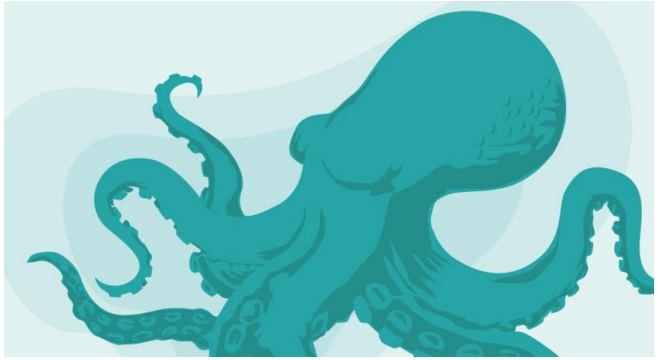
Introduction to Cognitive Science



Dr. Mark Miller

MONASH University
UNIVERSITY OF TORONTO
CHAIN





MINDS



MINIMAL MINDS

Bryce Huebner, Department of Philosophy, Georgetown University

> All the virus wants to do is break inside a healthy cell, steal its genetic machinery, and start profiting from the intrusion. To stop a thief, you need to throw a monkey wrench—or several—into his plans. That's exactly what anti-HIV drugs, known as antiretrovirals (ARVs) are designed to do.[1]

We sometimes speak, in a "loose and popular" way, as though viruses have human-like beliefs and desires. It comes as no surprise when such intentional idioms occur in the hyperbolic prose of the mainstream media. However, it is more surprising when scientific discourse relies on anthropomorphizing claims when discussing the nature of viruses. In recent papers, it has been suggested that if the HIV "virus wants to resist AZT, it needs to make a specific mutation at codon 215 and at another position, such as position 41"[2] and that the Hepatitis C virus must try to coexist with its host by reducing its visibility.[3] Yet, philosophical reflection suggests that although we *can* use intentional idioms whenever we find an entity that exhibits robust and systematic patterns of behavior, a plausible theory of mentality should not treat viruses as even minimally minded. After all, viruses are nothing more than packets of RNA (or sometimes DNA) encased in protein. So, although they are likely to be mechanical and complex, the type of complexity that we find in viruses is unlikely to implement the computational and representational capacities that are necessary for being in cognitive states or carrying out cognitive processes. Viruses are not the kind of entities that can *want to* threaten our wellbeing; they do not *make plans* and *adopt deceptive strategies* for navigating our immune systems; and they have not *learned* to outsmart our best anti-virals. Although many viruses exhibit systematic and predictable patterns of behavior, we can and should treat them as complex biological robots.[4] However, difficult theoretical issues arise in providing a more general strategy for distinguishing genuine mentality from witless mechanical behavior.

In this chapter, my goal is to establish the *minimal conditions* that must be satisfied for an entity to be in cognitive states or carry out cognitive processes. I begin with an examination of the philosophical assumptions that underlie the Cartesian assertion that linguistic capacities are necessary for genuine mentality. I argue that the explanatory resources provided by contemporary cognitive science undercut the force of these assumptions and provide compelling reasons for thinking that even invertebrates (e.g., crickets, cockroaches, termites, and honeybees) possess genuine cognitive capacities. While this claim may seem familiar, I extend the arguments for treating invertebrates as possessing *minimal minds* in two ways. First, I argue that minimal mindedness is likely to be realized by computations that operate over non-linguistic representations; thus, minimal cognitive states and processes are unlikely to be beliefs or desires. Second, I argue that the theoretical and empirical evidence that supports treating invertebrates as minimally minded also warrants the more intriguing conclusion that some sorts of *collective behavior* are best explained in terms of collective mental states and processes;

