Universidade de Aveiro Departamento de Educação e Psicologia
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Atenção Exógena e Memória para Faces após Ativação Contextual do Sistema Imuno-Comportamental

Exogenous Attention and Memory for Faces Following Contextual Behavioural Immune System Activation

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Psicologia da Saúde e Reabilitação Psicológica, realizada sob a orientação científica da Doutora Sandra Soares, Professora Auxiliar do Departamento de Educação e Psicologia da Universidade de Aveiro, e a coorientação da Doutora Josefa Pandeirada, Equiparada a Investigadora Auxiliar do Departamento de Educação e Psicologia da Universidade de Aveiro

Dedico o presente trabalho:

À minha família, os primeiros a acreditarem em mim.
Obrigada por me ensinarem que o mais importante é dar o meu melhor e nunca desistir; no final todo o esforço compensa, sempre.

o júri

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palavras-chave

Atenção exógena, memória, sistema imuno-comportamental, faces, nojo, ativação contextual

resumo

O sistema imuno-comportamental é caraterizado por processos afetivos, cognitivos e comportamentais que trabalham de forma articulada para prevenir a ocorrência de uma infeção. Da mesma forma, tanto a atenção como a memória evoluíram para aumentar as probabilidades de sobrevivência do organismo e, por isso, devem estar associadas ao sistema imuno-comportamental. Assim, o presente estudo investigou os efeitos da atenção e da memória para faces neutras após ativação contextual do sistema imuno-comportamental. Preocupações com doenças infeciosas ou não-infeciosas foram elicitadas nos participantes através da utilização de vídeos. Depois, eles realizaram uma tarefa de atenção exógena baseada na discriminação de letras alvo com faces neutras apresentadas como distratores, seguida de uma tarefa de reconhecimento surpresa para as faces. Os resultados mostraram que os participantes na condição de doença infeciosa apresentaram melhor desempenho na tarefa atencional do que os participantes na condição de controlo. Não foi encontrada nenhuma diferença significativa entre os grupos quanto à tarefa de reconhecimento. Em geral, estes resultados sugerem que o sistema imuno-comportamental pode estar associado a um estado de hipervigilância perante pistas sociais em geral e que a sua ativação por meio deste tipo de *priming* pode não ser suficiente para ativar mecanismos mnésicos.

keywords Exogenous attention, memory, behavioural immune system, faces, disgust, contextual activation

abstract The behavioural immune system (BIS) is characterized by affective, cognitive and behavioural processes that work in an articulated way to prevent the occurrence of an infection in the first place. Likewise, both attention and memory evolved to enhance the organism's chances of survival and should, therefore, be associated with the BIS. Thus, the present study investigated the effects of attention and memory for neutral faces after a contextual activation of the behavioural immune system. Participants were primed either with infectious disease concerns or non-infectious disease concerns, using film clips. Then, they performed an exogenous attentional task based on the discrimination of target letters with face stimuli presented as distractors, followed by a surprise recognition task for the faces. The results showed that participants in the infectious disease condition performed better in the attentional task than participants in the control condition. No significant difference between groups was found regarding the recognition task. Overall, these results suggest that the BIS might be associated with a hypervigilant state towards social cues in general and that BIS activation through this type of priming may not be sufficient to activate mnemonic mechanisms.

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List of Abbreviations

ACC - Accuracy
ADFES - Amsterdam Dynamic Facial Expression Set
BIO - Biological Immune System
BIS - Behavioural Immune System
KDEF - Karolinska Directed Emotional Faces
RaFD - Radboud Facial Database
RT – Response/Reaction Time
SPSS - Statistical Package for Social Sciences
VAS - Visual Analogue Scale
WSEFEP - Warsaw Set of Emotional Facial Expression

Introduction

Throughout human evolution, infectious diseases have posed a threat to survival and reproductive fitness (Miller & Maner, 2012; Schaller & Park, 2011; Tskhay, Wilson, & Rule, 2016). These continuous selection pressures from pathogens resulted in the development of two sets of immune systems: A biological immune system (BIO), capable of detecting harmful organisms that enter the body and provide defence against these intruders, and a behavioural immune system (BIS), which complements the BIO system (Miller & Maner, 2012; Oaten, Stevenson, & Case, 2009; Schaller, 2016; Schaller & Park, 2011). The BIS involves a set of psychological proactive mechanisms, apt to identify perceptual cues that signal the presence of potential sources of disease in the immediate environment and to facilitate its avoidance in order to prevent pathogens from entering the body. As such, this system grants a unique adaptive benefit by preventing the occurrence of an infection in the first place (Schaller, 2016; Schaller & Park, 2011). Furthermore, the BIS is not only sensible to specific cues that pose some sort of infection risk (e.g., faeces or contaminated water; Kiesecker, Skelly, Beard, & Preisser, 1999), but also to the presence of pathogens in conspecifics (Schaller, 2016); as stated by Goodall's (1986), the "avoidance of conspecifics showing abnormal behaviour may be highly adaptive since it reduces the risk of spreading contagious disease" (p. 234). In fact, several studies have shown that people can identify potential disease from various perceptual cues (e.g., obesity, rashes, noxious odours, contaminated food; Ackerman et al., 2009; Schaller & Park, 2011) and engage in avoidance behaviours, especially if the disease is perceived as potentially contagious (Oaten et al., 2009; Schaller & Duncan, 2007). When people are exposed to these stimuli, they display affective (e.g., disgust), cognitive (e.g., faster allocation of attention and higher recall rates), and behavioural reactions (e.g., avoidance) that help to protect them from potential disease carriers (Schaller & Duncan, 2007; Schaller & Park, 2011).

