The Toxic Personality of Toxoplasma gondii

By Karolina Lempert

“It is amazing that a single-celled organism is capable of such selfishness; its ends, like those of all of nature, are survival and reproduction, and it will do all it can to achieve them.”

When it comes to manipulation and exploitation, parasites are the professionals. From hairworms that induce their grasshopper hosts to commit suicide, to wasp larvae that change the way spiders build their webs, these generally miniscule creatures can have sizeable effects on the behavior of other organisms.

One such extraordinary parasite is the protozoan, Toxoplasma gondii. While the only host in which it can reproduce is the cat, T. gondii can be carried by the vast majority of warm-blooded animals and may even dramatically alter their hosts’ behavior. Some experiments on rats, for example, have concluded that parasite-infected rats display a fatal attraction to their feline enemies (1). Interestingly, these studies have prompted questions about T. gondii’s influence on humans, as the parasite has been found to infect humans ranging from 22% infection rate in the U.K. to 84% in France (1). While the infection only has seriously damaging consequences on those with compromised immune systems – such as fetuses, the elderly, and HIV patients – some research have linked the parasite to symptoms of schizophrenia, changes in IQ, and altered personality. Recently, vaccination strategies have been discussed in the prevention of toxoplasmosis, and perhaps this is necessary. These tiny protozoans may be more mischievous than we think.

The Center for Disease Control and Prevention reports that more than 60 million people in the United States may be infected with T. gondii. Contamination may happen in a number of ways, including ingestion of food or water that may contain feces of infected cats, or ingestion of raw or undercooked meat. Most people infected with T. gondii are unaware of it. However, individuals with compromised immune systems may experience severe symptoms, including damage to the brain, eyes or other organs. Infants may be born with severe toxoplasmosis if their mothers were infected with the parasite during or shortly before pregnancy. In fact, women are encouraged to get tested for T. gondii exposure if they are pregnant or planning to conceive. People with HIV/AIDS, those taking certain types of chemotherapy and those who have recently received an organ transplant are at risk for severe symptoms and should take the proper precautions to avoid infection. There are medications to treat the disease, but in most people, the minor symptoms go away within a matter of weeks (2). Hence, even though toxoplasmosis has a high prevalence, because of its usually insignificant consequences, vaccination has never been considered an obligatory measure.

Toxoplasma gondii and Attraction: The Rodent Studies

The mechanism of T. gondii infection and subsequent manipulation of host behavior is quite interesting and worthy of note. In a fascinating study on rats, Berdoy, Webster, and MacDonald found that the parasite targets the brain of rats for infection and manipulates the behavior of this intermediate host in order to increase the rats’ chances of being predated by cats, the definitive
real-life setting, rats infected with *T. gondii* would be at the behest of their predators. Yet, how does *T. gondii* infection alter host behavior? One proposed mechanism involves the neurotransmitter serotonin, which is implicated in controlling both anxiety and mood in humans. The parasitic infections effect a calming of the serotonin-sensitive predator-induced response, thereby reducing the anxiety-related anticipatory defense reactions of a host to a predator (1). It is amazing that a single-celled organism is capable of such selfishness; its ends, like those of all of nature, are survival and reproduction, and it will do all it can to achieve them.

Personality and Parasites

Still, what do these experiments have to do with us? After all, humans are a dead-end host for the parasite — no one is likely to be ingested by a cat! However, Dr. Nicky Boulter, an infectious disease researcher at the Sydney University of Technology, reported several interesting findings about the parasite’s effects on humans in Australasian Science in December 2006. Personality factor questionnaires and simple cognition tasks yielded significant differences between infected and uninfected groups of humans (4). According to some of these studies, men infected with *T. gondii* have lower IQs, shorter attention spans, and achieve a lower level of education than uninfected men. They are more likely to take risks, be more independent, suspicious, jealous and morose (3). These traits make them overall less attractive to women. Infected women, on the other hand, tend to be more attractive to men because they are more outgoing, friendly and promiscuous (3). Another study showed that people who carry *T. gondii* but do not show symptoms are...
on the human-parasite relationship, it is not difficult to imagine that *T. gondii* would prefer rats with decreased reaction times when faced with their predators. Although humans are a dead end host for *T. gondii*, the parasite may still induce similar effects on us as on mice.

### Cultural Differences?

If human carriers are really all that unusual, what can we make of the fact that different countries have different levels of infection among their populations? U.S. Geological Survey researcher Kevin Lafferty analyzed preexisting data on Toxoplasma prevalence and mean trait levels in 39 countries. He found a significant linear correlation between latent Toxoplasma prevalence and neuroticism. He found that the parasite seems to explain 30% of the variation in neuroticism levels among countries, 15% of the uncertainty avoidance among Western nations and 30% of the sex role differences among Western nations (5). It is telling that the United Kingdom has the lowest prevalence of the parasite and France has the highest, since the two nations seem to be diametrically opposed when it comes to levels of anxiety. This data could explain much of a society’s preference for or against strict laws, its uncertainty avoidance or lack thereof, and even its valuation of competitiveness versus relationship-building (6).