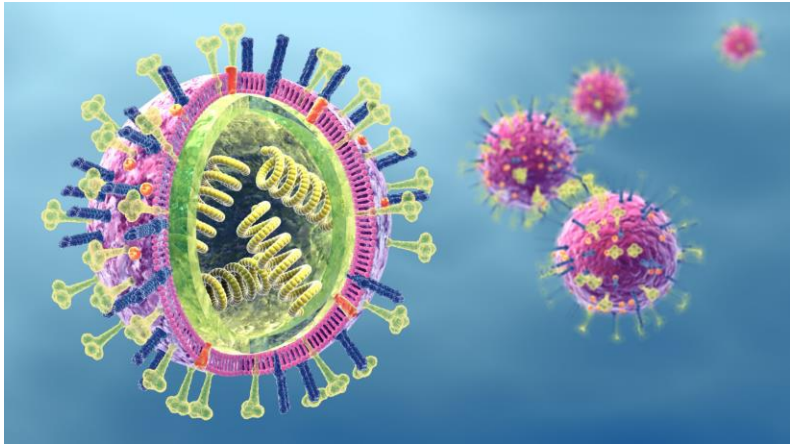
---

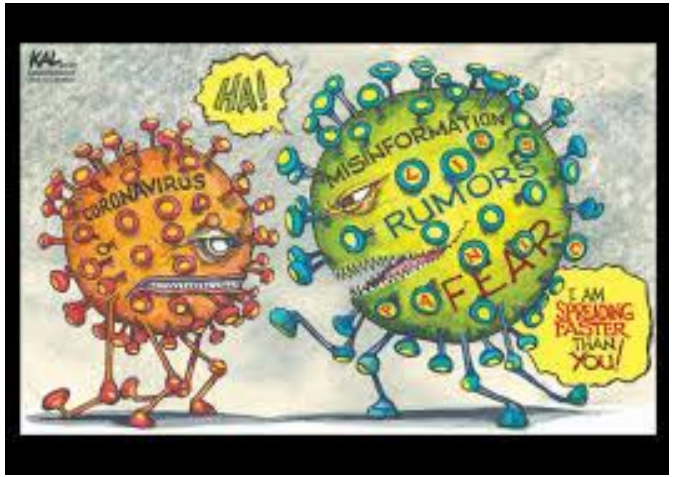
[1] Alice Park, "Beefing Up the Arsenal Against AIDS," *Time Magazine* (2007), http://www.time.com/time/health/article/0,8599,1595377,00.html (accessed August 9, 2010)

[2] David Ho, "Therapy of HIV Infections: Problems and Prospects," Bulletin of the New York. Academy of Medicine, 73 (1996), pp. 37.

[3] Vito Racaniell and Barbara Reherman, "Hepatitis C Virus: Infection When Silence is Deception," *Trends in Immunology* 24 (2003): 456-64.

[4] Cf. Daniel C. Dennett, *Kinds of Minds* (New York: Basic Books, 1996), pp. 21ff.

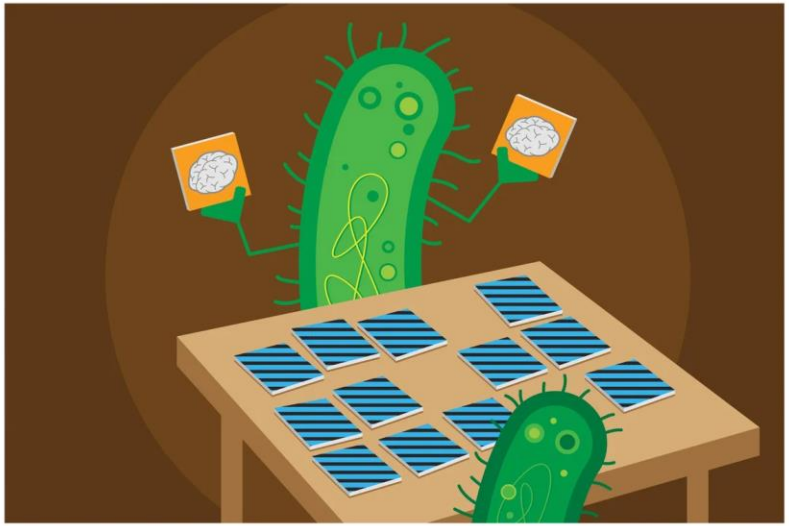




Viruses are often described as having intentionality – “The virus “**wants**” to invade a host cell, hijack its machinery, and reproduce”.

It lacks the **representational** and **computational** machinery needed for genuine cognition

A virus’s actions are fully determined by its genetic design, **with no flexibility or adaptation based on environmental feedback**.