Some authors believe that the BIS might be a psychologically unique motivational system since it enables functionally adaptive behaviours (Aunger & Curtis, 2013; Neuberg, Kenrick, & Schaller, 2011), hence being associated with emotions, namely the emotion of disgust (Schaller, 2016). Disgust is considered to be a basic emotion with a response pattern universally recognized and expressed across diverse cultures (Curtis, de Barra, & Aunger, 2011; Ekman & Friesen, 2003; Rozin & Fallon, 1987). It is triggered by a set of perceptual specific stimuli that signal an immediate risk of infection (e.g., bodily products, hygiene and contaminated food) and motivate behavioural avoidance (Curtis & Biran, 2001; Schaller &

Duncan, 2007; Schaller & Park, 2011). Thus, it seems that disgust evolved as an adaptive defensive mechanism capable of enabling behavioural avoidance of infectious diseases and, therefore, is associated with a universal disease-avoidance system in humans (Oaten et al., 2009; Schaller & Duncan, 2007). Accordingly, there is considerable research supporting the crucial role of disgust as a key component of the BIS (Ackerman et al., 2009; Oaten et al., 2009; Schaller, 2016). Besides disgust, cognitive mechanisms have also evolved to promote adaptive defensive mechanisms linked to the BIS, namely adaptive biases to threatening stimuli that induce avoidance behaviours (Ackerman et al., 2009; Schaller, Park, & Faulkner, 2003). Specifically, it has been proposed that the BIS involves the activation of a set of specific cognitive mechanisms, such as enhanced attention towards sources of contamination and retention of contaminants (Aylward, 2013; Liberman & Patrick, 2014), some of which are assumed as part of a threat management system (detection and threat encoding) (Ackerman et al., 2009; Neuberg et al., 2011).

Potentially threatening circumstances must be quickly detected, without the involvment of voluntary attention, so that all of the available resources can be directed at finding and executing the responses that maximize the chances of survival (Soares, Maior, Isbell, Tomaz, & Nishijo, 2017; van Hooff, Devue, Vieweg, & Theeuwes, 2013). This automaticity reflects exogenous attention, also known as automatic or stimuli-driven attention (Wolfe, 2011), a process that allows for the detection and processing of biologically-relevant stimuli that appear out of the current focus of attention (Carretié, 2014). Exogenous attention is, therefore, responsible for an adaptive attentional bias, an automatic orienting response towards stimuli that elicit danger (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007), such as disease salient information (Oaten, Stevenson, & Case, 2011). Moreover, disgust information, in particular, seems to favour an attentional bias that serves to protect the individual from possible contaminations (Williams, Mathews, & MacLeod, 1996). In fact, disgust-related stimuli seem to be more efficient at capturing and holding our attention than fear-related stimuli (Charash & Mckay, 2002; Ciesielski, Armstrong, Zald, & Olatunji, 2010; van Hooff et al., 2013). Thus, attentional bias is implicated in the BIS (Mogg & Bradley, 1998), making us hypervigilant for disease connoting stimuli in the environment (Schaller & Duncan, 2007).

Memory also evolved to solve adaptive problems related to survival and reproduction and, therefore, seems to be selectively sensitive to fitness-relevant information (Nairne & Pandeirada, 2008). Considering that disease-relevant information offers important survival advantages, memory should favour the retention of these kind of cues. Indeed, research shows that people have better memory for previously seen disgusting words and images (Aylward, 2013; Charash & McKay, 2002), disease relevant-information (Prokop, Fančovičová, & Fedor, 2014), objects that came in contact with or have been associated with disease cues (Fernandes, Pandeirada, Soares, & Nairne, 2017) and people who engage in behaviours perceived as disgusting (Bell & Buchner, 2010). Thus, evidence seems to support the existence of memory biases for fitness-related information, namely to disgust-related stimuli, a key component of the BIS (Aylward, 2013; Fernandes et al., 2017; Schaller, 2014).

Although several studies have already investigated the effects of the BIS on attention and memory, very little research has examined these effects following contextual activation of the BIS. Furthermore, only a few of these studies explored these effects using face stimuli and, even then, they only focused on the faces containing disgust cues; for example, Ackerman and collaborators (2009) only discussed the results between their priming conditions (i.e., disease sensitivity condition vs. control condition) for disfigured faces, while ignoring the control non-disfigured faces. The study of faces in the context of the BIS is relevant not only because they are highly salient in social contact (Kouznetsova, Stevenson, Oaten, & Case, 2012), but also because individuals preferentially attend to faces as one of the sources of social information (Ro, Russell, & Lavie, 2001). In line with this idea, studies have shown that abnormalities located on the face (e.g., facial lesions, asymmetry) are especially attention-demanding, which might be associated with the increased visibility and prominence that their location (the face) provides (Oaten et al., 2011). Therefore, the face provides valuable information about the health state of individuals, which is in turn essential to the elicitation/activation of avoidance behaviour (Kouznetsova et al., 2012). In an attempt to better understand the mechanisms underlying the BIS, our aim was to address this gap in the literature by investigating whether contextual/situational activation of the BIS would influence attention and memory of neutral faces.

