ARTICLE

Parasites, minds and cultures

Could the most human of qualities owe their existence to tiny, mindless organisms? **Justin H. Park** and **Mark Schaller** investigate

Parasites have had profound effects on human evolution. Recent research implicates the existence of a set of psychological adaptations that serve as a first line of behavioural defence against contact with parasites – the 'behavioural immune system'. The ordinary operation of the behavioural immune system has provocative implications for many different kinds of phenomena that are of interest to psychologists – including stigmatisation and prejudice, physical attractiveness and mating behaviour, and the origins of cultural diversity.

questions

What might be some evolutionarily adaptive reactions to people with infectious diseases?

How has our long history of living with parasites shaped how we think, feel and behave?

resources

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The littlest of things can have huge evolutionary significance. Before publishing *The Origin of Species* Charles Darwin spent years studying barnacles. If Darwin were alive today, we suspect that he would be mightily impressed by what we now know about the evolutionary impact of much smaller and more ancient things: viruses, bacteria, protozoa and intestinal worms that parasitise bigger organisms.

Where there is life, there are parasites – in immeasurable abundance. These parasites can seriously impair the health and reproductive fitness of the organisms that they infect. All living animals – including humans – are around today because their ancestors evolved ways to elude parasites, generation after generation. This evolutionary process has left huge footprints that researchers are just starting to discern (Ridley, 1993; Zimmer, 2000; Zuk, 2007).

The evolution of anti-parasite defence systems

Parasites don't look or act like lions or tigers, so people don't usually think of them as predators. But, in a sense, they are. Parasites attach themselves to the body of a host and exploit bodily resources in order to reproduce. In doing so, they can harm that host, sometimes lethally. As a consequence, host species have evolved elaborate anti-parasite defence systems.

We are all familiar with one of these defence systems: the immune system. The immune system is an amazingly sophisticated suite of adaptations, designed by natural selection to detect parasites that intrude on our bodily tissues and – once those parasites are detected – to mobilise physiological means of repelling, killing or neutralising them.

While an immune system has undeniable benefits, it has undeniable drawbacks. Mounting an immune response consumes considerable metabolic resources, which may result in temporary debilitation (e.g. fatigue, exhaustion) while the parasitic infection is being fought. Specific kinds of immune responses (e.g. fever) can be further debilitating. Most importantly, the immune system is incapable of the simplest form of defence: preventing parasites from coming into contact with the body in the first place.

It has thus been suggested that animals evolved an additional system of defence that enables them to physically avoid germy things and other infected hosts. This system is designed to employ perceptual cues (appearance, odour, etc.) to detect the presence of infectious parasites in other things – including other individuals. In some animals – including humans – the detection of such cues may trigger aversive emotional and cognitive responses that motivate behavioural avoidance. This behavioural mechanism offers a first line of defence against disease-causing parasites and hence has been called the 'behavioural immune system' (Schaller & Duncan, 2007).

Psychological implications of the behavioural immune system

Lots of animal species show evidence of perceptual sensitivity to cues of parasitic infection in other members of their species and of consequent behavioural avoidance (Goodall, 1986; Kavaliers & Colwell, 1995; Kiesecker et al., 1999). Humans are no exception. Recently, there has emerged a body of research exploring the implications of the behavioural immune system for human emotion, cognition and behaviour. For instance, there is evidence suggesting that the

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emotion of disgust evolved to serve as an affective signal of parasite infection (Curtis et al., 2004; Oaten et al., 2009). This line of evidence not only has implications for psychologists' understanding and measurement of disgust, but also may help to explain why feelings of disgust influence moral judgements and interpersonal relations (e.g. Tybur et al., 2009).

Additional implications are emerging as well. In the sections that follow, we briefly review three particularly intriguing sets of findings that illustrate the wide-ranging psychological implications of the behavioural immune system. One set of findings pertains to the psychology of stigmatisation and prejudice; a second set pertains to the psychology of physical attractiveness and mating behaviour; and a third set bears on the origins of culture and cross-cultural differences.

Stigmatisation and prejudice

Because most parasites are virtually invisible, people must rely on superficial cues (e.g. anomalous physical features) to detect their presence. Because cues are imperfectly correlated with parasitic infection, there emerges a signal-detection problem in which errors are inevitable. Any attempt to limit the number of 'false-positive' errors (erroneously inferring the presence of parasites where there are none) inevitably leads to an increase in 'false-negative' errors (erroneously inferring the absence of parasites where, in fact, they exist), and vice versa.

Historically, people suffering from diseases such as leprosy have been highly stigmatised

How is this signal-detection problem resolved? An answer is provided by the 'smoke detector principle' (Nesse, 2005). A smoke detector is typically calibrated to be supersensitive to anything that superficially resembles smoke, in order to minimise the likelihood of failing to register the presence of a house fire (a very costly false-negative error). The inevitable consequence – which people happily tolerate – is lots of (relatively less costly) false-positive errors: the smoke detector may sound its alarm anytime someone is harmlessly braising a steak or boiling a pot of pasta.