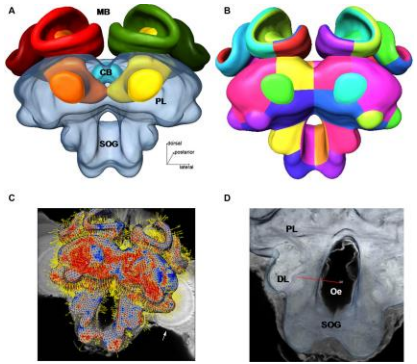


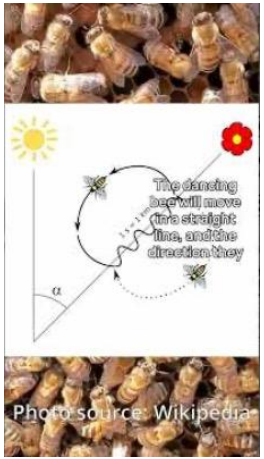
Bacteria have shown themselves capable of semi-autonomous functional **reorganization** in **response** to environmental stressors

The bacteria are **not internally complex enough** to **store** and **redeploy** skills from past experiences in novel situations. Every time bacteria face a challenge, they have to attempt functional reorganization afresh

However, there is **no system for generalizing past learning to new contexts**, and they **lack anything like the sophisticated neural circuits** seen in animals that allow for robust representational capacities… **Or can they?**

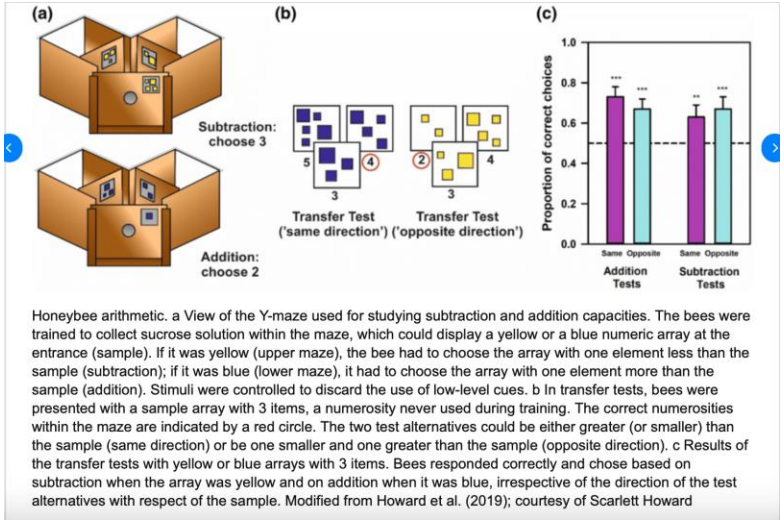






Honeybees exhibit behaviors that suggest they possess a rudimentary capacity for representing their environment. They use the famous **waggle dance to communicate** not just the presence of food, but its distance and direction relative to the hive

Bees can **construct cognitive maps** that encode **spatial relationships** and rely on geometric **representations of space**. Honeybees can also **recalibrate their internal maps** using landmark information encountered during their travels.



Honeybee arithmetic. a View of the Y-maze used for studying subtraction and addition capacities. The bees were trained to collect sucrose solution within the maze, which could display a yellow or a blue numeric array at the entrance (sample). If it was yellow (upper maze), the bee had to choose the array with one element less than the sample (subtraction); if it was blue (lower maze), it had to choose the array with one element more than the sample (addition). Stimuli were controlled to discard the use of low-level cues. b In transfer tests, bees were presented with a sample array with 3 items, a numerosity never used during training. The correct numerosities within the maze are indicated by a red circle. The two test alternatives could be either greater (or smaller) than the sample (same direction) or be one smaller and one greater than the sample (opposite direction). c Results of the transfer tests with yellow or blue arrays with 3 items. Bees responded correctly and chose based on subtraction when the array was yellow and on addition when it was blue, irrespective of the direction of the test alternatives with respect of the sample. Modified from Howard et al. (2019); courtesy of Scarlett Howard





This ability to **learn from past experiences** and **apply that learning in novel contexts** points to the existence of an **internal representational system**

This **decision-making process** shows that the bees were engaging in **a form of cognitive evaluation** that required **integrating multiple sources of information** about their environment

However, these representations are still **tightly coupled to their sensory inputs**—they don't form abstract, decoupled representations in the way humans do.