In the current study, participants were primed, using film clips, either with infectious disease concerns (infectious disease condition; flu prime) or non-infectious disease concerns (non-infectious disease condition; heart-disease prime). In order to maximize the priming effect of the video, participants were told they would be asked questions about its content; these questions were presented after watching the video. Afterwards, they underwent an exogenous attentional task, in which they were required to complete a letter discrimination task with face stimuli presented as distractors. They then performed a surprise recognition task for the faces.

We predicted that there would be an automatic attentional capture by faces presented in the infectious disease condition, i.e., participants primed with infectious disease concerns would take longer and make more errors in the attentional task, as compared to participants in the control condition. Furthermore, considering the evolutionary importance of memory on survival and its sensitivity to disease relevant-information (Nairne & Pandeirada, 2008; Prokop et al., 2014), we predicted that participants in the infectious disease condition would show better recognition memory of the faces than participants in the control condition.

Method

Participants

One hundred and six undergraduate students from the University of Aveiro (81 females, 25 males; M_{age} = 21.0 years; *SD* = 2.7) participated voluntarily in this study. All participants provided written informed consent (see Appendix A) and were either rewarded with course credits or by becoming eligible to win tickets for the Academic Festivities' week of the University of Aveiro. Data from 42 participants were excluded, two for not having normal or corrected to normal eyesight and 14 for being ill in the past two weeks prior to the task, as revealed by the participants' self-report. The remaining 26 participants were excluded for having reported trying to memorise the faces during the encoding phase, which precluded the incidental nature of this task. The final sample included 64 participants (50 females, 14 males; M_{age} = 21.2 years; *SD* = 2.8).

Materials

To manipulate disease threat and, consequently, activate the BIS, we presented participants with one of two videos (see Tskhay et al., 2016). Participants in the infectious disease condition viewed a brief educational video about the flu virus (02:18min) and participants in the non-infectious disease condition viewed a brief educational video about cardiovascular disease (02:30min). Both videos are freely available on the RochePortugal Youtube Channel and were edited in order to have similar durations and contents. Information regarding the immune system's response or any possible treatment was deleted from both videos, so that they would solely raise disease concerns.

Stimuli pictures included 84 colour front-oriented female faces, Caucasian and with a neutral emotional expression from multiple databases (Karolinska Directed Emotional Faces [KDEF], Lundqvist, Flykt, & Öhman, 1998; Warsaw Set of Emotional Facial Expression [WSEFEP], Olszanowski et al., 2015; Radboud Facial Database [RaFD], Langner et al., 2010;

FACES Database, Ebner, Riediger, & Lindenberger, 2010; and Amsterdam Dynamic Facial Expression Set [ADFES], van der Schalk, Hawk, Fischer, & Doosje, 2011). The pictures were selected from a pool of 101 faces from a previous study that collected attractiveness ratings for the Portuguese population (Pandeirada, Fernandes, & Vasconcelos, 2014) to have an average level of attractiveness (M = 3.2; SD = 0.8). Four of these faces were used in the practice trials of the attentional task, whereas the remaining 80 were divided into two groups of 40 each, with similar means of attractiveness (M_1 = 3.46, SD_1 = 0.68; M_2 = 3.49, SD_2 = 0.70; $t(78)$ = -0.17, p = .87, r = .02). Each group of faces was used an equal number of times as targets (faces presented during encoding and in the recognition task) and as distractors (faces presented only in the recognition task) across counterbalancing versions of the experiment. This procedure was adopted in both the infectious disease and the non-infectious disease activation conditions (totalling four versions of the experiment). Since data from some participants who reported being recently ill were excluded, an uneven number of participants in each version/condition emerged; 17 and 16 participants responded to one of the versions of the experiment in the infectious disease and the control conditions, respectively; the other version involved 14 participants in the infectious disease condition and 17 in the control condition. In order to assess whether this unbalanced distribution of participants between conditions was critical to our results, statistical analyses were performed (see Results section).

To program the experimental task, we used *Software E-Prime 2.0 Professional* (Schneider, Eschman, & Zuccolotto, 2002). We also used headsets (Sony MDR-XD150) during the presentation of the videos (the priming stage) so that participants could listen to the audio. All tasks were performed on computers (21.5 inches monitors) from the Evo-CogLab at the Department of Education and Psychology, University of Aveiro.

One of the main characteristics of the BIS is that it probably evolved to be functionally flexible and reactive to regulatory cues, such as individual differences regarding perceived vulnerability to disease (Schaller et al., 2007). Given that behavioural avoidance "might be especially strong among individuals who are chronically concerned about the spread of contagious diseases", as suggested by Schaller and Duncan (2007, p. 300), we considered this factor in the data analysis. Furthermore, considering the possible role of disgust on Obsessive-Compulsive Disorder and the association between disgust sensitivity and specific fears and phobias (Woody & Teachman, 2000), we also deemed these factors as potentially relevant for analysis. Therefore, four questionnaires were administered at the end the experimental task for control purposes: 1) Sociodemographic Questionnaire (one version for each of the experimental conditions; see Appendix B and C), 2) Perceived Vulnerability to

Disease (PVD, Duncan, Schaller, & Park, 2009; Ferreira et al., Portuguese version under validation), 3) Disgust Propensity and Sensitivity Scale – Revised (DPSS-R, Fergus & Valentiner, 2009; adapted by Ferreira et al., 2016); and, 4) Maudsley Obsessional-Compulsive Inventory – Portuguese Version (MOCI, adapted by Nogueira et al., 2012).

