

'People have been ignoring the body for a long time'

Our editor Jon Sutton spoke to cognitive neuroscientist and 'master of illusion' Henrik Ehrsson at last year's European Congress of Psychology in Stockholm

You create and study body illusions, which seem to be the poor relation of visual illusions. There are entire conferences and prizes devoted to visual illusions, but you don't really see the same thing with body illusions. No, they've been a bit forgotten. Vision has always been the model system for neuroscientists and psychologists to understand how the mind works, how the brain works. We know more about vision than any other system in the brain. It's easier to study – it's easy to present visual stimuli on a computer screen, the response properties of neurons can be categorised quite well, with controlled stimuli. Vision is of course very important, in a large part of the brain, so it has been the system that scientists have used when they want to understand awareness and perception.

The body is more forgotten, it's more complicated, there are more sources of information, from different sensory systems, different sensors, different receptors in the body. Of course the body has been studied in neurology, from a slightly different perspective, in terms of stroke rehabilitation, speech problems, things like that. A lot of clinicians are interested in the body, but more basic scientists and neuroscientists tend to work on vision.

So how did you get started in this area?

I did my PhD in motor control and then I got introduced to a fascinating body illusion that was more fun than my PhD project! It was tendon vibration: when you put a massager over the tendon and the muscle, the biceps for example, and you ask the person to close their eyes, if you vibrate at the right frequency – about 70Hz – you will start to feel that the arm is moving. Then it goes to an impossible posture, the hand continues down... it's very fascinating, you can't really believe what you're feeling. You get

funny things like if you grab your nose while you vibrate, your hand is still moving and your nose extends: the Pinocchio illusion.

These are illusions described by physiologists in the 1970s, and we did a couple of experiments using that illusion to study the sense of limb movement. I thought it was really intriguing, fascinating, especially when you move into these more complex illusions. It seemed to me important to understand how the brain generates this model of your own body. And then I read about the rubber hand illusion, got my own prosthetic hand, tried it, it seemed to work. When I went to the UK for a



Professor Henrik Ehrsson
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postdoc I was encouraged to work on what I thought I wanted to work on: it's a great British tradition, that postdoc

freedom! And then I did an experiment on the rubber hand illusion. I was particularly fascinated by the fact that it seemed to change the identity of your body, it was not just like the earlier illusions that I knew about where you sense a limb movement or an elongation, it's about a change in ownership. The out-of-body illusion is fascinating as well – people think they are in a different place from their actual body, and they treat their actual body like it is someone else.

So this is more than a cheap magician's trick, is it saying something quite fundamental about the self?

Yes, and about human perception of the body and about the discrimination between self and non-self. I think about them as perception illusions rather than as a mind trick that a stage performer or illusionist would use. Those involve manipulating your attention, your expectations, things like that. We try to control for that by the design of the experiments, for example presenting the same rubber hand but slightly rotated, or just touching the rubber hand and real hand slightly out of sync. These are more sensory manipulations, rather than high-level manipulations of expectation or attention, the things that magicians are very good at.

It's all so upfront, people can see that there's a rubber hand, they know what's coming, but that doesn't stop the illusion.

That's what they say about perception illusions, they should be cognitively impregnable, you shouldn't be able to think it away. Same as optical illusions.

It's clear you've moved the field away from the extent of the illusion to something that is more about the identity. From that you've come to a hypothesis about multisensory neurons, can you explain that?

Well, I'm not a psychologist, I'm a former medical student and both my PhD and postdoc supervisors were neuroscientists thinking about brain areas and connections. So it's natural for me to think about possible brain mechanisms, how it's implemented in the brain. I was reading the multisensory literature and I thought I could think about the rubber hand illusion and sense of body ownership in a similar way. Maybe the feeling of ownership of a hand is the same thing as a multisensory integration mechanism, from a reductionist

Ehrsson's illusions

The third hand: The rubber hand illusion was described in 1998 by Matthew Botvinick and Jonathan Cohen (see tinyurl.com/p52gnbq). It convinces people that a fake hand is their own by hiding their real hand under a table, placing a rubber one (or even an inflated rubber glove) in front of them, and stroking/tapping both in the same way at the same time (see tinyurl.com/32vmxsv and tinyurl.com/ycdelxe for it in action). Ehrsson extended this illusion so that a rubber right hand, placed beside the real hand in full view of the participant, was perceived as an extra limb belonging to the participant's own body. This effect was supported by questionnaire data in conjunction with physiological evidence obtained from skin conductance responses when physically threatening either the rubber hand or the real one.

