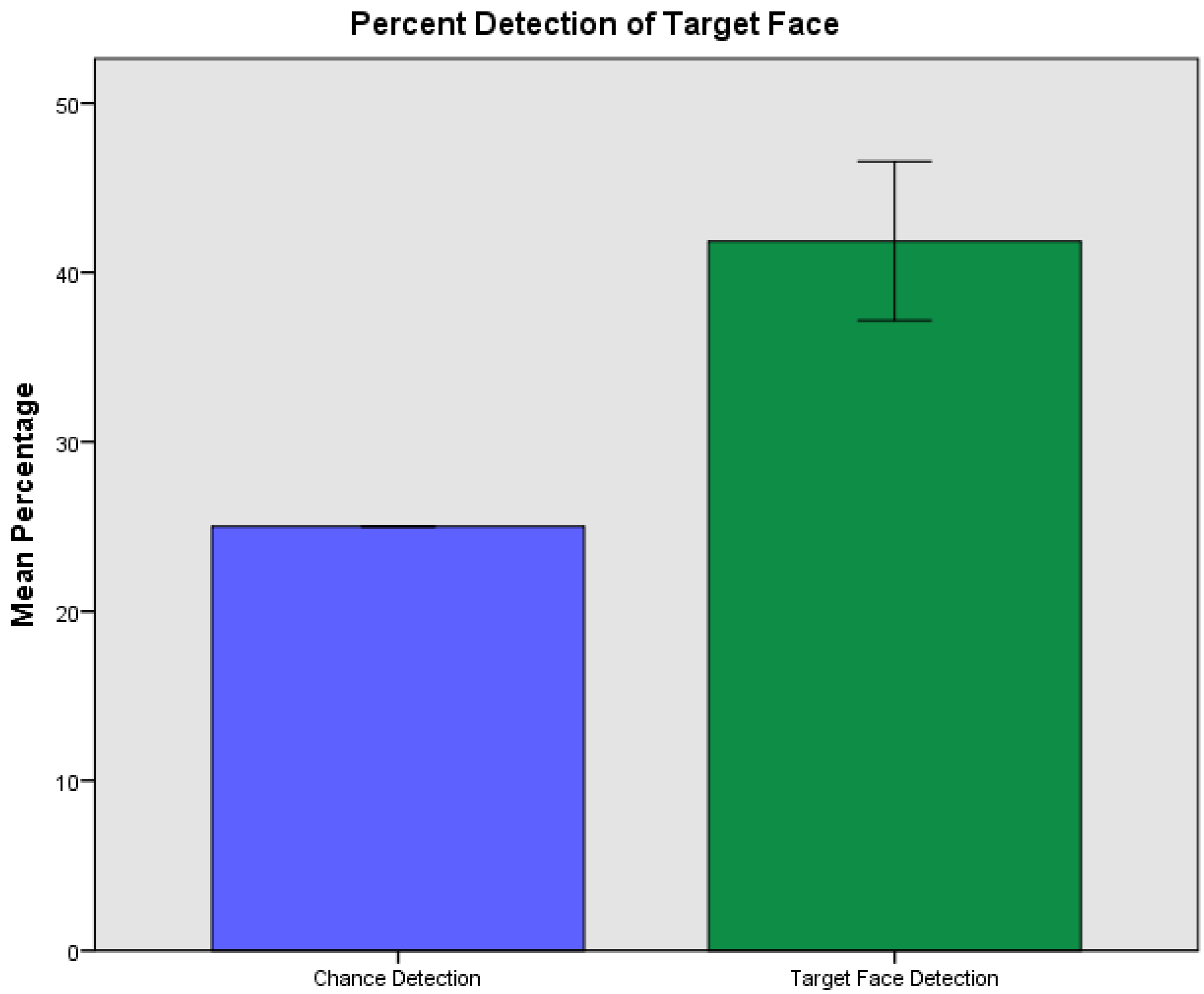

Figure 2. Percentage of target faces detects against chance rate of 25%.