The PVD is a self-report instrument with 15 items that measures individual differences regarding concerns about the transmission of infectious diseases. It is composed by two subscales: "Perceived Infectability", which assesses people's beliefs about their own susceptibility to infectious diseases, and "Germ Aversion", which assesses the emotional discomfort in contexts where there is a higher potential for pathogenic transmission. Responses are given on a seven points scale (*1 = Strongly Disagree … 7 = Strongly Agree*) and the total score varies from 15 to 105. The internal consistency is high, with an *Alpha coefficient* of .804 for the subscale of "Perceived Infectability" and .746 for the subscale "Germ Aversion" (Ferreira et al., in preparation).

The DPSS-R includes 12 items and assesses the easiness with which people experience disgust ("Disgust Propensity") and how unpleasant the experience was ("Disgust Sensitivity"). Participants have to rate each statement based on a five points scale (*1 = Never … 5 = Always*) and the total score can range from 12 to 60. The internal consistency for the subscale "Disgust Propensity" is .778 and for the subscale "Disgust Sensitivity" is .808 (Ferreira et al., 2016).

MOCI is a self-report measure of obsessive-compulsive symptoms composed of 30 true/false items that divide into three subscales: "Doubting and Rumination", "Checking" and "Cleaning". The MOCI *Cronbach's Alpha* is .785, revealing a high internal consistency, with an *Alpha coefficient* of .72 for the subscale "Doubting and Rumination", .66 for "Checking", and .63 for "Cleaning" (Nogueira et al., 2012).

Procedure

Four undergraduate students from University of Aveiro (M_{age} = 23.5 years; *SD* = 3.3) participated in a pilot study, which aimed to verify if the experimental task was running as expected and whether the duration of the distraction task and performance levels were adequate.

In the experimental study, up to five participants were tested in each session, which lasted approximately 30 minutes; distance between computers was maintained in order to minimize potential sources of distraction among participants. Participants were randomly assigned to one of the four versions of the experimental task, while also ensuring a similar number of participants per version. Participants in both conditions watched their assigned video and were asked to briefly describe its main theme and to indicate, using a Visual Analogue Scale (VAS; *None* [0] to *Very* [100]), the intensity with which each emotion (i.e., disgust, anger, happiness, sadness or fear) was triggered by the video. Following this stage, participants proceeded to the attentional task, which followed a procedure adapted from van Hooff and collaborators (2013, 2014). Figure 1 describes the sequence of events in one trial of this task. Each trial began with the presentation of a central fixation cross (1000 ms), followed by a face presented in the middle of the screen (202 x 274 pixels; 11º visual angle viewed at 65 cm). After 200 ms of the cue onset, a target stimulus (letter Z or N, font Arial, size 12) appeared for 50 ms (left or right, randomized and with the same probability; 4.5º visual angle from the middle of the screen). The time interval between trials was 500 ms. Each picture was paired with both target letters on the right and left side, with each picture appearing only once in one of the four non-randomized blocks of 40 trials each (resulting in a total of 160 experimental trials); within each block, the display of the pictures was randomized. Therefore, each picture was repeated four times during the entire task. The participants' task was to indicate, as accurately and quickly as possible, which target letter was presented, by pressing the corresponding keyboard button. The picture remained on the screen until a response was given or after a maximum response interval of 1200 ms. Previous to the experimental trials, participants responded to a set of four practice trials during which they were given feedback regarding their performance ("Correct", "Incorrect" or "You didn't answer, please be faster").

At the end of this task, participants were given two minutes to complete a word search paper and pencil task (distractor task), after which the recognition task followed. Participants were presented with 80 faces displayed in a random order, 40 of which were targets (old faces; i.e., faces presented during the attentional task) and 40 were distractors (new faces; i.e., faces not presented during the attentional task), and were asked to identify if they had previously seen each of the faces; responses were given by pressing the corresponding keyboard button (Yes [S] or No [N]). After this task, participants were asked if, during the initial phase, they suspected that they would be asked to remember the faces presented during the attentional task and if they tried to memorise them. Finally, the four questionnaires mentioned above were answered in the following order: Sociodemographic Questionnaire, PVD, DPSS-R and MOCI. All participants were then debriefed and thanked for their participation.