### Toxoplasma gondii and Schizophrenia

Latent toxoplasmosis may affect behavior, but the effects of acute toxoplasmosis on the brain may be much more severe. Some cases in adults are associated with psychiatric symptoms, such as delusions and hallucinations (7). In three studies of patients having their first episode of schizophrenia, there were statistically significant differences in the antibody levels of anti-*T. gondii* between these patients and the general public (7). Hence it is possible, because of the way that the parasite affects the brain, that *T. gondii* plays a role in the etiology of schizophrenia and similar thought disorders.

Once it enters the body, *T. gondii* crosses the intestinal or placental epithelium (depending on the mode of infection) as a free parasite and enters circulating cells such as macrophages or dendritic cells. It may use such cells to gain access to privileged sites such as the brain. The parasite may form cysts within a variety of brain cells, including microglia, astrocytes and neurons (8), which are usually dysfunctional in schizophrenia. Numerous studies have shown that the progression of schizophrenia starts in the early stages of development, which is consistent with the fact that *T. gondii* often infects the pre-natal brain. The parasite may even alter gene expression and influence whether or not a genetic predisposition to schizophrenia will manifest itself (7).

There is some epidemiological evidence linking *T. gondii* with schizophrenia. France was reported to have first-admission rates of schizophrenia 50% higher than those in England (7). Also, two studies found that people with

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Figure 2. According to some studies, infected men have lower IQs, shorter attention spans and achieve a lower level of education than uninfected men. They are more likely to take risks, be more independent, suspicious, jealous and morose (3). These traits make them overall less attractive to women. Infected women, on the other hand, tend to be more attractive to men because they are more outgoing, friendly and promiscuous (3).

2.7 times more likely than uninfected people to be involved in car accidents – as a driver or pedestrian (3). Taking the rodent studies into account, these results make sense. Infected rats were obviously less risk-averse; the case is probably the same for humans. While the men were considered less attractive than the women, they showed similar characteristics. Both groups seem to be less neurotic, less inhibited, and more likely to take risks. The car accident statistic supports this view further, because people who get into car accidents may be the ones who cross the street knowing that there is a car coming at top speed – the risk-takers.

It is likely that *T. gondii* affects our serotonin response as well, since we are simply intermediate hosts to this protozoan. This is intuitive; if humans were continually being preyed upon by some terrible creature, who would be more likely to be eaten if not the outgoing, risk-taking, infected individuals? In addition, some studies have shown decreased psychomotor abilities in humans latently infected with *T. gondii* (4). While this has no effect

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schizophrenia had a greater exposure to cats in childhood, which would expose them to greater levels of infectious *T. gondii* (7). However, there is still a need for more research to determine any level of causality in this domain.

The Vaccination Issue

Vaccination strategies against *T. gondii* have focused on three different approaches, each corresponding to a mode of transmission of the parasite (9). The first approach aims to protect against congenital toxoplasmosis, ensuring the parasite is not passed on to the offspring, result in stillbirth or spontaneous abortion. The only vaccine to prevent congenital transmission is a live vaccine that is considered fairly risky for human use. A second option is vaccination of intermediate hosts to reduce *T. gondii* tissue cyst levels, which would decrease our intake of the parasite through undercooked meat. Finally, we can vaccinate to prevent parasite oocysts, or zygotes, from forming in cats and contaminating the environment. A mutant strain of *T. gondii* which only undergoes partial development in the cat is being investigated as a possible control mechanism (9). In any case, *T. gondii* may be simple enough to treat and control, but it is very difficult to kill completely. In most cases, even when someone has been treated for the parasite, a few cysts will remain in the body for life.

The best vaccination results are achieved when a live vaccine is used, but using live vaccines in humans always carries some risks. In addition, like many other parasites, *T. gondii* can quickly develop resistance to vaccination (9). Is it worth all the trouble to reduce infection? After all, most symptoms of toxoplasmosis are very mild, and more serious symptoms can often be readily treated. Furthermore, would vaccinating everyone change the entire level of causality in this domain.

The Toxic Traits of Toxoplasma gondii

*T. gondii* is a typical parasite in many ways. It uses other organisms solely for its own benefit, altering their bodily structures and functions to suit its own needs. It is manipulative from the start; first, using macrophages to get to the brain, then changing behavior so that its host harms itself—in the case of rats, allowing itself to be eaten by a cat. *T. gondii* is unique, however, in how widespread and seemingly harmless it is to most humans. Should we be worried about unforeseen personality shifts and other consequences? Indeed, evidence for a link between *T. gondii* and schizophrenia is suggestive, and *T. gondii* infection in children is particularly dangerous. Also, while outgoing personality traits may seem attractive, they may be dangerous in an environment full of risks. On the other hand, maybe *T. gondii* helps make us who we are. Subclinical toxoplasmosis may simply contribute to one’s personality. It may be no wonder “cat people” are so friendly.

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References: