

Out of body

Pinocchio, self-mutilation, having someone else's limbs and feeling presences – our sense of body is a strange and wonderful thing.

Marcello Costa asks, who am I, where is me?

HOW WONDERFUL it is to be able to move my fingers whenever I want, to feel that the fingers are mine and that, while I am writing this article, all of my body appear to follow my will. I look at the world from inside me, I am aware of where I am in space. I easily recognise people and place. I can speak to myself without uttering words, but I can clearly distinguish this inner speech from that of other people speaking. This is a remarkable and powerful deep feeling of being a single self, able to reflect on who I am.

There are moments when we may have uncanny illusions of being somewhere else, or having already seen something that we experience for the first time, or making a gesture we did not really intend.

Extraordinary

experiences of this kind are more common than realised. They can occur in normal people or are revealed dramatically in some abnormal conditions. These 'illusions' are a window on the way in which the brain works and neuroscience is beginning to explain their neural bases.

When a blindfolded participant taps the nose of another person while somebody else taps the blindfolded person's nose in synchrony the blinded subject feels their nose growing. This is known as the Pinocchio illusion, from the famous children's story by the Italian author Collodi of the living wooden puppet Pinocchio, with his nose growing as he tells lies. This simple test reveals that perception of our own body can be altered with no obvious physical change.

Conversely a limb may have been amputated but the subject still feels it as being there. This 'phantom limb' illusion is due to the normal voluntary motor signals from the brain looping back to within the brain itself, replacing the signals that normally would have come from the intact limb. Our own body-image can be felt detached from the physical body, and take on a phantom existence.

The subjective image of our body emerges from the convergence of multiple senses, the visual system, the balance system,

and the sense of body position and movement (proprioception), in a particular part of the brain near the angular gyrus.

This strongly suggests that the brain continuously checks and compares the sensory signals from the body with the motor signals, building a strong sense of 'embodiment', ie of a self localised within one's bodily borders as if the body fits like a glove.

Conversely the concept of 'disembodiment' is used to describe situations in which people feel they have an abnormal body. This may lead to abnormal behaviour including an overwhelming desire to amputate one or more healthy limbs or other parts of the body (body integrity identity disorder, also known as amputee identity disorder). Disturbances of body image may well be responsible for numerous and diverse problems of many adolescents and adults.

Vilayanur Ramachandran, a neuroscientist at the University of California, has been a master in exploring peculiar cases of deficits and what these tell us about the nature of self awareness and awareness of the world (Ramachandran, 1998, 2004).

The most extreme experience of disembodiment is the 'out-of-body' experience (Cardena et al, 2000). Some individuals report feelings of being outside their own body, hovering above it and seeing themselves from

above. These experiences are often associated with near death experiences or a variety of neurological disorders. Such bizarre out-of-body experience can be elicited by electrical stimulation of an area in the lateral parts of the cortex, the angular gyrus, in patients evaluated for epilepsy surgery (Blanke et al 2002).

This strongly suggests this kind of anomalous experiences may be due to malfunctioning of the normal 'embodiment' process.

Some patients, usually left-side hemiplegics who have suffered from a stroke, will experience a disassociation with their paralysed limbs (anosognosia). For example, some may be convinced that their paralysed leg is not really theirs but belongs to a stranger. They will maintain that their real leg has disappeared, and will even attempt to kick their own leg out of bed. This abnormal feeling is often due to lesions on the right side of the parietal cortex.

Recently neuroscientists used simple methods for inducing feelings of out-of-body experiences in healthy volunteers. Two teams of cognitive neuroscientists, led by Bigna Lenggenhager and Olaf Blanke, both of the Swiss Federal Institute of Technology in Lausanne (Blanke et al. 2002) and by Henrik Ehrsson of the Karolinska Institute in Stockholm, Sweden (Ehrsson, 2007), independently used head-mounted video

displays to give people a different perspective on their own bodies. Each team also drew upon the sense of touch to enhance the illusion. People in both experiments reported feelings of dissociation from their bodies. Ehrsson, referring to his own experience after the experiments, said that he really felt that he was sitting in a different place in the room and was looking at this thing in front of him that looks like himself and he knew was himself but it didn't feel like himself. These experiments highlight the potential of modifying deep personal experiences by 'virtual realities'.

Even the mysterious and odd feeling of a mysterious 'presence' felt by some individuals next to or behind them, usually attributed to some paranormal phenomenon, is likely to be due to abnormal activation of the brain process normally involved in giving us the feeling of being within the boundaries of our body.

Olaf Blanke's team found that electrical stimulation of a patient's angular gyrus elicited the weird sensation that another person was lying beneath her on the bed. The figure felt like a 'shadow' that did not speak or move (Arzy et al. 2006). These spooky feelings of foreign presence nearby is probably an exaggeration of normal functions of great survival value, as being aware of danger. What was a field of purely

mystic experiences is becoming a subject of fascinating scientific exploration of human experiences.

The Cotard syndrome represents the ultimate extreme feeling of disembodiment, that of being dead, when probably all the senses become disconnected from the emotional centres (Ramachandran, 2004). A more localised disconnection between the 'fusiform face area', a region of the cortex involved in face perception, and the amygdala (almond shaped) which is involved in the emotional responses to familiar faces, results in a syndrome called Capgrass. Patients feel that even family members may be alien impostors, as they do not recognise them emotionally (Ramachandran, 2004).

This sense of bodily experience can be extended to an habitual tool or prosthesis use that effectively extends the body's area of influence. It is likely that this illusion of extended body space has been instrumental for tool making in human cultures. This has profound implications for designing complex machinery to extend manual skills taking into account the remarkable ability of the brain to build a 'personal' space with an extended self.