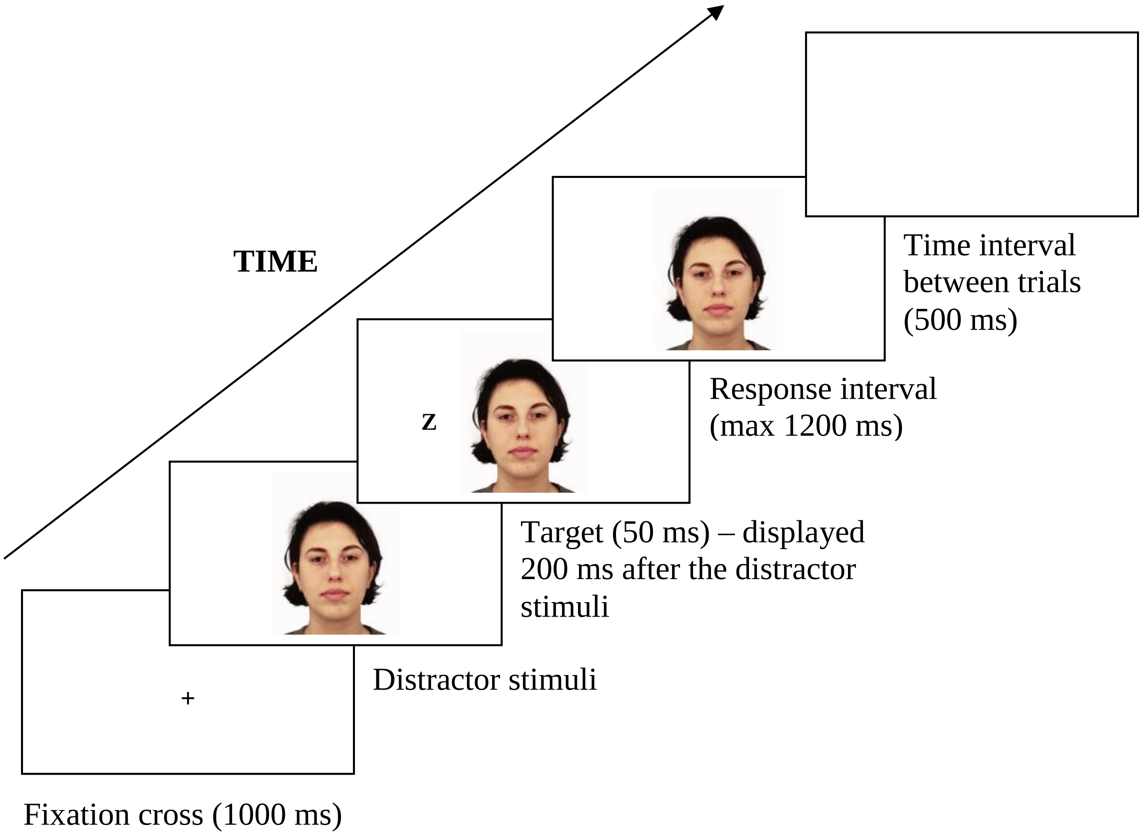

Figure 1. Sequence of events in one trial of the attentional task. *Note:* Participants had to identify the target letter (Z or N), which was presented either to the right or left of the central distractor stimuli (i.e., face)[1].

Results

Analyses were performed using the Statistical Package for Social Sciences (IBM SPSS), version 21. The statistical level of significance was set at $p < .05$ for all analyses.

Priming Manipulation Check

To ensure that our priming manipulation successfully triggered concerns about disease, we first examined whether the subjective ratings of the videos differed in terms of the elicited emotions (see descriptive values in Table 1). The results showed that the participant's disgust ratings varied significantly between videos, with the infectious disease activation video being rated as more disgusting than the control video; the remaining set of emotions did not differ significantly between videos. Thus, our priming manipulation was confirmed given that disgust is a key component of the BIS activation, as previously mentioned.

[1] F_KDEF17

Table 1

Mean (and SD) values obtained for each video for each of the emotions assessed after the visualization of the video; statistics regarding the comparison between conditions are also provided.

	Condition		
Emotion	Infectious Disease	Control	Test Statistics
Disgust	26.03(26.63)	6.91(16.01)	$F(1,62) = 12.300$, $p < .001$, $\eta_p^2 = .166$
Anger	6.87(16.46)	6.09(12.34)	$F(1,62) = .046$, $p = .830$, $\eta_p^2 = .001$
Happiness	10.16(17.97)	9.00(14.55)	$F(1,62) = .081$, $p = .777$, $\eta_p^2 = .001$
Sadness	19.42(22.90)	23.85(24.70)	$F(1,62) = .552$, $p = .460$, $\eta_p^2 = .009$
Fear	13.87(19.60)	22.27(25.77)	$F(1,62) = 2.135$, $p = .149$, $\eta_p^2 = .033$

Attentional Task

Accuracy (ACC) for the identification of the target letters was significantly higher in the infectious disease condition than in the control condition, $F(1, 60) = 4.306$, $p = .042$, $\eta_p^2 = .067$ (see Figure 2), suggesting that participants whose BIS was activated were better at identifying the correct letter target. This result contradicts our initial hypothesis, which predicted that participants in the infectious disease condition would make more errors than the

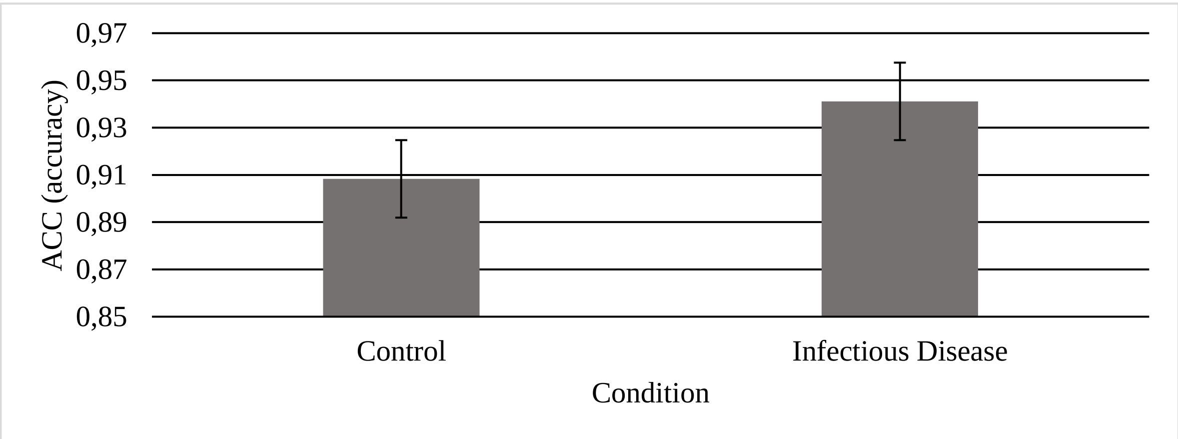

Figure 2. Proportion of correct responses for the letter identification task.

participants in the control condition[2].

