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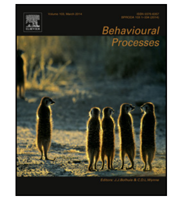

Parasites enhance self-grooming behaviour and information retention in humans

Q1 Pavol Prokop[a,b,*], Jana Fančovičová[a], Peter Fedor[c]

[a] Department of Biology, Trnava University, Trnava, Slovakia
[b] Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia
[c] Department of Environmental Ecology, Comenius University, 84215 Bratislava, Slovakia

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ABSTRACT

Self-grooming is a common behavioural strategy used by various animals to reduce parasite loads. We experimentally tested the adaptive significance of self-grooming model in a sample of Slovak participants. Propensity to self-grooming was activated by visual presence of parasites with verbal information about health risks caused by parasites suggesting that the programmed grooming model works in humans. People who think of themselves as more vulnerable to disease transmission reported higher frequency of self-grooming suggesting that there is a link between the immune system and parasite avoidance behaviour. Considering that the emotion of disgust plays a role in activation of parasite avoidance behaviour, we suggested that knowledge of disgusting stimuli (parasites) would be better retained than knowledge of non-disgusting (hormones), and, thus, non-life-threatening stimuli. As expected, knowledge on parasites tested immediately after the experiment was significantly better than knowledge on hormones suggesting that survival-relevant information is better retained than survival-irrelevant data. However, scores on memory tests did not seem to be influenced by the individual's immune system. Overall, this study showed that self-grooming in humans was functional when disease threat was salient. Human memory systems are tuned to information relevant to survival providing further evidence that human cognition is shaped by natural selection.

1. Introduction

Survival and reproduction largely depends on an individual's ability to combat with disease-causing parasites. Parasites are therefore considered to be strong evolutionary forces influencing the evolution of human physiology and behaviour (Schaller and Duncan, 2007; Wolfe et al., 2007; Prokop and Fedor, 2013). While physiological mechanisms that eliminate disease threat are activated in the second line of individual's defence against disease (the biological immune system, BIS; Parham, 2009; Schaller et al., 2010), the first line of defence comprises a set of cognitive, emotional and behavioural mechanisms which allows individuals to detect the potential presence of parasites in objects (or individuals) and act to prevent contact with them (the behavioural immune system, BEH; Schaller, 2006; Schaller and Duncan, 2007; Neuberg et al., 2011). Both physiological and behavioural mechanisms interact with each other suggesting that the activation of one of these systems may trigger activation of the other system (Schaller et al., 2010; Miller Q3 and Maner, 2011).

Grooming is a common behavioural strategy used by animals in an effort to reduce transmission of ectoparasites (Hart, 1990, 1994; Moore, 2002). Grooming is documented also in parasite-free environments (Hart et al., 1992; Mooring and Hart, 1997; Mooring et al., 2006) suggesting that it has an endogenous component (Moore, 2002; Mooring et al., 2004). Two non-mutually exclusive models (Mooring and Samuel, 1998) are used to explain neurophysiological regulation of grooming. The "programmed grooming" model postulates an existence of central programming (ultradian clock or endogenous generator) that periodically activates a bout of grooming in order to remove ectoparasites before they are able to attach/bloodfeed (Hart et al., 1992; Mooring et al., 2004, 2006; Hawlena et al., 2008). This model assumes that a host invests in antiparasitic grooming on a regular basis irrespective on the presence of parasites in the environment (Hart et al., 2002; Mooring et al., 2006) and that the frequency of grooming may be modu- Q4 lated by some cues that are associated with increased vulnerability

Q2 * Corresponding author at: Department of Biology, Trnava University, Trnava, Slovakia. Tel.: +421 33 55 14618; fax: +421 33 55 14618.
E-mail addresses: pavol.prokop@savba.sk, pavol.prokop@post.cz (P. Prokop), fedor@nic.fns.uniba.sk (P. Fedor).

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to ectoparasite infestation (Hart, 1997; Hawlena et al., 2008). The "stimulus driven" model postulates a peripheral mechanism that is a direct response to cutaneous irritation caused by sucking by ectoparasites (Willadsen, 1980; Wikel, 1984; Hawlena et al., 2008). According to this model, a host is not expected to invest in grooming in absence of a relevant stimulus (Wakelin, 1996). Similar to other primates (Hart, 1990; Dunbar, 2012), humans also groom themselves (Thompson, 2010), but whether the programmed grooming model is applicable to our species is not yet clear. Considering the ectoparasite reduction function of grooming, it is assumed that individuals who think of themselves as more vulnerable to infectious diseases groom themselves more than individuals who perceive themselves as less vulnerable to infectious diseases (Thompson, 2010).

