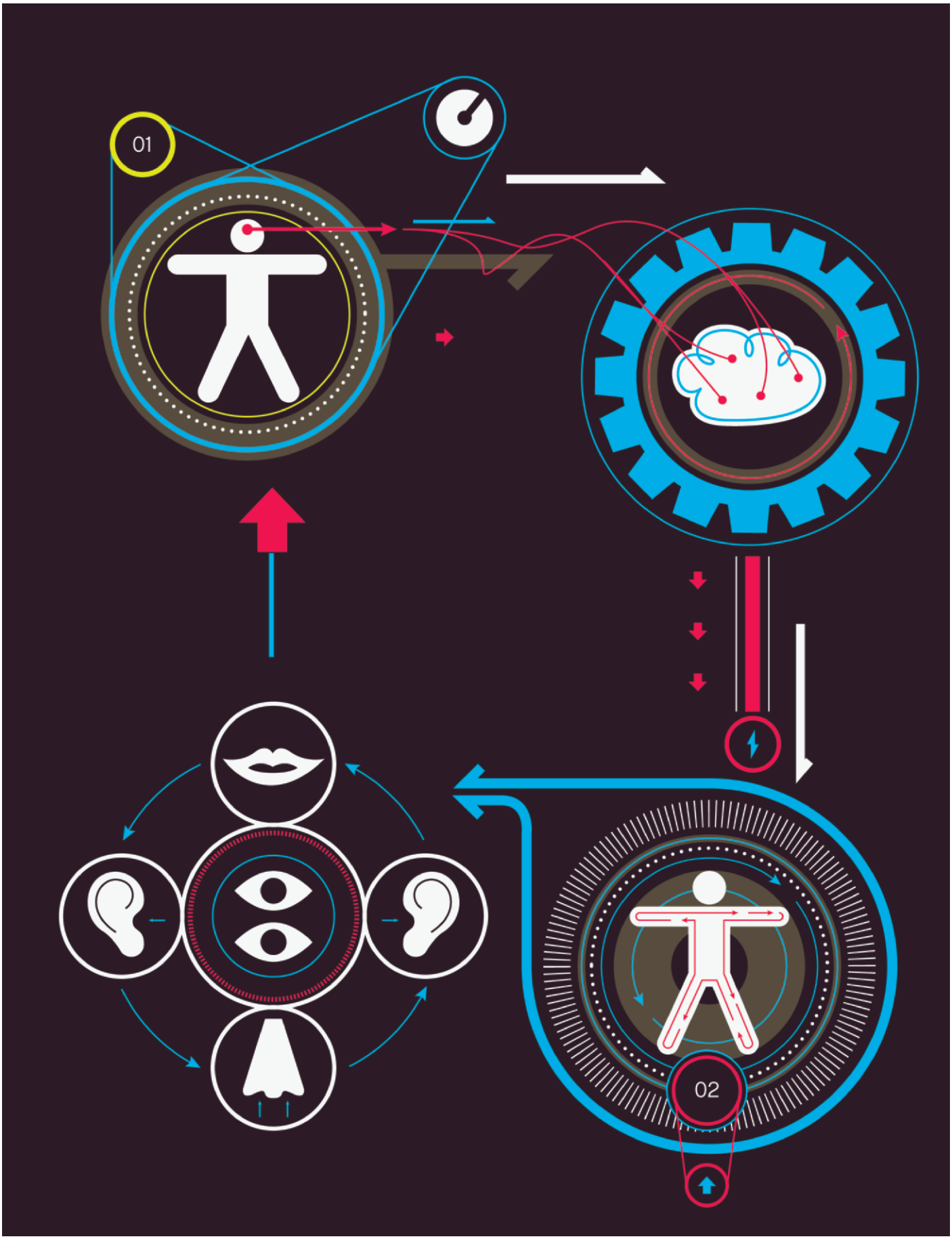

LEANDRO CASTELAO

Your clever body

It's not just your mind that does the thinking, David Robson discovers

TAKE a minute out of the hustle and bustle of your busy life and sit very still. Now, place your hands on the arms of the chair or the desk in front of you, and try to focus your attention on counting your heartbeats. Can you feel a throbbing drum roll, a slight murmur or nothing at all? How does your bladder feel – is it empty or will you need to dash for the bathroom within the next half hour? You may be surprised to learn that these bodily sensations are helping you think.

We tend to view the mind as an aloof, disembodied entity but it is becoming increasingly clear that the whole body is involved in the thinking process. Without input from your body, your mind would be unable to generate a sense of self or process emotions properly. Your body even plays a role in thinking about language and mathematics. And physiological sensations, such as those from your heart and bladder, influence such diverse personal attributes as the strength of your tendency to conform, your willpower and whether you are swayed by your intuitions or governed by rational thought.

In the past few years, discoveries about mind-body connections have overturned the long-held view of the body as a passive vehicle driven by the brain. Instead there is more of a partnership, with bodily experiences playing an active role in your mental life. "The brain cannot act independently of the body," says Arthur Glenberg at the University of Wisconsin-Madison. Tune in to the body's signals, and you can exploit this to improve your creativity, memory and self-control.

René Descartes must be turning in his grave at these findings. In his *Meditations on First Philosophy*, published in 1641, he famously argued that the mind and body are, in essence, two separate entities that could theoretically exist entirely independently of one another. The book sparked a fierce debate into the exact nature of the mind-body connection – a debate that continues to this day. At the centre of the modern discussion is the puzzling sensation of embodiment. The feeling that we own the flesh and blood that stretches from the tips of our toes to the crown of our head is the essence of our sense of self. As such, embodiment is central to consciousness, yet, until recently, we knew little about it.

The first hint of the answer came from an eerie illusion discovered in the late 1990s by Matthew Botvinick, then a doctoral student at Carnegie Mellon University in Pittsburgh, Pennsylvania. He had the idea that embodiment emerges from the brain's need to integrate the information it is receiving from various senses. A Halloween party gave him the perfect opportunity to test this, when he discovered that someone had brought a rubber arm along as part of their costume. Placing the fake arm where he could see it on a table, while hiding his real arm from view, Botvinick asked an accomplice to stroke both rubber and real arms at equivalent places and in time with one another. As he suspected, in an attempt to reconcile the tactile and visual stimuli, he began to feel as if the stroking sensation was coming from the arm he could see. It was as if his brain had forgotten about the real arm and now felt it owned the fake one. He was suitably spooked by the sensation: "I was so unsettled I threw the arm across the room."

> **"Mathematical thinking seems to piggyback on our experience of movement and space"**

Subsequent lab experiments confirmed the result wasn't just the product of a hard night's partying. Importantly, Botvinick also found that the illusion did not occur when brush strokes on the real and fake arm were out of sync, because then the brain was not receiving confused messages that it had to resolve (*Nature*, vol 391, p 756).

Soon, other groups saw the potential of the rubber-hand illusion for unlocking the secrets of embodiment. Brain scans taken as people fell for the trick showed that we have a crude body map in the brain's right temporoparietal junction. When our senses provide information about our bodies, this is compared and integrated with the map in the premotor and parietal cortices (see diagram, page 36). Any mismatch must be resolved at this stage, leading to illusions such as the rubber hand. However, it is only when the integrated information reaches another area called the insular cortex that the feeling of embodiment pops into conscious awareness.

That's not all. The insular cortex also ›