For the response times (RT), and following standard procedures in attentional tasks (e.g., Lundqvist & Öhman, 2005; Miller & Maner, 2011), response times +/- than three standard deviations from the mean of the participant were excluded; the response times from trials with incorrect responses were also excluded. No significant difference in reaction time was found between conditions, $F(1, 60) = .554$, $p = .460$, $\eta_p^2 = .009$, although participants in the control condition tended to be faster ($M = 416.62$, $SD = 66.98$) than participants in the infectious disease condition ($M = 432.53$, $SD = 77.01$)[2].

To explore the possibility that performance changed throughout the task due to habituation effects, we analysed the results by quartile and conducted a 4 (Quartiles: 1, 2, 3, 4; within-subjects variable) x 2 (Condition: infectious disease vs. control; between-subjects variable) repeated measures ANOVA; in each quartile, the number of responses could be slightly different because we only considered the response times for the correct responses and also excluded outlier RTs. Regarding ACC, no significant effects of quartile nor significant interactions with this factor were found; the main effect of condition remained the same. However, for the RTs, a significant main effect of quartile was obtained, $F(3, 180) = 6.056$, $p < .001$, $\eta_p^2 = .092$. Response times in the first quartile ($M = 433.95$, $SD = 80.62$) were significantly longer, as compared to the fourth quartile ($M = 415.40$, $SD = 74.19$; $p = .007$), and marginally longer than the second ($M = 422.60$, $SD = 73.41$; $p = .092$) and third ($M = 419.68$, $SD = 73.80$; $p = .080$) quartiles. No significant effect of condition nor interaction between quartile and condition was found.

Recognition Task

No significant effect of condition was found in the hit rate (i.e., the proportion of old items correctly recognized as old) of the recognition task, $F(1, 60) = 2.024$, $p = .160$, $\eta_p^2 = .033$ ($M_{control} = .36$, $SD_{control} = .16$; $M_{disease} = .41$, $SD_{disease} = .18$); descriptively, though, the hit rate was highest in the infectious disease condition, as predicted[2]. Although our pilot study was aimed at ensuring adequate levels of performance, the final results revealed a very low level of performance in this task. To test whether the participants' hit rate was significantly different from chance (in this case, a probability of 50%), we conducted a one sample t-test

[2] The same pattern of results was obtained when the counterbalancing version was considered as an additional between-subjects variable. The interactions involving counterbalancing versions were also non-significant.

and found that performance in the recognition task was below chance level for both conditions, $t_{control}(32) = -5.068$, $p < .001$ and $t_{disease}(30) = -2.656$, $p = .013$.

Effects of Individual Differences

Considering that all three individual variables assessed by the questionnaires used are associated with disgust, we expected them to be correlated with each other. Indeed, the PVD scores correlated significantly with the DPSS-R, $r = .347$, $p < .01$, and the MOCI scores, $r = .271$, $p = .030$; however, the DPSS-R and the MOCI did not significantly correlate with one another, $r = .082$, $p = .518$.

One-way ANCOVAs were also conducted to determine if the pattern of results described on ACC, RT and hit rate remained, while controlling for each of these three measures. A significant effect of condition on ACC, controlling for perceived vulnerability to disease (PVD), $F(1,59) = 4.169$, $p = .046$, $\eta_p^2 = .066$, and marginally significant effects while controlling for disgust propensity and sensitivity (DPSS-R), $F(1,59) = 3.742$, $p = .058$, $\eta_p^2 = .060$, and obsessive-compulsive symptoms (MOCI), $F(1,59) = 3.988$, $p = .050$, $\eta_p^2 = .063$, were found, with participants in the infectious disease condition producing more correct responses than participants in the control condition. No significant effects of condition on RT or hit rate, while controlling for the three measures, were found (all *ps* > .05).

Discussion

The BIS evolved to protect the organism against possible sources of disease and is characterized by affective, cognitive and behavioural processes that aim to reduce the chances of an infection occurring in the first place (Schaller & Park, 2011). Since both attention and memory have also evolved to solve adaptive problems related to survival, it seems plausible that these processes should be implicated in the BIS (Fernandes et al., 2017; Mogg & Bradley, 1998). Accordingly, we hypothesized that, following contextual activation of the BIS (video depicting an infectious disease), there would be attentional and memory biases towards neutral faces.