Awareness of being in the world, here and now

When everything works well and we feel that our body fits like a glove, we then feel part of a surrounding world. We feel that we are 'here and now'. This feeling also involves an extraordinary integration of external sensory experiences combined together in the brain to give us the sense of being in a 'real' world.

But what happens if the brain makes up some sensory experiences? These are called hallucinations. Hallucinations can be defined as any perceptual experience in the absence of



external stimuli and must be sufficiently compelling to be considered a true perception. There are many different conditions that can create hallucinations, including the psychedelic drugs of the hippie culture. LSD, like most such drugs, abnormally activates the neurochemical processes in the brain involved in the building of a realistic experience. It simulates the action of the endogenous transmitter serotonin. Its powerful action not only produces rich visual hallucinations but can also disrupt the very fabric of the experience of time and space. The ease with which our experience of reality can be disrupted by merely changing a tiny chemical in the brain suggests that the normal functioning of the brain nerve cells weaves the very experience of reality, usually in a way that is consistent with what is out there. Disruption of such processes is likely to result in 'abnormal' experiences such as happens in schizophrenia and other mental disorders or as a result of other 'psychotropic' drugs.

Lesions of some parts of the right parietal cortex, caused by certain neurological disorders, lead to strange behaviour. Patients do not appear to be aware of any object in the external world on the left of their visual field, despite not being blind. This 'spatial neglect' discovered by Italian neurologists a few decades ago, opened a new perspective in the understanding that it is the brain that 'constructs', in a very crafty way, our experience of what is out there.

What happens if there is some cross-wiring between the different sensory components? The result is a mixing up of experiences, with sound being felt like colours and perhaps vice versa shapes and colours felt as sound. Synesthesia, the term to describe this odd situation, is a relatively common condition, probably due to the excess growth of neural connections between different parts of the brain. Small changes in the expression of the genes involved in the normal wiring of the growing brain are probably responsible for this. Increased creativity and perceptive imagination may be the positive side of synesthesia.

However, as the human brain evolved, there must be a delicate balance between experiencing just enough of what is there and enriching the experience too much.

For survival the brain must be able to establish quickly if what is out there is similar or different from what has been experienced before. This is an ongoing

process of checking and comparing memory events against new experiences. The part of the brain involved in this delicate process is the hippocampus (the sea horse shaped part of the cortex). Dr Tonegawa of the Picower Institute at MIT genetically modified in mice some mechanism of communication between neurons involved in the process by which animals know where they are (McHugh et al, 2007). The result was an impairment in the ability to distinguish between two similar but not identical environments. This process may be at the bases of the phenomenon of *déjà vu*, from the French "already seen" (or lived) that is experienced by a majority of normal individuals at some point in their lives. The sense of having seen something that has already been seen is a small shift in the ability to distinguish what is new and what is familiar.

The feeling of some individuals that they can predict the future is probably a similar small step further and reveals the subtle ongoing processes that bind us to a safe here and now. The mysticism about reincarnation and past life experiences may reflect similar processes.

Being in control

The most ingrained feeling of being a 'self' is that of being in control of our own actions.

Awareness of moving involves predicting the consequences of planning movements using ongoing sensory information. We are aware of the movements we intend to make rather than those we actually make. We are just ahead of time when we move, as the feedback is too slow to give us the appropriate awareness. Tampering with this brain process leads to feelings of either not being in control, or delusions of control.

The bizarre feeling that one's hand takes on a mind of its own is known as the 'alien hand syndrome'. This occurs in cases where a person has had the two hemispheres of their brain surgically separated, a procedure sometimes used to relieve the symptoms of extreme cases of epilepsy. It also occurs in some cases after other brain surgery, strokes, or infections. The inability to distinguish self- and externally-produced actions is reported by many psychiatric patients. These probably have disorders of those areas of the medial motor frontal region of the brain and parietal lobe where the integration of 'agency' is

built. An alien hand feeling can be elicited in normal people by hypnosis and by some clever laboratory manipulation of visual and touch stimuli. Accounts of 'alien abductions' are most likely to represent the extreme examples of such an illusion.

Hearing voices as coming from other beings is a common hallucination in schizophrenic patients and is probably due to misattribution of inner speech. In many ancient cultures the experience of auditory verbal hallucinations or 'hearing voices' was considered a message from the gods or other spiritual entities (Jaynes, 1976).

A lot of popular and religious cultures have taken these phenomena as evidence of the separation of a soul from the body. More natural explanations, on the basis of neural circuits of the brain and their interconnections, are beginning to replace such supernatural explanations.

The extraordinary experiences mentioned above represent a window into the hidden working of the brain. We, as individuals, are made up in a continuous fashion by the interaction between our brain, body and environment, binding these different threads of experience into one. The early interest of philosophers such as Sartre, Husserl, Heidegger, Merleau-Ponty and others in the field of subjectivity and self-awareness, has become a legitimate subject of investigations by neuroscientists.

Conclusions

It takes about half a second for neural activity to generate a conscious experience (Libet, 2004). During this time, millions of signals in parallel spread in the networks of neurons. Bringing together all this into one unified state, associated with the strong experience of being a unified in-control self, is one of the most dramatic events in biology, and one that happens continuously in every human as result of ongoing interaction of our organism, brain and body in a life-long dance with the environment.

However, given the ease of tampering with the self, how can we be sure that we are capable of making free decisions? Are we automatons without free will? I would rather postpone this discussion until next time.

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