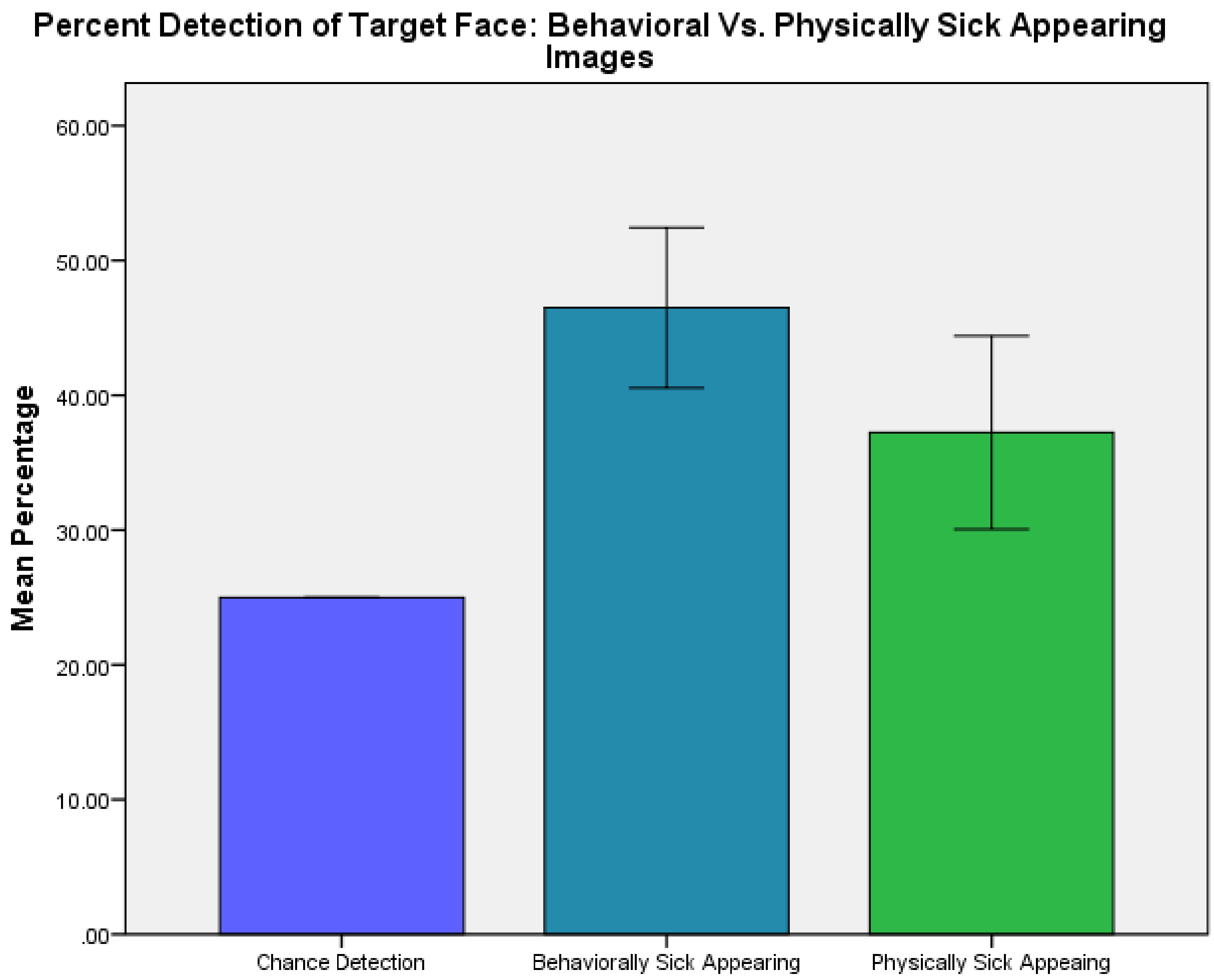

Figure 3. Percentage detection rate of behaviorally sick appearing and physically diseased appearing against chance of 25%.

Figure 4. Comparison of mean scores on Questionnaire #2 for control (before) and experimental (after) groups