Regarding our first hypothesis, our results showed that participants whose BIS was previously activated performed better in the attentional task than participants in the control condition, as revealed by the accuracy (ACC) results. This result does not support our initial hypothesis regarding an attentional bias towards neutral faces after BIS activation. This prediction was based on the premise that the BIS is associated with heightened vigilance towards possible sources of contamination, in this case, the face stimuli. Therefore, we expected that faces would interfere with the participants' ability to identify the target letters, which should result in longer RTs and more errors in this condition (as compared to the control condition). Regarding ACC, one possible explanation for the improved performance (i.e., higher accuracy) in the infectious disease condition might be due to a general hypervigilance associated with the BIS's activation, and not to a specific hypervigilance towards disgusting stimuli, as previously suggested (Aylward, 2013; Schaller & Duncan, 2007). In fact, this result occurred despite the fact that we were using neutral stimuli, suggesting that the BIS itself is capable of automatically heighten our attention towards stimuli in general, even in the absence of threat/disgust-related stimuli; these latter stimuli have been the focus of most of the previous studies (e.g., Ackerman et al., 2009; Miller & Maner, 2011). Furthermore, even though neutral faces do not seem particularly effective at holding our attention, even after priming participants with disease concerns (i.e., no significant difference for RT was found), our results do show that these participants exhibited longer RTs, which may suggest that, to some extent, they are indeed capturing attention (Ackerman et al., 2009; Miller & Maner, 2011). Since we are activating the BIS prior to the attentional task – i.e., our organism will be hypervigilant for signs of threat - and that visual attention is implicated in immediate threat processing (Ackerman et al., 2009), one possible explanation for this result might be associated with a more automatic threat processing of these faces so as to assure the individual's safety. Thus, our results suggest that the activation of the BIS is associated with a hypervigilance towards stimuli in general and that this hypervigilance might be related to an automatic cognitive processing of the social environment.

The results from the memory task revealed no significant difference on the recognition hits between conditions. This result contradicts our initial hypothesis regarding a potential memory bias for disease relevant-information. A possible explanation for this finding might be associated with the type of stimuli used. In fact, several studies have demonstrated that emotionally arousing stimuli are better remembered than non-threatening stimuli (e.g., neutral stimuli) and that the latter are likely to be disregarded by the organism, thus inhibiting further processing (Mogg & Bradley, 1998; Nairne, Pandeirada, & Thompson 2008). Moreover, Ackerman and collaborators (2009) suggested that depending on the qualities of the stimuli presented, there may exist certain disjunctions in the linear relationship between attention and memory, i.e., enhanced attention does not necessarily imply better retention, as is the case in our study, where despite neutral stimuli successfully capturing some attention, that did not translate in better performance in the recognition task.

Furthermore, our analysis of the data by quartile showed that the general response speed increased over the course of the attentional task, with no significant drop in ACC. Considering that the main task was to identify the target letter, as the task proceeded participants may have developed effective strategies to ignore the distracting face and focus more effectively on the task at hand. Consequently, participants have also payed less attention to the faces, which negatively impacted memory for them. This might explain the below-chance levels of performance in the recognition task, which also limits the observation of any memory effect of our manipulation. Another factor that may underlie the lack of effects on memory might be associated with emotionality effects on memory. In fact, several studies have demonstrated an advantage of emotional items over neutral items (Kensinger, 2009), an effect that is more robust in mixed list designs, that is, when neutral items are presented with emotional items in the same list (and not a pure list design, such is the case) (Mather & Nesmith, 2008; Talmi & Moscovitch, 2004). Our procedure is more similar with a "pure-list" design given that all stimuli (faces) were processed in the infectious disease or control condition; thus, the lack of significant results is not very surprising. Furthermore, it is possible that the emotional activation afforded simply by the context induction was probably not arousing enough to elicit a memory effect. Finally, given that the hit rate in both conditions was very low (even lower than chance level), these results preclude any firm conclusions regarding the memory task.

Although several studies have focused on the effects of attention and memory towards disgusting stimuli, no study, to our knowledge, had yet investigated the effects of attention and memory towards neutral stimuli, specifically faces, after a BIS activation. Thus, this study proposes that following BIS activation people might be hypervigilant not only to disease-connoting stimuli, but also to stimuli in general that can represent some sort of threat to the individual's well-being. However, it is important to emphasize that the effect found in our study was specific to the perception of social cues. Since the avoidance of diseased individual's acts as a form of protection against the spread of disease and that some diseases do not have visible cues to signal their presence, this heightened attention towards social cues in general (i.e., without any distinct disease cue) may have been adaptive in ancestral environments. More research is needed to better understand the possible implications of this hypothesis.

In line with previous assumptions, future studies should continue to investigate the effects of attention and memory. It would be interesting to study the effects of these processes with medical personnel, since they encounter disease individuals daily; frequent contact with these individuals might, to some extent, modulate the expression of said processes. Additionally, given that the BIS is greatly associated with avoidance of infectious diseases and that the face serves as an important indicator of the health state of individuals (Kouznetsova, et al., 2012), future studies should investigate whether faces with infectious disease cues are more effective at capturing and holding our attention than faces containing no such cues. Although some studies on attention have already used faces with disease cues (e.g., Ackerman et al., 2009), these were not symptomatic of contagious diseases. Some studies on memory have already started to use these kind of cues, which demonstrates its fitness-relevant importance (Fernandes et al., 2017). Finally, since the activation of the BIS relies on disgust and given that this emotion is associated with the activation of the autonomic nervous system (Kreibig, 2010), future studies might also consider using physiological measures (e.g., heart rate, skin conductance) to ensure its activation. Indeed, these physiological processes are not under the domain of voluntary control and are rapidly mobilized by the organism, hence its importance for future studies.

Overall, the present study allows for a better understanding of the basic cognitive mechanisms underlying the BIS. Our findings suggest that the BIS leads to a hypervigilant state towards social stimuli in general, and that BIS activation through contextual priming may not be sufficient to activate the particularly effective mnemonic mechanisms.