A similar set of functional priorities applies to the behavioural immune system. In order to avoid the highly costly consequences that may follow from contact with parasites (e.g. illness, death), the system is calibrated to be supersensitive to superficial cues (e.g. a wide range of morphological or behavioural anomalies) connoting the possible presence of parasites. The result is that the behavioural immune system may sound its alarm (and trigger aversive affective, cognitive and behavioural responses) whenever a person perceives someone else whose superficial physical appearance or behaviour deviates from whatever prototype people perceive to be 'normal'.

There is another important consideration to keep in mind. Just as the activation of the 'real' immune system has costs, the activation of the behavioural immune system has costs as well (e.g. consumption of metabolic resources). Therefore, the behavioural immune system is likely to be especially supersensitive and especially likely to trigger aversive responses when its benefits are especially likely to outweigh its costs; that is, whenever perceivers are, or merely perceive themselves to be, especially vulnerable to the transmission of disease.

This line of reasoning has two broad implications for our understanding of stigmatisation and prejudice. First, the ordinary operation of the behavioural immune system may contribute to the stigmatisation of people whose appearance deviates from some subjective sense of normalcy. Second, prejudicial responses to these people are likely to be exaggerated under conditions in which perceivers are (or merely perceive themselves to be) especially vulnerable to parasite transmission.

This analysis thus helps us understand why people suffering from some diseases (such as leprosy) have historically been more highly stigmatised than people suffering from other diseases (which may be more virulent and infectious, but are associated with less overt morphological anomalies).

More provocatively, this analysis suggests that psychologically similar prejudicial responses may be directed against individuals who aren't actually suffering from any infectious disease whatsoever – and that these prejudicial responses vary depending on the extent to which perceivers feel vulnerable to parasite transmission.

In our own labs, we have conducted studies to assess the extent to which people are especially likely to implicitly associate the concept 'disease' (as well as other aversive cognitions) with specific categories of people. One set of studies implicated the behavioural immune system in implicit prejudices directed against people with superficial facial birthmarks and physical disabilities (Park et al., 2003; Schaller & Duncan, 2007). Another set of studies implicated the behavioural immune system in prejudicial responses to obesity (Park et al., 2007). Among other findings, we discovered that when the threat of

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parasite transmission is made temporarily salient (e.g. with a brief slideshow depicting germs and their presence all around), people are especially likely to implicitly associate obese individuals with the semantic concept 'disease'. These findings not only help to illuminate the causes of weight-based prejudice, they also illustrate the point that the behavioural immune system responds not to rational assessments of parasite infection (after all, parasite infection is more likely to lead to weight loss than weight gain), but instead to relatively crude and wide-ranging perceptual cues.

Ethnocentrism and xenophobia also appear to be rooted, in part, in the irrational operation of the behavioural immune system. People who feel especially vulnerable to parasite transmission are especially likely to favour contact with familiar rather than foreign peoples (Faulkner et al., 2004). A particularly provocative finding was reported by Navarrete et al. (2007): women in the first term of pregnancy – whose bodies are naturally immunosuppressed – show especially high levels of xenophobia and ethnocentrism.

Physical attractiveness and mating behaviour

Thus far, we have emphasised the point that the behavioural immune system is sensitive to superficial cues connoting possible parasite infection. This point has a logical flip side as well: in the context of close interpersonal relationships, the behavioural immune system is likely to be sensitive to superficial cues connoting resistance to parasite infection. A body of research suggests that subjective appraisals of physical attractiveness may serve as such a cue.

We all know that physical attractiveness is a rather important determinant of a person's sexual allure. That is hardly news. But the story becomes a lot more interesting when we dig deeper and ask more specific questions. Exactly which morphological features are considered to be subjectively attractive? And why exactly do those features (rather than others) connote attractiveness?

Answers to that first question include bilateral facial symmetry and feature prototypicality (Fink & Penton-Voak, 2002; Rhodes, 2006). People with more symmetrical faces are perceived to be more attractive, as are people whose specific facial features are closer to the population average (e.g. a nose that is neither especially big nor small, but is just right).

But why do these particular features inspire subjective appraisals of attractiveness? An abundance of research in the behavioural ecology literature suggests that, for many species, bilateral symmetry and phenotypic prototypicality may be indicators of a healthy immune system (e.g. Thornhill & Møller, 1997). Applied to humans, the implication is that a subjective appraisal of physical attractiveness may serve as a crude indicator of the extent to which another person is resistant to parasitic infection.

Additional, somewhat more sophisticated evolutionary logic provides an explanation for why women are attracted to 'masculine' facial features (e.g. strong jaws) that are associated with higher levels of testosterone (Zuk, 2007). We do not have space here to articulate the evolutionary analysis in detail, so we simply emphasise the bottom line – these facial features may also serve as advertisements to potential mates, and what these features advertise is an especially strong immune system.

> "People with more symmetrical faces are perceived to be more attractive"

Thus, one reason why subjective appraisals of physical attractiveness are so important in the mating game is that these appraisals are helpful in identifying mates who are likely to be, and to remain, free from parasitic infections. There is some evidence that individuals – especially women – who are subjectively perceived to be physically attractive do, in fact, live healthier lives (Weeden & Sabini, 2005). And, among perceivers, it appears that physical attractiveness is easily learned – and then used – as a cue connoting health (Zebrowitz et al., 2003).