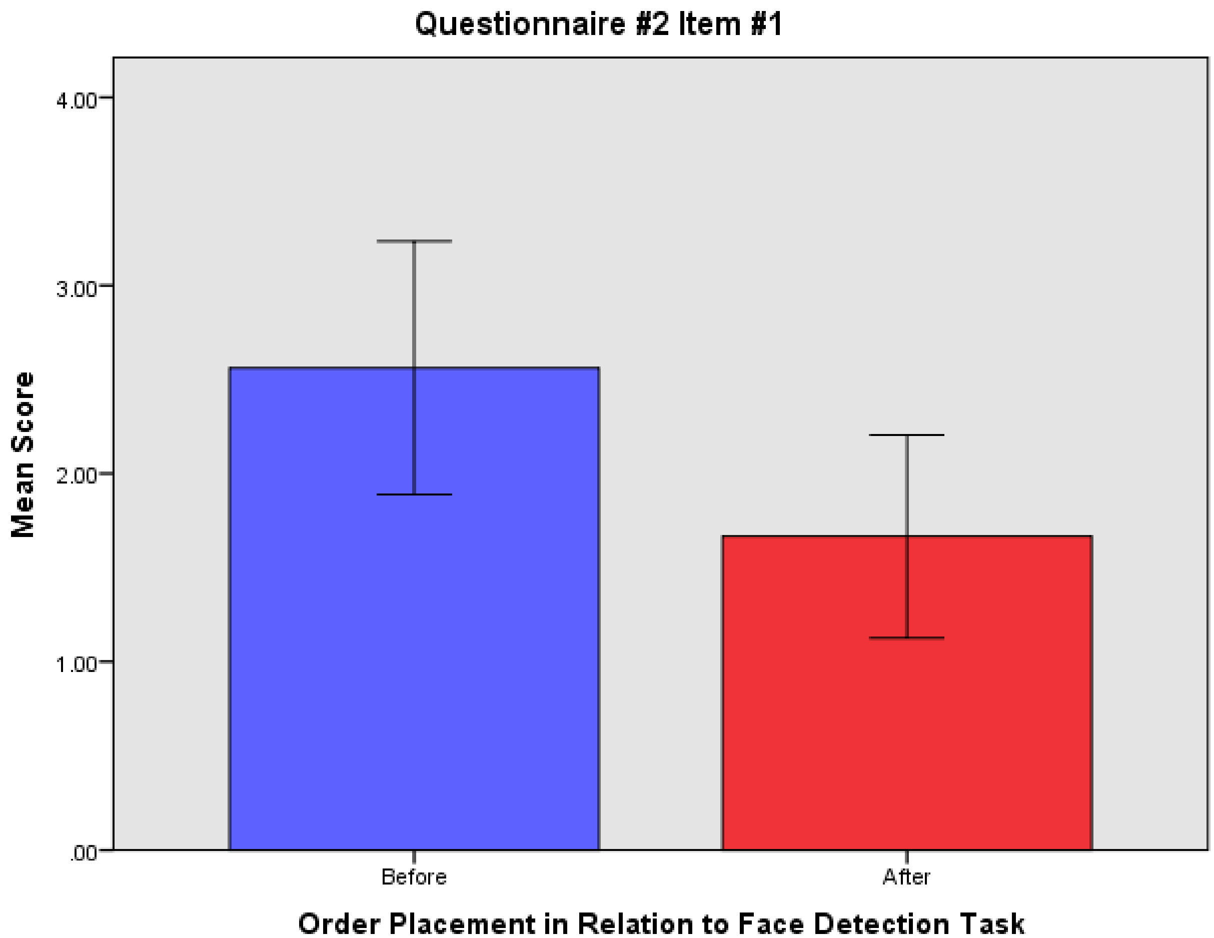

Figure 5. Comparison of mean score on item #1 on Questionnaire #2 of the control (before) and experimental (after) groups.

Appendix A

All answers to the following questions will be kept confidential and anonymous. For the integrity of the experiment please answer every question honestly.

1.) What gender do you identify with? (circle one) MALE or FEMALE

2.) What is your age? _______

3.) What is your race/ethnicity?

4.) How many hours per week do you exercise? (Circle one)

<1 hour 1-3hours 4-6hours 7<

6.) On average, how many hours of sleep do you get each night? (Circle one)

4 hours or less 5-6 hours 7-8 hours 9 hours or more

8.) Do you use corrective eyewear? (Circle one) YES or NO

If YES, are you NEAR sighted (you have trouble seeing objects/words far away) or FAR sighted (you have trouble seeing objects/words up close)? (Circle one)

If YES, are you wearing your glasses or contacts now? (Circle one) YES or NO

9.) How often do you watch T.V. during a given week?

<1 hour 1-3hours 4-6hours 7<

Appendix B

Please answer on a scale of 1 to 7 for how comfortable you would feel with the following hypothetical situations, 1 being not at all comfortable and 7 being completely comfortable. As many of the questions are very personal you do not have to answer all of the questions if you feel uncomfortable doing so. All answers to the following questions will be kept completely confidential and anonymous. For the integrity of the experiment please respond honestly in the answers that you provide.

A man notices that his sandwich has a little bit of mold on it, instead of eating it he offers the sandwich to a homeless person.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

A woman places her coworker's already opened lunch in a sterilized bed pan as a practical joke.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

Two people who are in a committed relationship but are not married having sex.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

While house sitting for his grandmother, a man and his girlfriend have sex on his grandmother's bed.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

A woman enjoys masturbating while cuddling with her favorite teddy bear.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

Two individuals of the same gender engaging in sex together.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

A man finds a sweater that he had meant to be a gift for an ex girlfriend and forgotten. He gives the sweater to his current girlfriend as a gift.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

Last year at tax time, a small business owner in a local town found that he could not afford his tax burden due to unexpected medical costs that had gone toward a surgery for his mother. He therefore carefully reported only the income for which he could pay taxes, leaving several thousand dollars unaccounted for.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

A family’s dog was killed by a car in front of their house. They cremate the dog, and sprinkle the remains in the sandbox where the neighborhood children play.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7

After they have been sexually active for over a year, a woman and her boyfriend discover that they have the same father—they are actually half brother and sister, but were raised in separate families from the time they were born. They decide that the new information doesn't matter, and continue their sexual relationship. The couple is careful to use protection.

Not at all comfortable						Completely comfortable
1	2	3	4	5	6	7