what is behavior?

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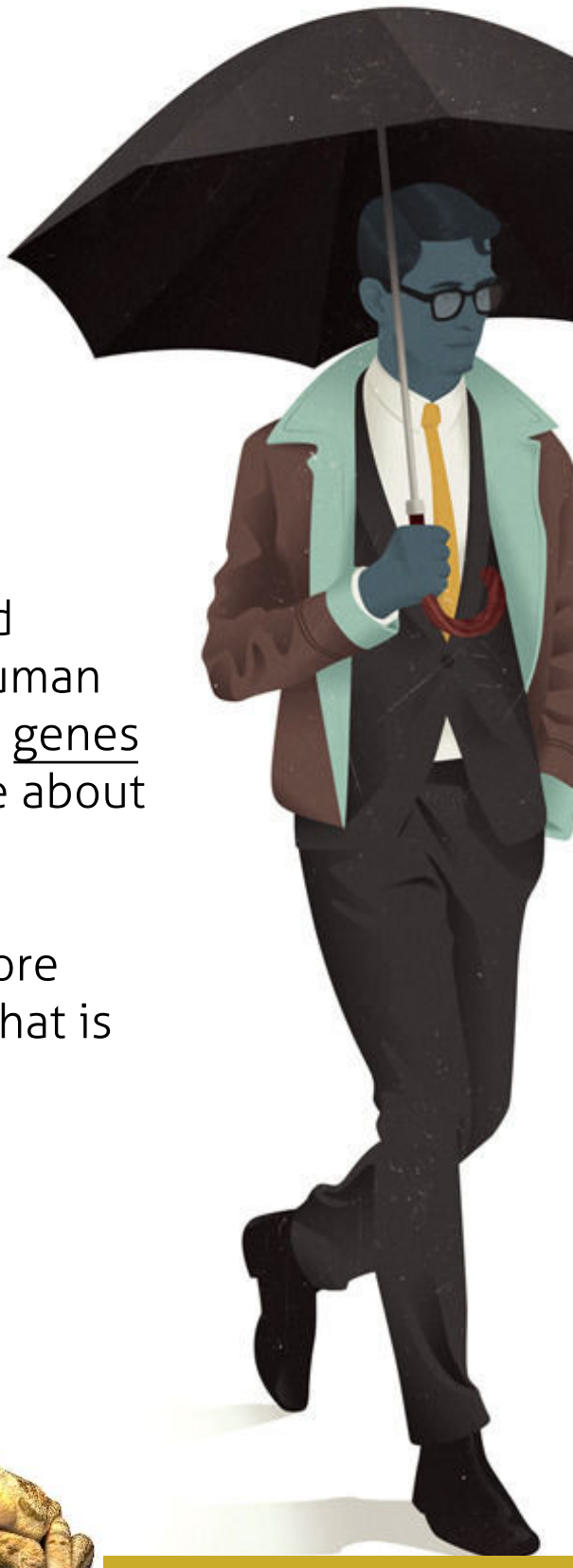
Summary:

What is behavior? An air conditioner, a flower with a brain, a mindless toad, and John with an umbrella. Let’s begin!



We have already published 2 detailed articles regarding human behavior; one about genes and gender, and one about psychology.

This one asks the more general question: What is behavior?

