‘If I only had a brain’: Do you need a brain to be intelligent?

The Brain. It’s the ever elusive organ that has fascinated us since antiquity. And yet the more we come to realise about this bundled blubblery network of nerve cells, glial cells and cerebrospinal fluid, the more questions we have about it. With its grooved surface, like the clints and grikes of a limestone pavement, the brain is central to everything about us. It’s certainly frustrating - with each attempt to simplify its function, its structure or dynamic nature, we begin to appreciate more and more its seemingly unfathomable complexity. The whole organ is quite humbling really.

There are Yellow pages upon Yellow pages of jobs and services that the brain coordinates, cooperates and controls. Many of them we still don’t fully understand. But Intelligence, we might conclude, is one such capability.

Now the complexity of the brain doesn’t just end with its biology. Intelligence, the psychological concept or phenomenon, and more specifically what intelligence exactly entails, is highly complex - or at least highly complicated and confusing. To some, it might appear like we’re closer to living on Mars than we are to ever deciding on a definition for intelligence. As of 2007, there were 70 recorded and widely distributed definitions of intelligence (Leggs & Hutter, 2007)[1]. Renowned psychologist R.J. Sternberg even commented that in the case of intelligence - “There seem to be almost as many definitions of intelligence as there were experts asked to define it”. Oh dear, it seems everyone thinks about it slightly differently. And we haven’t even gotten into the difference between intelligence and cognition. *Is there even a difference? And what about intelligence vs intelligent behaviour, you can’t be one without out displaying the other? How are we even measuring intelligence? Can we do IQ tests on dogs?*

It’s so easy to get bogged down in the semantics of it all. For the purposes of this discussion we’re going to decide on a definition inspired by those 70-odd definitions.

“Intelligence is the capacity to acquire knowledge or information as well as the ability to apply this knowledge to a multitude of scenarios, specifically ones that might require the abstraction of such information for the purposes of reasoning, planning, problem-solving, learning and memory.”

For instance, if we consider intelligence in an academic setting. In order to do well in an exam, you need to have the capacity to acquire knowledge related to whatever topic is on the exam. You also want to actually acquire that knowledge and then be able to draw from it in the exam to answer whatever questions thrown at you.

Later on we’ll get to why the undecided nature of the definition poses a somewhat significant challenge in synthesising all proposed instances of the trait or behaviour.

[1] https://arxiv.org/abs/0712.3329

In humans, we contend that our brain, and perhaps even more specifically, the prefrontal cortex, is attributable to our intelligent capabilities. But what if you didn't have a brain? For Frank's Baum Scarecrow in the Wizard of Oz, this was his very conundrum. He felt hopeful that the great Wizard would fill the hole in his head, so that he might finally scare the crows on his munchkinland farm.

"Who are you?" asked the Scarecrow when he had stretched himself and yawned. "And where are you going?"

"My name is Dorothy," said the girl, "and I am going to the Emerald City, to ask the Great Oz to send me back to Kansas."

"Where is the Emerald City?" he inquired. "And who is Oz?"

"Why, don't you know?" she returned, in surprise.

"No, indeed. I don't know anything. You see, I am stuffed, so I have no brains at all," he answered sadly.

"Oh," said Dorothy, "I'm awfully sorry for you."

"Do you think," he asked, "if I go to the Emerald City with you, that Oz would give me some brains?"

"I cannot tell," she returned, "but you may come with me, if you like. If Oz will not give you any brains you will be no worse off than you are now."

But most living things on this planet get by just fine without one. Brains and nervous systems like ours are only a relatively recent evolutionary development. Brains of all shapes, sizes and capabilities are a hugely widespread feature of the animal kingdom, but what about the other biological kingdoms? If they don't have brains, we animals must be pretty unique. We can do so much precisely because of our brains. Things like eating, sleeping and repeating. Things like knowing the chances of you winning the lotto are slim to none. Things like acting intelligently.

But are animals the only organisms capable of intelligence, and even still are humans the only ones capable? Over less than a decade, it seems that the waters around these questions are getting muddier by the day. More recently it seems a flood of research to suggest otherwise, suggesting intelligence beyond animal systems, some research seems more persuasive than others, some more controversial than others. And herein lies the very question; Do you need a brain to be intelligent?

Basal cognition & Plant intelligence: what is it and what are examples

What is Basal cognition?

Basal cognition is the idea that cognitive traits can be applied to organisms lower in the phylogenetic tree. More interestingly,this applies to single-celled organisms and aneural multicellular organisms suggesting that they, with animals, are also capable of cognitive function

and show hallmarks of intelligent behaviour. What are these proposed hallmarks of intelligence? Proponents of basal cognition suggest learning, memory, problem-solving, communication, decision- making and motivation or goal-orientation as examples of such hallmarks.

Plant intelligence factors into the discussion around basal cognition in the fact that plants also do not have nervous systems or brains, and therefore have traditionally been thought of as unable to act intelligently.

Why have we not noticed these intelligent behaviours up until now? At least in the case of plants, there is the issue of 'plant blindness', which is the phenomenon which explains our own blindness to plant life[2]. This temporal aspect of plant blindness has to do with the fact that plants, for the most part, carry out actions or responses much too slow for us to observe in real-time so it appears at least to us that plants are static and immobile. And I mean in the case of microbes, most are so microscopic that you couldn't see them with the naked eye, not individually at least. Even if you squint really hard!

Okay so we've established what basal cognition is, but what's the evidence for it? Research into basal cognition and plant intelligence has come only recently. Even those in the field consider it still an immature area of study[3], but so far some compelling cases have been made or at least sparked a discussion about these issues.

You'd be hard pressed to find someone who hasn't heard of the Venus flytrap. The carnivorous plant has captured the attention of many because of its mouth-like flytrap which can snap shut, entrapping its entomological prey. What you might not have heard is that the Venus flytrap can count[4]!

Now you're probably wondering how on earth does it do that? The flytrap is made of two lobe structures that hang off the stem of the plant and lie open to form a cup-like shape, not too dissimilar to the cup shape you can make with your own two hands. Now imagine you have some hairs growing out of the palms of both hands. For the flytrap it's these trigger hairs that are key players involved in being able to count. Each time these hairs are touched, say by a fly or by an animal passing by, an action potential is generated. Action potentials in our own nervous system are changes in electrical potential across cell membranes of neurons in a cascading manner from one neuron to the next. These are responsible for transmitting signals up and down the body and perhaps most importantly, to the brain.

In a ted talk a couple of years ago, Neuroscientist and science communicator Greg Gage demonstrated how this electrical signalling can occur in plants too.

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[2] https://www.youtube.com/watch?v=RpwW9Lw2Ku4&t=4385s

[3] https://www.youtube.com/watch?v=mbvrEBajXPg&t=455s

[4] https://www.cell.com/trends/plant-science/abstract/S1360-1385(17)30280-7

Okay touching the trigger hair generates an action potential, but we still haven't discussed how the fly can count? Or what does it even count? Does it count the number of flies caught in the trap? Not quite.

Why would a plant need to count the number of seconds between the generation of successive action potentials? In short, it's because it needs to be sure there's a fly in the trap or not. It takes a lot of effort to open up the trap itself once its closed, even up to 24 hours, and it's not a very efficient way of getting fed if you're just hoping at random that you've caught a fly this time, and won't have to wait another day to try again. You might be thinking wow even with the flytrap and its counting, it's still not a very efficient way to get fed - only at least one fly every 24 hours? Well it turns out that flies are not the primary food source for the plant, it's not a surprise that the sun is that primary food source. Depending on the environmental conditions above and below the soil, the plant decides whether it needs its fly-fix. In fact, it's not always the best idea for the plant to eat flies, it can only open and shut each trap a few times before the trap itself dies, which then leaves the plant one trap down and one less chance to catch flies.

If you find yourself in the national botanic gardens and find a venus fly trap, you can try this very experiment for yourself!

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Another organism that has become quite famous for its so-called intelligent abilities is the slime mould. Researchers studying the slime mould are fascinated by its ability to seemingly solve challenges like identifying the shortest path from entrance to exit in a maze that your average 3 year old wouldn't be able to complete[5][6], or cracking the two armed bandit task[7] suggesting it would make a surprising profit at the slot machines. These all seem like suspiciously crazy tasks for a protist to carry out, but the driver of such behaviours is somewhat more obvious. And for the slime mould it's all in the name of food or sometimes more specifically oat flakes which seems to be a particular favourite. What is the fastest and best way to get to my meal, what decisions can I make to ensure that happens, and how can I remember those decisions and pathways so that I can do it all again if presented with a similar scenario.

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Up to this point we've talked about intelligence in organisms that don't have a nervous system. These organisms that don't have brains, but what about an organism that has a brain but through some form of events, loses it?

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[5] https://www.youtube.com/watch?v=lls27hu03yw&t=25s

[6] https://www.pnas.org/doi/abs/10.1073/pnas.1215037109

[7] https://royalsocietypublishing.org/doi/10.1098/rsif.2016.0030

Planaria are a type of flatworm with a very basic neuronal system and a tiny brain-like structure in its head. And the funniest thing is that if you cut off this head, give it two weeks until there's a new one right in its place! Safe to say, the guillotine in the French Revolution would have been entirely useless if the French royalty were anything like these planaria!

The ability to grow more than one head is almost entirely unique to planaria. In particular, it's a feature that has been exploited over and over in order to investigate the extent to which this small animal depends on its brain for functioning and more specifically intelligent behaviours such as memory. Scientists carrying out these experiments noticed that when they trained a group of planaria to like a certain edible treat like a piece of liver **(yummy sounds, sounds of eating)** the planaria would move towards the treat when it encountered it. If you cut their heads off (**queen of hearts saying 'off with their head' & sound effect of guillotine)**, you'd expect this learned memory to go with it, but somehow when a new head grew back they still retained this learned behaviour and moved towards the treat they knew and loved.

What did researchers take from this? Well they concluded that in planaria, the brain was not essential to preserve memories, through some other mechanism these memories are maintained and called upon in a given scenario. Some even go so far as to say that these memories are held within each cell and that its this 'collective intelligence' of cells that gives the planarian the ability to remember without a brain[8] [9].

[8] https://www.youtube.com/watch?v=RwEKg5cjkKQ&t=2024s

[9] https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2016.00902/full

Source of the music:

https://pixabay.com/music/

Audio clips taken from

1. Electrical experiments with plants that count and communicate https://www.youtube.com/watch?v=pvBlSFVmoaw&t=407s
2. Slime mould smarts https://www.youtube.com/watch?v=lls27hu03yw

Quotes taken from 'The Wonderful wizard of Oz' in the public domain and readings sourced from English audiobooks youtube channel https://www.youtube.com/watch?v=a4vBqP8nywA&t=1373s

Clips taken from Wizard of Oz 1939 film also found online

Audio was edited and recorded in Audacity software

Definition of intelligence read by Mark O'Loan

A huge thank you to Dr. Mitchell for allowing me to interview him for this piece

I attest to the fact that this is my own independent piece of work which, other than for the interviewee and reader, I wrote, recorded and edited myself.

So now lets ask that question again; Do we need a brain to be intelligent?

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“Oh, no, my dear; I’m really a very good man, but I’m a very bad Wizard, I must admit.”

“Can’t you give me brains?” asked the Scarecrow.

“You don’t need them. You are learning something every day. A baby has brains, but it doesn’t know much. Experience is the only thing that brings knowledge, and the longer you are on earth the more experience you are sure to get.”

“That may all be true,” said the Scarecrow, “but I shall be very unhappy unless you give me brains.”

The false Wizard looked at him carefully.

“Well,” he said with a sigh, “I’m not much of a magician, as I said; but if you will come to me tomorrow morning, I will stuff your head with brains. I cannot tell you how to use them, however; you must find that out for yourself.”

“Oh, thank you—thank you!” cried the Scarecrow. “I’ll find a way to use them, never fear!”

Do we need a brain to be intelligent? What do you think now? Have you changed your mind or are you unconvinced?

If you said the latter, personally I would agree with you. At least in this discussion, I’ve only outlined 3 examples of intelligence beyond the brain so it would be entirely reasonable to remain highly sceptical of such a conclusion. But these behaviours and arguments for intelligence outside of a brain and nervous system are definitely some interesting food for thought at the very least.

Another person who remains somewhat sceptical about the arguably v rapid and far-reaching conclusions surrounding aneural intelligent behaviour and basal cognition, is Professor Kevin Mitchell.

Dr. Mitchell has worked and written extensively in the field of neuroscience, neurogenetics and developmental neurobiology and his lab at Trinity College Dublin seeks to understand how the brain is wired early in development and beyond. More importantly, he’s exactly the type of person to talk with about this research.

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Interview with Dr. Mitchell

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So it seems at least that there’s a long way to go in terms of defining intelligence and also confidently applying the term and its features to aneural organisms, however moving away from

an animal and human centric view of cognition, could elucidate about its more basic traits and functions. So while scarecrow realised he didn’t need a brain, what the wizard convinced him was that he needed a diploma.

Back on earth I think we all agree that you don’t need a diploma to be intelligent, and some have even suggested that you might not even need a brain!