This line of reasoning has another interesting implication. If physical attractiveness is an indicator of parasite resistance, then people are especially likely to prioritise physical attractiveness under conditions in which there are more parasites around to contend with. This implication has been tested – and supported – by cross-cultural evidence. In places with more parasites, women show a stronger preference for more masculine faces (Penton-Voak et al., 2004). More generally, regional variation in the presence of parasites predicts cross-cultural variation in the value of attractiveness. In places with historically higher levels of disease-causing parasites, people place a higher value on a potential mate's physical attractiveness (Gangestad et al., 2006).

The origins of cultural variation

We have now entered conceptual territory that may surprise some readers who assume that evolution has no bearing on cross-cultural differences. This assumption is wrong. As we emphasised earlier, evolved psychological mechanisms are highly responsive to the contexts in which people find themselves. Just as the 'real' immune system is more chronically activated under ecological circumstances that put people into more regular contact with parasites, the behavioural immune system is also likely to be hyperactive under ecological circumstances characterised by a higher prevalence of parasites. Thus, to the extent that specific kinds of cognitions and behaviours put people at risk for parasite infection, those cognitions and behaviours are likely to predictably vary across human populations, depending on the prevalence of parasites in the local ecology. This has profound implications for our

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understanding of cross-cultural differences.

Consider, for example, differences in sexual behaviour. Sexual contact has obvious benefits for reproductive fitness, but also potential costs, as it puts people at higher risk for parasitic infections. The ratio of benefits to costs varies, depending on the actual prevalence of parasites in the local ecology. This implies predictable cross-cultural differences in the extent to which people are 'restricted' rather than 'unrestricted' in their sexual behaviour. Indeed, in regions characterised by a higher prevalence of parasites, people (especially women) are more restricted in their sexual behaviour (Schaller & Murray, 2008).

The same logic applies to personality traits such as extraversion and openness to experience. These traits may confer specific kinds of benefits (contact with new friends and new technologies). But both are also likely to be associated with a specific kind of cost: greater exposure to parasites. These costs are greater in regions with a high prevalence of parasites. The implication, supported by empirical evidence, is that in regions characterised by a higher prevalence of parasites, people are less extraverted and less open to new ideas (Schaller & Murray, 2008).

Many other cultural norms may also serve as buffers against parasite transmission (especially norms pertaining to hygiene and food preparation; e.g. Sherman & Billing, 1999). This has implications for the emergence of broader systems of cultural values, such as those implicated by the individualism–collectivism dimension that is so important to the study of human cultures. Collectivism is defined in part by an emphasis on conformity to existing traditions and norms, whereas individualism is defined in part by a tolerance for deviance. Individualism therefore connotes a greater risk for parasite transmission. It follows that collectivistic value systems are especially likely to emerge and persist in regions characterised by a high prevalence of parasites, whereas individualistic value systems are most likely to take hold in regions with a relatively low level of parasites. This appears to be the case (Fincher et al., 2008).

These and other findings (e.g. Thornhill et al., 2009) suggest that many important cross-cultural differences may owe their existence, in part, to parasites and to the context-contingent responses of the behavioural immune system that evolved in response to parasites.

Direct behavioural effects of a parasite?

The brain parasite *Toxoplasma gondii* is mostly harmless and surprisingly common, infecting over 50 per cent of people in some countries. It infects other mammals too (e.g. mice, cats, dogs, deer), and in these other animal populations, *T. gondii* is known to have effects on the behaviour of its hosts (Webster, 2007). Might it have effects on human psychology and behaviour? Maybe. There is some evidence, for instance, that the prevalence of *T. gondii* infection in human populations is correlated with cross-cultural differences in traits such as neuroticism and uncertainty avoidance (Lafferty, 2006). These results are probably best described as preliminary, but they are provocative. And they highlight yet another way in which human psychology may be shaped by the presence of parasites.

Envoi

We have focused here on how the human mind is adapted to minimise the threat of parasite infection and on the psychological consequences of those adaptations. But this is not the only means through which parasites may influence human psychology. A rather different line of research explores the possibility that some parasites – when they do successfully infect human beings – may directly manipulate human cognition and behaviour (see box for an example).

Scientific progress is often a humbling affair that demands abandonment of cherished ideas: we are not at the centre of the universe, our bodies are not animated by vital essence, our minds are not ethereal spirits. Judging by the tenacious resistance even today, it would seem that Darwin's insights instigated some of the most profound – and humbling – pieces of scientific work to date. Science marches on, because the price of forfeiting cherished ideas is offset by the benefit of deeper, fuller understanding of the world and our place in it.

The recent advances regarding the evolutionary impact of parasites (of which only a sliver was described in this article) may demand further changes in views. Perhaps nothing is as humbling as learning that the most human of qualities – patriotic feelings, appreciation of beauty, sexual passion, cultural diversity – may owe their existence to tiny mindless disease-causing organisms. But by giving parasites their due attention, we are beginning to get a handle on some of the oldest questions and discovering that psychology is even more profound than it first appears.

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