Out of body: You wear goggles displaying the view from a camera pointing at your back. Your chest is tapped with one plastic rod while a second one prods at the camera, in sync. 'You feel that you are being touched directly in the chest by the experimenter standing in front of you and that a "stranger" is sitting in front of you with their back towards you,' says Ehrsson. 'What is really happening – and you still know this – it that you are looking at your back through the goggles and the experimenter is standing right behind you.' Watch the illusion at tinyurl.com/oo5adma.

Body swap (see photo: Ehrsson on left): Head-mounted displays are connected to cameras mounted on a mannequin's head. The experimenter then uses a short rod to simultaneously stroke your stomach and the mannequin's. You feel the movement on your own body while seeing the same movement on the artificial stomach. This can lead to the sense of the touch of the rod on your stomach, but more importantly that the mannequin's body is your own body. Watch it at tinyurl.com/oq7rns5.



perspective. Maybe the binding together of all that visual, tactile and proprioception information is the same thing as the conscious experience that 'this is my hand'. Other people have more complicated models, but I quite like simple models! It might be too simple, but it's a good starting point.

What do other neuroscientists and psychologists think of your work?

It's generally received well. It's been cited. I've been invited to speak to neuroscientists and psychologists. I think it has gone down particularly well with psychologists actually.

Excited about the applications, I guess?

Yes, I'm very interested in applications, and there are a number of possible directions I can go. I've talked about neuroprosthetics, and there's the possibility of investigating the psychotic brain. Perhaps some of the mechanisms we have studied are impaired in schizophrenics. The problem there is that there are so many cognitive functions that seem to be impaired, it might not only be the body, but they do seem to have a

disturbed sense of self.

Then there's also eating disorders and all those body image disorders, a lot could be done in clinical psychology in terms of a more hardcore experimental psychology approach. Very important clinical research is going on, but I think there's also room for some more mechanistic and basic studies in that field. We know very little about the neuroscience of eating disorders and body image disorders.

Do these illusions work on everyone?

No, the rubber hand illusion works in about 70 per cent of individuals, the out-of-body illusion over 80 per cent, the invisible hand around 70 per cent. We don't know why some people are immune. I have two brothers, one experienced the rubber hand illusion vividly like I do, the other one just looks at it and says 'what are you talking about?'

I've never participated in anything like this, but for some reason I would be surprised if they worked on me. Are the people who it doesn't work with

those who say right from the outset 'it's not going to work with me'?

No, I don't think so. So many people just don't believe it. I had this orthopaedic surgeon at the arm prosthesis unit who thought it was the most ridiculous thing he'd ever heard in his whole life, but then we saw his face, his eyes popped out, he couldn't believe it!

Of course we know in psychology that expectations and placebo can influence people's reports, but we think that if your multisensory brain is wired up in a certain way you will experience it, whether you want it or not.

And there are other indicators that they are experiencing it?

Yes, how they will report the position of a hand, localised more towards the rubber hand; if you feel the illusion your skin conductance response will be elevated if I stab the rubber hand; and the stronger you feel the illusion, the stronger your brain activity in the multisensory areas; and the stronger that brain response, the more your pain matrix will light up if we stab the rubber hand. So there's all this evidence which suggests that it's there.

So why are some people immune? Our explanation that we need to test would be that different brains put different weights on vision, touch and proprioception. It's a conflict, there's not really anything right or wrong – your vision and touch is contradicting your proprioception. It's a conflict, and one side will win. Maybe in some brains proprioception is weighted higher, that information is more important, for whatever reason.

Why do we have these individual differences? We don't know, but one possibility would be that if you're an athlete, or a guitarist, you're very used to the position of your limbs in space, without looking, you might be better at proprioception and therefore less fooled. This is a testable hypothesis. I would expect academics to be more susceptible than dancers, for example. Of my two brothers, one is an academic like me, the other brother plays the guitar. I don't know whether that's why he isn't fooled...

Do your experimental interests influence your personal interests?

Yes, there is a link with some of the research we do and contemporary experimental art and performance. The technology used by some artists, when you're experiencing something that is surreal... you don't know why you like it, it just feels great to look at. Sometimes these illusions can give you similar, surrealistic experiences.

I've been talking to some Swedish artists, based in the UK actually, called Lundahl and Seidl, who have been doing art installations that involve looking at yourself from outside perspectives, or being blindfolded and taken into dark rooms, listening to earphones that give you instructions.