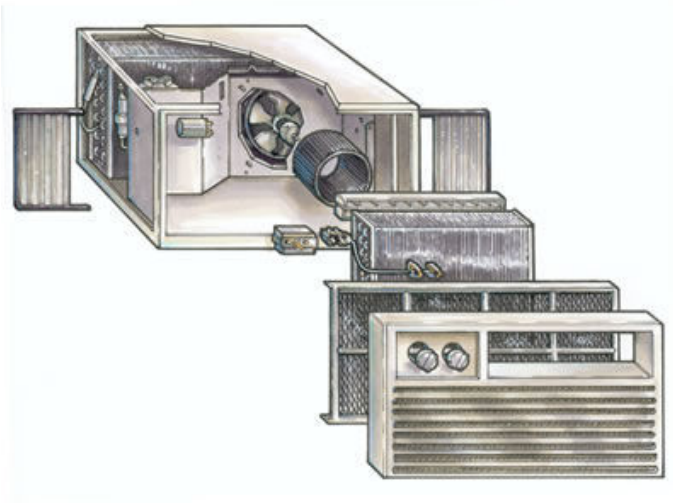
A FLOWER WITH A BRAIN

JOHN WITH AN UMBRELLA

AN AIR CONDITIONER

A MINDLESS TOAD

AN AIR CONDITIONER



It's damn hot in the house. The A/C turns on. It cools the air. People are happy. How did the A/C know?

This 'thing' is a human invention that, basically, deals with the moving of particles and creates a few thermal reactions through a bunch of pipes, fans, radiators, etc.. All of these relatively complex reactions make your interior environment cool or warm.

A/C's can be connected to multiple sensors that analyze the indoor temperature and, according to that, they 'behave' to extract more or less of the warm air out of the building. If it detects a 37 Celsius (98F) temperature in your house, it will pump cool air to get the temperature to 24C (75F), if that's the temperature you chose.

So, we give it a simple instruction - the desired indoor temperature of a room or house - and it 'behaves' accordingly to bring about and maintain that temperature.

It is basically hardware (a machine with a bunch of sensors) that reacts according to the way you program it. The more sensors it has, and the more complex the software that makes sense of these sensors and hardware are, the more things it can do.

For instance, a sensor could monitor your child's body temperature and, accordingly, adjust the indoor temperature for maximum health. Some sensors may detect when you arrive, automatically adjusting the A/C to the temperature you prefer. You may have manually entered that information into a simple control panel, or the software could be made smart (complex) enough to store and recall your more varied preferred temperatures under different conditions.

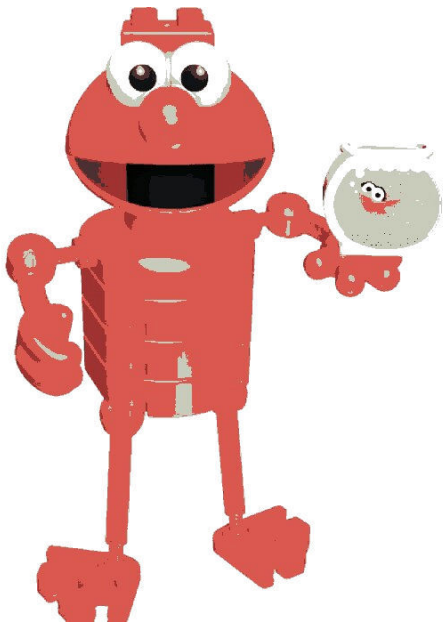
Some software and sensor combinations can reduce the consumption of energy, and so on. All sensor information is interpreted by the software, and the A/C will respond according to how that software is written.

The A/C exhibits a 'behavior' that is in accordance with its hardware, software, and the environment. It's a behavior that humans can understand and control, if they know a thing or two about mechanics and engineering.

However, if the person writing the software for this A/C were to program it to decrease an additional 1C (33F) degree lower each time someone chooses a temperature above 26C (78F) degrees, that would produce a different kind of 'behavior' than what's expected, and people will say things like "*Hmm, the A/C is broken. Fix it man! It doesn't 'behave' as it should!*" That's because the A/C will start to 'behave' in a way that does not make sense for someone who does not know how it was programmed.

Any kind of machinery can be designed in a way that makes it difficult to understand its 'behavior' due to the complexity of its software and hardware. Some software can even be designed to rewrite itself, thus becoming even more difficult to understand the machine's 'behavior'.