A minimal mind requires that an entity:

1.Possess internal states and processes that have the function of **adjusting the entity's behavior** in ways that allow it to cope with features of its environment in ways that are **not fully determined by the design of the system**;

2.These states and processes must be **capable of standing-in for various features of the environment** that are significant for the system, and they must be capable of doing so even **in the absence of immediate environmental stimuli**;

3.These states and processes must be **part of a larger representational scheme t**hat allows for a variety of possible contents to be represented (in a systematic way) by a corresponding variety of possible representations; and,

4.There **must be norms governing** the proper production, maintenance, and use of these representations under various environmental conditions.



A minimal mind requires that an entity:

1. Possess internal states and processes that have the function of adjusting the entity's behavior in ways that allow it to cope with features of its environment in ways that are not fully determined by the design of the system;

Honey bees exhibit flexible foraging strategies, **adjusting their behavior based on factors such as the availability of food sources, weather conditions**, and the needs of the hive.

They use internal processes to modulate their activities, such as choosing when to forage or stay in the hive, in a way that **isn't strictly determined by genetic programming or their immediate sensory input.**

Their decision-making in foraging can be **influenced by past experiences**, such as learning which flowers offer the best nectar, rather than being purely reactive.



A minimal mind requires that an entity:

2. These states and processes must be capable of standing-in for various features of the environment that are significant for the system, and they must be capable of doing so even in the absence of immediate environmental stimuli;

Honey bees **use waggle dances** to communicate the location of food sources to other bees in the hive.

Waggle dance **encodes information about direction, distance, and quality of a food source**, allowing bees to understand and act on this information even when the food source is **not immediately present**.

This dance serves as an **internal representation that stands in for various features of the environment**, helping the hive collectively navigate toward resources without immediate sensory input.



A minimal mind requires that an entity:

3. These states and processes must be part of a larger representational scheme that allows for a variety of possible contents to be represented (in a systematic way) by a corresponding variety of possible representations; and,

Structured Communication: The **waggle dance is a systematic form of representation** where the angle of the dance relative to the hive represents the direction of the food source in relation to the sun, and the length of the waggle indicates distance.

Variety of Representations: This scheme allows honey bees to convey a range of information about multiple potential food sources, indicating that their **representational system can accommodate a variety of contents**.



A minimal mind requires that an entity:

4. There must be norms governing the proper production, maintenance, and use of these representations under various environmental conditions.

Proper Production and Use of Representations: There are **norms governing how the waggle dance** is performed and interpreted within the hive. For example, the **precision and accuracy of the dance** are crucial to its effectiveness in guiding other bees to food sources.

Adaptive Adjustments: Bees **adjust their dance** based on environmental conditions like the **position of the sun or wind patterns**, showing that they have norms for when to modify their communication based on changing circumstances.

Error Detection and Correction: Bees can also **update their internal maps** and foraging patterns **if the environmental cues they relied upon change**, indicating a capacity for maintaining and adapting their representational schemes.



A minimal mind requires that an entity:

1.Possess internal states and processes that have the function of **adjusting the entity's behavior** in ways that allow it to cope with features of its environment in ways that are **not fully determined by the design of the system**;

2.These states and processes must be **capable of standing-in for various features of the environment** that are significant for the system, and they must be capable of doing so even **in the absence of immediate environmental stimuli**;

3.These states and processes must be **part of a larger representational scheme** that allows for a variety of possible contents to be represented (in a systematic way) by a corresponding variety of possible representations; and,

4.There **must be norms governing** the proper production, maintenance, and use of these representations under various environmental conditions.



Peter Carruthers argues, bees can hold representational states like "There is nectar 100 meters east of the hive" and "There is pollen 50 meters west of the hive." However, it's unlikely that they can combine these representations into more complex propositions like "The nectar is further east than the pollen."


ANY
QUESTIONS?

Introduction to Cognitive Science



Dr. Mark Miller

MONASH University
UNIVERSITY OF TORONTO
CHAIN