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Appendix A

Consentimento Informado

No âmbito da dissertação de mestrado em Psicologia da Saúde e Reabilitação Neuropsicológica da Universidade de Aveiro, orientada pela professora Dra. Sandra Soares e coorientada pela professora Dra. Josefa Pandeirada, será realizada uma investigação constituída por duas partes, com a duração aproximada de 40 minutos: A primeira parte engloba a visualização de um vídeo, seguida da realização de uma tarefa de atenção (em que terá de discriminar entre as letras Z e N), enquanto a segunda parte envolve o preenchimento de questionários.

A sua participação neste estudo não envolve qualquer tipo de risco, para além dos normalmente encontrados no seu dia-a-dia. Qualquer que seja a sua decisão, não será prejudicado(a) nem por participar, nem por recusar participar no estudo. O benefício que poderá encontrar passa pela oportunidade de passar por uma experiência diferente, de refletir sobre si próprio(a) ou ainda de poder contribuir para a investigação científica em Psicologia.

A informação fornecida ou quaisquer dados recolhidos ao longo deste estudo serão mantidos em confidencialidade e não serão associados a qualquer informação sua, sendo portanto inteiramente anónimos. Além disso, os dados que recolhermos serão tratados, analisados e divulgados apenas em grupo, nunca individualmente.

A sua participação neste estudo é voluntária, sendo que, portanto, tem direito a não querer participar. Se concordar em participar poderá desistir a qualquer momento, sem qualquer penalização. Caso queira desistir, a meio ou no final do estudo, todos os dados recolhidos a seu respeito serão eliminados.

Todos os esclarecimentos, bem como os objetivos deste estudo, foram expostos oralmente e/ou por escrito. Os dados recolhidos serão usados unicamente para fins de investigação.

Eu, ____, declaro que fui informado(a) acerca dos objetivos deste estudo e dos procedimentos que serão realizados, comprometendo-me a seguir as instruções fornecidas.

Compreendi as instruções e aceito, de livre e espontânea vontade, participar no estudo, podendo, a qualquer momento, desistir do mesmo.

Data: ______/______/_________

Assinatura:

____

Pretende ter acesso aos resultados deste estudo? Sim__ Não __

Se respondeu SIM e/ou se optou pela participação no SORTEIO, deixe-nos, por favor, o seu contacto (endereço eletrónico) de modo a informá-lo(a), posteriormente, dos resultados do estudo e/ou do sorteio.
____

Appendix B

Questionário Sociodemográfico – Infectious Disease Condition

Por favor, responda às seguintes questões com sinceridade. Os dados recolhidos são confidenciais e, em momento algum, serão associados à sua identidade.

1. Idade: _______
2. Sexo: Masculino ____ Feminino ____
3. Lateralidade: Dextro(a) ____ Canhoto(a) ____ Ambidestro(a) ____
4. Profissão: ____

   4.1.Se for estudante, indique o curso, o grau académico e a instituição.

   ____

5. Tem algum problema de saúde física ou psicológica? Em caso afirmativo, identifique.

   ____

6. Tem algum problema visual? Em caso afirmativo, está corrigido?

   ____

7. Esteve doente nas duas últimas semanas? Sim_____ Não _____
8. Contactou com alguma pessoa doente nas duas últimas semanas? Em caso afirmativo, que doença tinha?

   ____

   8.1. Se esteve em contacto com alguma pessoa doente, indique o grau de proximidade.

   Familiar _____ Amigo _____ Conhecido _____ Desconhecido _____

9. Está a tomar alguma medicação (medicação prescrita, suplementos vitamínicos ou outros)? Em caso afirmativo, indique os nomes dos medicamentos que está a tomar.

   ____

10. Já conhecia o vídeo que visionou, no início da tarefa? Sim_____ Não _____

Appendix C

Questionário Sociodemográfico - Non-infectious Disease Condition

Por favor, responda às seguintes questões com sinceridade. Os dados recolhidos são confidenciais e, em momento algum, serão associados à sua identidade.

11. Idade: _______
12. Sexo: Masculino ____ Feminino ____
13. Lateralidade: Dextro(a) ____ Canhoto(a) ____ Ambidestro(a) ____
14. Profissão: ____

    4.2. Se for estudante, indique o curso, o grau académico e a instituição.

    ____

15. Tem algum problema de saúde física ou psicológica? Em caso afirmativo, identifique.

    ____

16. Especificamente em relação a doenças cardiovasculares, padece de algum problema relacionado? Em caso afirmativo, identifique.

    ____

    6.1. Indique, ainda, se tem algum familiar próximo com algum problema cardiovascular.

    ____

17. Tem algum problema visual? Em caso afirmativo, está corrigido?

    ____

18. Esteve doente nas duas últimas semanas? Sim_____ Não _____
19. Contactou com alguma pessoa doente nas duas últimas semanas? Em caso afirmativo, que doença tinha?

    ____

9.1. Se esteve em contacto com alguma pessoa doente, indique o grau de proximidade.

Familiar _____ Amigo _____ Conhecido _____ Desconhecido _____

20. Está a tomar alguma medicação (medicação prescrita, suplementos vitamínicos ou outros)? Em caso afirmativo, indique os nomes dos medicamentos que está a tomar.

____

21. Já conhecia o vídeo que visionou, no início da tarefa? Sim_____ Não _____