# How mind-controlling parasites can get inside your head

April 4 2016, by Alex Ford, University Of Portsmouth

Credit: AI-generated image (disclaimer)

Imagine that pesky tabby cat has been pooing in your backyard again. Unbeknown to you, it has transferred some of the parasite spores it was carrying onto your herb garden. Unintentionally, while preparing a tasty salad, you forget to wash your hands and infect yourself with the *Toxoplasma gondii* spores. For months you display no symptoms, then after six months you are driving your car more aggressively, taking chances in road junctions and generally filled with more road rage as you angrily gesticulate with fellow drivers. Could all this be linked to that tasty salad?

*T. gondii* is a fascinating protozoan parasite which, like many similar organisms, needs to move between several different host species in order to fully develop and reproduce. As such, it appears to have evolved clever methods to make transmission between hosts more likely. For example, studies have found that once rats – intermediate hosts – are infected they display less caution towards cats – the final stage hosts – and so the parasite is more likely to be passed on.

An increasing number of studies suggest humans known to be infected with these parasites could be more susceptible to schizophrenia, bipolar disorder, aggression and even increased suicide. Studies have even suggested you are two to three times more likely to have a car crash if your blood tests positive for the parasite. This is particularly striking when it has been predicted that 30%-50% of the worldwide population may carry the parasite.

## Chicken or egg?

Very often criticisms of these studies come down to a chicken and egg question. Correlation doesn't necessary mean causality. Are those aggressive, fast-driving people or those with behavioural conditions more likely to catch the parasites, or does the parasite cause these behavioural traits?

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Many of the studies were done retrospectively rather than looking at someone's behaviour before and after they became infected with the parasites. A more recent study found there was no evidence for a link between infection and abnormal behaviour, in a cohort of 1000 people followed from birth. So for now, we can't say for sure whether your road rage really was linked to your salad.

What we do know is that there are plenty of examples in wildlife where parasites can manipulate the sex, growth, maturation, habitat and behaviour of their hosts. Hair worms, for instance, complete their lifecycle in a river or stream and appear to make their hosts – crickets – attracted to water.

The effects of the parasite don't stop there, either. The hapless crickets can provide fish with an alternative food source to their usual diet of aquatic invertebrates and, for parts of the year, can form a substantial part of their diet. So manipulating parasites can be important to maintaining healthy ecosystems.

Some ant species infected by trematode flukes are manipulated in a way that makes them cling to the tops of blades of grass, which means they're more likely to be eaten by sheep. This enables the fluke to complete its life cycle in the sheep.

A type of barnacle parasite known as a rhizocephalan, which eats its crab host from the inside out, is known to feminise its male hosts by castrating them. Scientists have suggested they are then more likely to look after the parasite sac that bursts through their abdomens, much like a female would tend to her eggs.

## Switching on genes

Through advances in molecular biology, we are increasingly working out how these parasites can change behaviour by altering gene expression – the way genes can be turned on or off. For example, work in our labs at the University of Portsmouth is trying to uncover the mechanism that enables a newly discovered species of trematode parasite make their shrimp-like (amphipods) hosts more attracted to the light.

These amphipods would prefer to be hiding under seaweed on our shores, escaping their bird predators as the tide recedes. By chemically mapping the brains of infected shrimp, scientists have discovered that parasites somehow altered the shrimps' serotonin, a mood neurotransmitter found throughout the animal kingdom. Our recent studies have indicated that infected shrimp have subtle alterations to their serotonin receptors and the enzymes that produce serotonin.


Trematodes: little blighters. Credit: Josef Reischig/Wikimedia Commons, CC BY-SA

Other studies have shown amphipods hosting similar parasites are over 20 times more likely to be eaten compared to non-infected specimens. Again, this highlights the often-overlooked importance of brain-bending parasites in the natural order of food webs.

We often think we must have discovered all the species possible in well-studied locations such as the UK, but many fascinating new manipulating parasites are yet to be discovered on our doorsteps. Our knowledge of how these brain-bending parasites interact with human species will no doubt develop more strongly over the next decade.

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