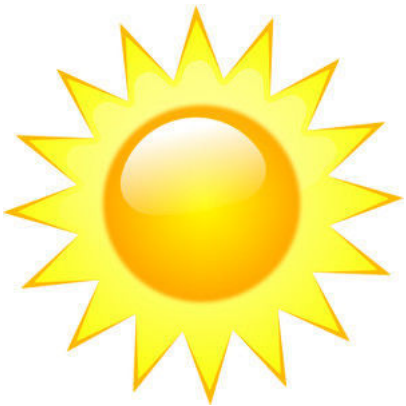
Another way of looking at this: let's say that the sensor that detects the room temperature gets broken and it does not properly detect the room temperature anymore, thus feeding wrong data to the A/C and therefore changing the A/C's initial programmed 'behavior'. This way it will make the A/C behave in a way that it is very hard to understand.



I once had an electric Elmo toy. A creature from cartoons, with batteries and some 'hidden' hardware. If I clapped it made a noise, if I put it down it says "Put me Up!", if I turned off the light some leds light up, and so on. It took me many days to figure it out how this toy 'behaved', but I could only figured it out by trying all sort of things with this toy: talking to it, punching it :), shaking it, putting it upside down and so on. It had a particular way of 'behaving' but it could only do so much.

All of these machines, as complex as they may seem, they can be regarded as 'behaving', yet I would suggest the correct way of thinking about them is 'reacting' instead of 'behaving'. The A/C reacts to stimuli, the Elmo toy the same. And all of them react in accordance to how they are programmed, thus making it relatively easy to deconstruct their 'behavior' and understand the series of reactions that creates it.

A FLOWER WITH A BRAIN



A flower follows the Sun. Gets its energy. Now is happy. How does the flower know about the Sun?

A flower is more complex than all, or almost all machines ever invented by humans. A lot of people still don't properly know, for instance, how a flower converts sunlight into chemical energy.

This complex 'thing' has a bunch of sensors and characteristics and this is mainly why we have many types of flowers.

For instance if you observe flowers for a few days period you will notice how they follow the Sun, as if they know that this is the Sun somehow. Many studies have been done and researchers realized that the flowers react to light, and not only Sunlight, even artificial light.

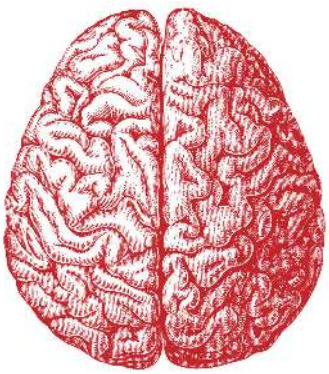
The process is not entirely known but using rigorous tests we can understand this type of behavior, which, as in the case of the machines, I think it is more correct to call it 'reaction' since the flower reacts to stimuli.

Sure, the reaction is complicated, but still, it is only a reaction.

What if we put a brain on the flower though? Let's imagine that!

Suppose that the flower has a capacity for memory now (because it has a brain) and connects the dots between soil moisture, light, its movement, etc. Perhaps, since these dots are connected now, the flower may react in very different ways than before.

For instance if it follows the Sun and you create a shadow on the flower (covering the Sun's light), it may continue its movement in sync with the movement of the Sun in the sky, since it memorized these motions in its brain and repeats them. In time, if you do that for many days or months, maybe the flower's brain energy starts to slightly diminishes because of the shadow you created and the inability of the flower to produce more energy because of that, and the connections in its brain are getting weaker, therefore when you create a shadow again, it does not move in sync with the Sun anymore. It loses that connection. That 'memory'.



What I want to show is that the brain, as an organ, can be very flexible, thus creating complex reactions that we call 'behaviors'. A brain can control a body like a software controls a machine. And a brain, like a software, can be influenced by many external and internal factors such as nutrition and energy, damages, mutations, etc.

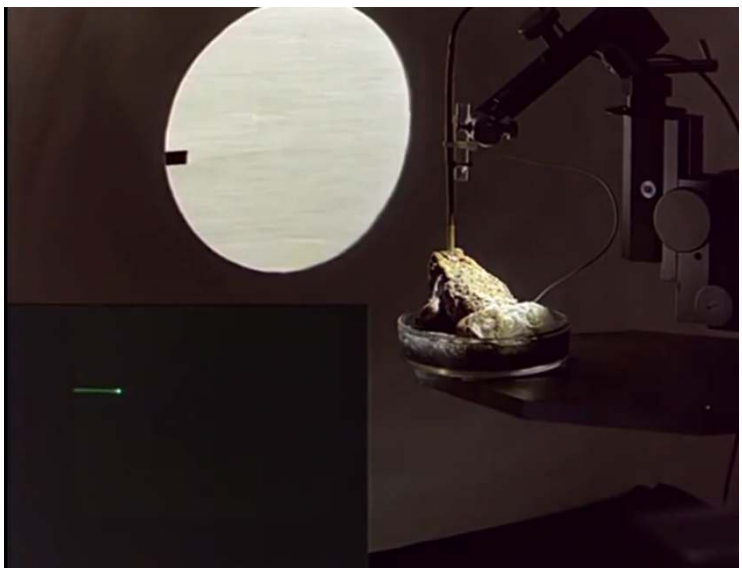
So you see, the flower without a brain is similar to a complex A/C, but with a brain it becomes more like an A/C with a complex software that rewrites itself according to external stimuli, events from the environment or even internal events (damages, mutations, etc).

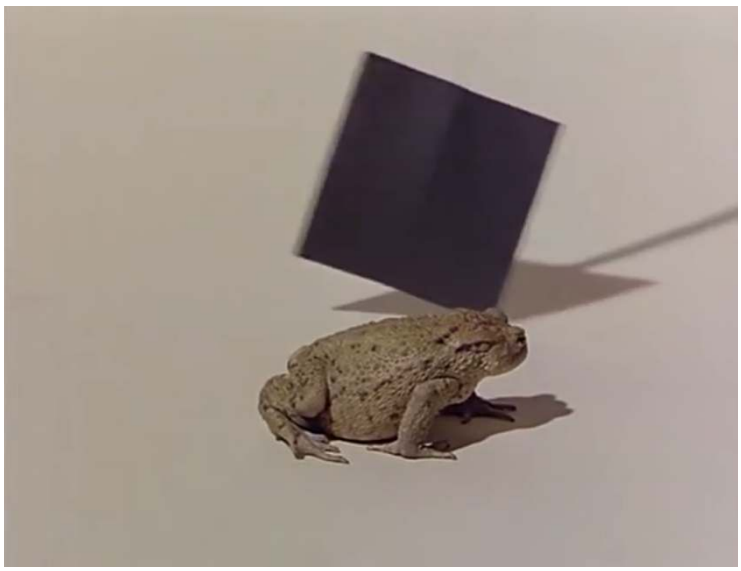
A MINDLESS TOAD

A toad sees a worm. It attacks. It eats the worm. Now it's happy. What did the toad see?

A wonderful study has been done in the same way I did with my Elmo electric toy :). Researchers brought a toad into their laboratory. What they realized is that the toad reacts only to lines that move parallel to their length (these lines are similar to worms that crawls on the ground). If you take the same line and move it opposite to its length or any other direction, then the toad does not react at all.

They scanned the toad's brain and saw that it had strong neural activity when the line moved parallel to its length, but no neural activity when the line moved in other directions. This way, they realized that the toad reacts to visual stimuli and it is basically blind when the line moves any way other than parallel with its length.





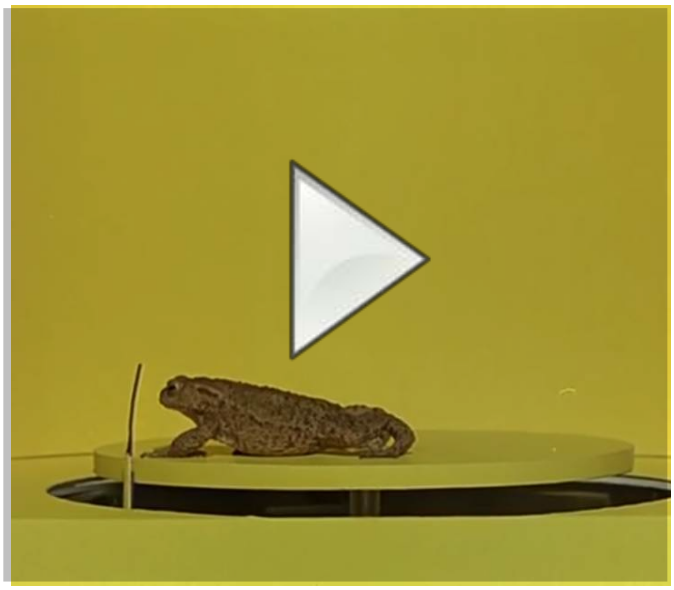
They then performed brain surgery on the toad to see if the toad would change its reactions/behavior if they connect the 'spots' in its brain that light up during the reaction to the line's movement. It did! After surgery, the toad started to react to any moving object (line or other shapes), behavior that was not present before the surgery.

They showed a strong correlation between patterns of neural activities and connections with the way the toad reacts: attacks, runs, etc.. It was similar to a machine. They decoded the toad's reaction to the line's movement.

The key is the following experiment: they fed worms from a human hand to another toad that did not have brain surgery. The toad initially ran when it saw the hand, but after a few days, the toad approached the hand, ate the worm, and an amazing thing happened: the toad wasn't afraid of the hand anymore. It associated the worm 'reward' with the hand's shape. After a few more days, the toad started to 'attack' the hand even when it had no worms as 'rewards'. The same thing can happen in nature. When the toad becomes accustomed to eating worms that are around a particular shape, the toad may attack anything that has that particular shape.

The researchers realized another thing: the toad's brain changed with this experiment, becoming somewhat similar to the brain of the toad that they had operated on. So, events from the environment changed the toad's brain structure similar to brain surgery.

Here, you can watch the entire experiment:



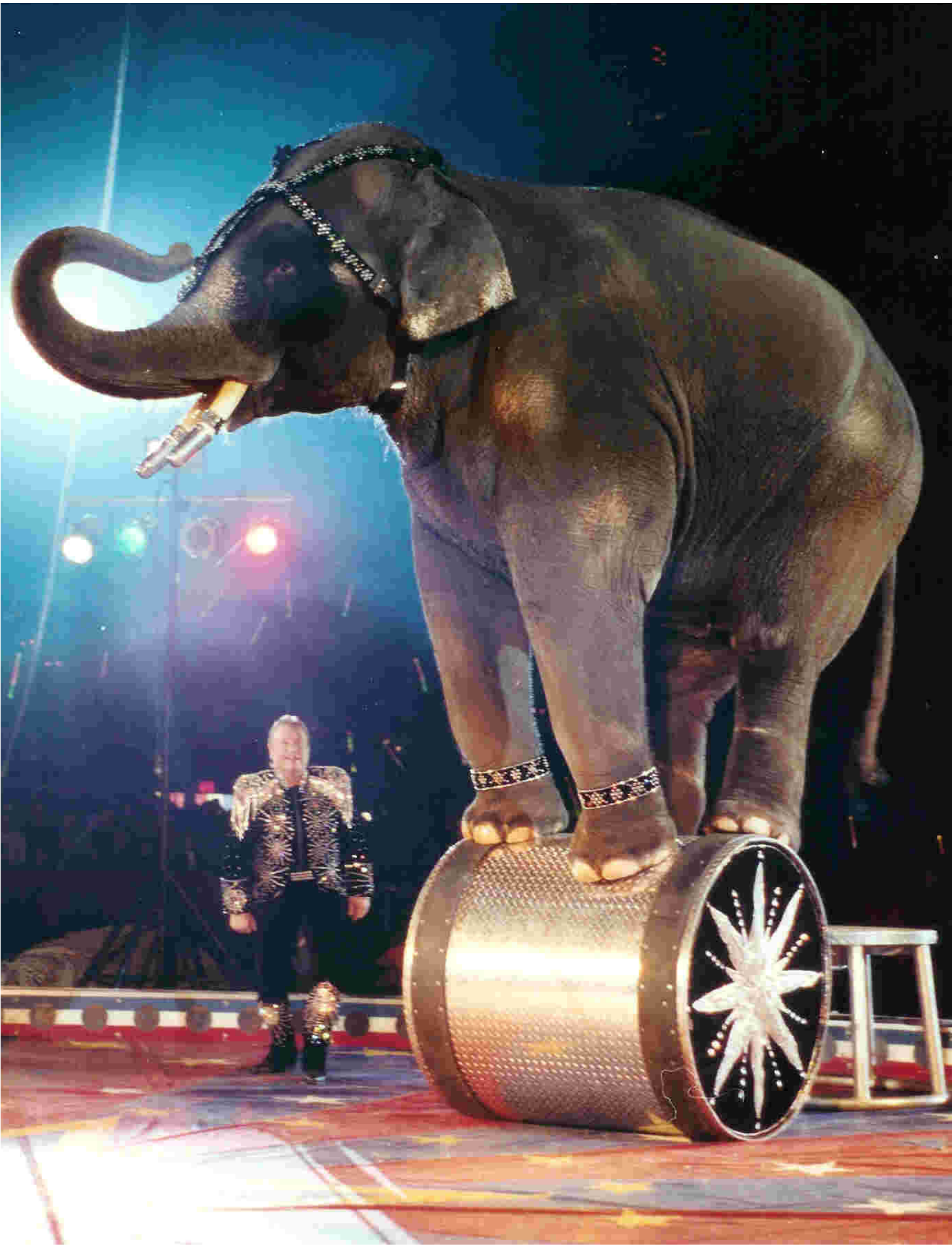
This is how and why creatures with a brain are shaped by the environment so much. This is also why creatures with a brain have such a complex set of reactions to a multitude of stimuli.

One could use the old language and say: the toad attacked the worm because the toad is the hunter and the worm is the prey, but that way of analyzing behavior says nothing about behavior.

The toad's behavior, as shown in the scientific experiment, was just a very complex series of reactions, exactly like software that rewrites itself after being influenced by external events.

This toad seems not so different from that flower with a brain. We may not be able to decode all complex brain reactions, but it's true that we can learn to manipulate and predict them.

This is why we have circuses and you can see a bear riding a bicycle, a lion that jumps through a hula hoop ring, or an elephant that 'paints'.



JOHN WITH AN UMBRELLA

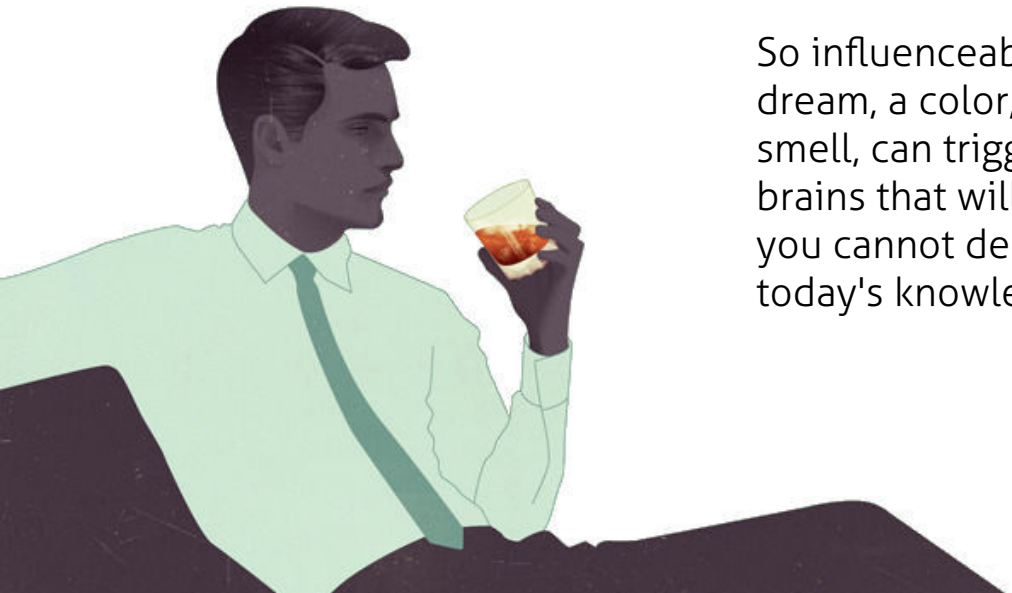
John goes outside. It starts to rain. He opens the umbrella. Now is happy. Why did John use an umbrella?

Well John has a computer with an internet connection. John visits a website that shows him the weather 7 days in advance. John got wet once when it rained and he didn't like that. John has an umbrella at home. John learned all that, and now he can behave accordingly.

Even if John didn't get wet and felt cold, so that he did learn that next time he should have an umbrella when the weather app says it might rain, John could learn in advance from other people, or just by reading about it, that if it rains he will get cold and feel uncomfortable.

This is why humans have such a complex behavior, because their neural connections are hugely complex and highly influenceable.

So influenceable that a question, a dream, a color, a memory, a song or slight smell, can trigger a chain reaction in their brains that will become so complex that you cannot decipher it. At least not with today's knowledge and technology.



Think about that rain. What is it and how does it form? Well weather is the perfect model to understand the human brain's complexity. A sneeze in Japan can trigger a tornado in Colorado. And that's not exaggeration.

All the types of particles that make up the atmosphere and their movement (wind), all the shapes of the landscape, the Sun's rays, all that creates this complex thing that we call the 'weather', which is why it is so hard to predict. There are too many variables.

Actually, there is no way you can fully explain the weather, given the movement of every particle, so why don't we say that the weather exhibits 'behaviors'?

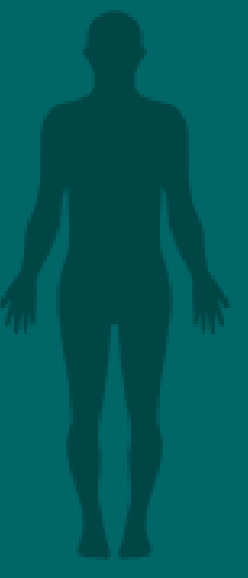
John, like the toad, has a brain, but this brain is many times more complex. This is why it seems non-mechanical and quite 'magical'. Yet the movements of John's hands, legs, eyes and so many other things that make John, John, can be explained in detail by mechanical events: muscles, nerves, etc. So, a good part of what John is can already be explained by mechanical means.

Just read about human anatomy to see complex details about 'John'. Neuroscience is another branch of study that makes John's brain activities 'understandable' from a mechanistic perspective. Again, it is true, the relationships John has with his friends, his thoughts, dreams, language, are very very complex, but they all are happening in John's brain, which is an organ and it is more and more deciphered by scientists.

Humans choose to say that the A/C reacts while a toad 'behaves', yet as we have shown, both react. In the same way John seems to 'behave' while it actually follows a series of feedbacks and reactions to events.

It seems to me that everything is a series of reactions. Every single machine humans make, every creature or event. And humans use the word 'behavior' to describe reactions that are very complex and cannot be fully explained right now.

The A/C, the Elmo electric toy, that toad, John and the weather, are all part of complex reactions and interactions



John plays with his Elmo toy too much and it drains its batteries.

He is pissed off now because of that and kicks the A/C. The A/C is damaged and now pumps only hot air.

John's toad dies of overheating.

The drained energy from Elmo's batteries and the hot air pumped by the A/C are the only bits of energy the weather needs to create a rain.

John remembers the weather app said there are chances of rain. He takes his umbrella and goes out.

Now it rains. ;)

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