Also, we were collaborating with a team of virtual-reality researchers in Europe, with Mel Slater, and we tried to implement some of our illusions in virtual reality. You can do more crazy stuff that might be difficult to do in real reality! Even in virtual reality, people have been ignoring the body for a long time, it's been all about environments. How you model the actual body could enhance the experience you have.

Give me an example.

So say you're training firefighters, and you have a virtual fire, you're going to get more realistic sensations and reactions if the sense of body ownership is such that the person feels the virtual body is in



Being Barbie

In this experiment, published with Björn van der Hoort (shown here with Ehrsson lying down), you can experience ownership of a tiny (30cm and 80cm) or a huge (400cm) body. Looking at the artificial body through a set of head-mounted-displays, you see the body from the perspective of the doll with 3-D vision. To induce the illusion of owning the artificial body, the experimenter strokes your body and the doll's body at the same place and at the same time. These synchronous strokes cause the your brain to interpret the felt touches as caused by the rod that you see touching the doll. This makes it seem as if the doll's body is your body. Next, you see a cube and have to show the size of the cube with your hands. Having the illusion of owning a tiny body causes the world to appear gigantic, and owning a huge body makes the world appear smaller. Watch the illusion at tinyurl.com/hebarbie.

some way their own. You want to get the feeling that your body is actually there. It has to move away from feeling like an advanced computer game. If you want to cure a phobia of spiders, it's going to be more effective if you actually feel the virtual hand is your own.

Don't mention spiders! So what's next?

We're interested in how the brain distinguishes between an internally generated signal and signals from the world. How does the brain know what is a construct of your mind, your

imagination, and what is real sensory data?

Now that we've shown the brain can mix up different types of external sensory data, and it can have a profound effect on your sense of body, we need to

work at a higher cognitive level... do you need to have ownership of your thoughts? We have shown that if you ask people to imagine things, for example sound or seeing a white flash on the screen, basic

things like that, those imagined stimuli can influence and merge with real stimuli and you can elicit some of the classic multisensory illusions if in one of the sensory modalities the real stimuli have been replaced with imagined stimuli. You can get these illusion effects which are part imagination and part real. So we're looking not just at ownership of body, but are trying to understand more about ownership of thoughts.

Do these effects happen quickly, and if so does this tell us anything about the brain?

Around 10 seconds. So there's still some time there for the brain to reconcile these differences... in brain terms that's a long time! Of course we don't know how far you can go with more prolonged exposures... things that we now think don't work in the rubber hand illusion, like a block of wood for example, what would happen if we had someone exposed to that for days, weeks? How could long-term plasticity and training influence those basic constraints of what your body could look like?

"You can get these illusion effects which are part imagination and part real"

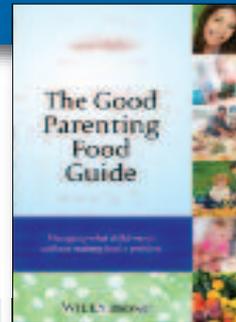
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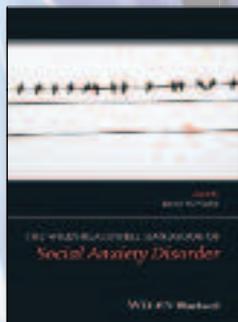


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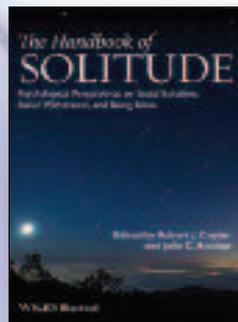
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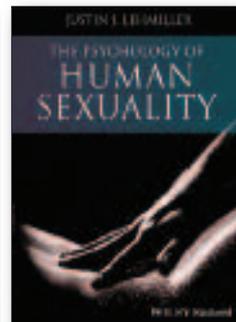
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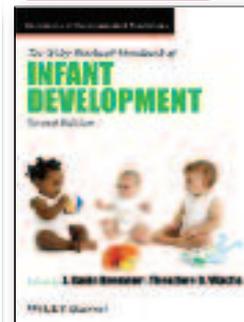


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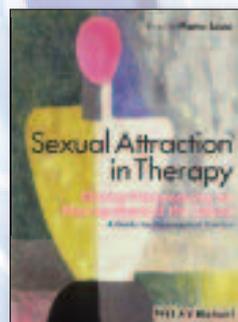


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