According to evolutionary views, human memory may have evolved to solve adaptive problems relevant to fitness (adaptive memory; Nairne et al., 2007; Nairne and Pandeirada, 2010). Research shows that words relevant to survival (Nairne et al., 2008; Kang et al., 2008), dangerousness of animals (Barrett and Broesch, 2012), poisonousness of plants (Prokop and Fančovičová, 2014) and life-threatening situations (Pynoos and Nader, 1989) are better retained than fitness irrelevant information. Furthermore, our memory processes seem to be positively influenced by the emotion of disgust, because disgusting stimuli are retained better than neutral-looking stimuli (Charash and McKay, 2002; Silva et al., 2012). Given that the emotion of disgust evolved as disease-avoidance mechanism in humans (Curtis et al., 2004; Oaten et al., 2009; Tybur et al., 2013), the association between adaptive memory and disgust-evoking stimuli is reasonable.

In this study we aimed to investigate (i) whether the programmed grooming model is applicable to humans, (ii) whether human memory preferentially retains information about disgusting and disease-relevant stimuli compared with non-disgusting and disease-irrelevant stimuli, and, finally, (iii) whether the BIS activates cognitive processes that facilitate action and the detection of parasites (BEH). Specifically, we hypothesized that (1) self-grooming would be induced by visual contact and information about parasites (activation of BEH) and that (2) self-grooming would be positively correlated with the self-perceived vulnerability to diseases to test the existence and functionality of the programmed grooming model. Furthermore, we hypothesized that (3) Information about parasites, as explicit examples of disease carriers, would be better retained than information on non-disease carriers to test the adaptive memory theory in humans. Finally, we expect that (4) People who think of themselves as more vulnerable to infectious diseases will retain more information on parasites than less disease vulnerable people in order to test the activation of BEH by the biological immune system (BIS).

2. Methods

2.1. Participants

A total of 95 Slovak students with mean age 30.11 (SD = 8.52) years (range = 19–47 years) attending Trnava University participated in the study. An additional 24 students were not included, because they were not present in the both sessions (see below). The mean age of the university students was higher than a typical undergraduate sample because these students at the campus where the study was conducted differ from traditional students, such as being employed full-time and/or having children. This yielded a more diverse sample of participants along several demographic variables compared with studies that include only full-time university students. Due to a strong female-bias in educational faculties in Slovakia, only four students were men. We therefore decided to not compare possible gender differences. Removing men from a sample did not change results of the statistical analyses. All participants received an extra credit from a Human biology course for their participation on the research.

2.2. Research instruments

2.2.1. Perceived vulnerability to disease scale (PVDS)

The PVDS (Duncan et al., 2009) was used to assess the participants' self-perceived vulnerability to disease. This scale consists of 15 items; one subscale assesses beliefs about one's own susceptibility to infectious diseases (perceived infectability [PVD-PI]; 7 items with $\alpha = 0.83$); the second subscale assesses emotional discomfort in contexts that suggest an especially high potential for pathogen transmission (germ aversion [PVD-GA]; 8 items with $\alpha = 0.64$). Items were rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Negatively worded items were scored in reverse order. An additional item that precisely estimate the number of infectious diseases in past year (How many times were you contaminated by infectious disease [e.g. cold, influenza, etc.] during the last year?) modified according to Prokop et al. (2010a,b,c) was used to examine actual vulnerability to infectious diseases.

2.2.2. Pathogen disgust scale (PDS)

The PDS ($\alpha = 0.7$) scale was adopted from Tybur et al. (2009). This scale is designed to measure disgust elicitors caused by sources of various pathogens (e.g., stepping on dog poop). Participants responded to items on a five-point Likert scale from not at all disgusting (1) to extremely disgusting (5).

2.2.3. Human parasite avoidance scale (HPAS)

The HPAS is a self-constructed, three-item scale designed to measure propensity to self-grooming in humans. Our restriction to *propensity* rather than normal self-grooming was made because social norms may inhibit these behaviours during educational process where the research was carried out. Thus, participants were expected to partially or completely supress self-grooming or other forms of hygiene. Known similar scales (e.g., Prokop and Fančovičová, 2010, 2011) do not contain grooming behaviour (except for washing hands) and could not be therefore used. The items were: how many times during the last 45 min did you feel a need *to scramble yourself*?, How many times during the last 45 min did you have a feeling that something is *crawling on your body*? (responses for both items were 1 = 0 times, 2 = 1–3 times, 3 = 4–5 times, 4 = 6–7 times, 5 = 8 times and more). The final item was how much do you feel a need to *actually wash your hands*? (1 = absolutely not, 5 = extremely much) modified after Prokop and Fančovičová (2011). Reliability of the HPAS was established before and after the treatment (see Section 3).

2.3. Procedure

The research was carried out in two sessions with two separate groups of students. The first part of the experiment was conducted in November 2013 (session 1) with two groups of students. The second part of the experiment with the same two groups of students was conducted in December 2013 (session 2). Both sessions were realized on the same time of day (one group in the morning, second group in the afternoon on session 1 and the same on session 2). On session 1, all students received the PVDS and PD questionnaires. Then the experimenter (PP) lectured an oral presentation about the skeletal and circulatory system (45 min each with one 10 min break). After the presentation the HPAS was administered to students. On session 2, students received oral presentations from the same experimenter about hormones and about

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