Living Books About Life

Nerves of Perception

Motor and Sensory Experience in Neuroscience

Edited by Anna Munster

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Introduction: Neuro-perception and What's at Stake in Giving Neurology Its Nerves?

For the last few years, all things 'neuro' have been doing the rounds in the creative arts and humanities. We have had the declensions 'neuropolitics' and 'noopolitics'; we have panicked about screen media and the internet rewiring our plastic brains; we have marvelled at artists incorporating MRIs into videos, photomedia and installations. Little wonder at such a response – after all, weren't the 1990s officially declared, by US Presidential proclamation to be the 'Decade of the Brain'? Neuroscience – the collective nomenclature we give the sciences of the brain – is in fact a disparate assemblage of disciplines, methods and practices for understanding, healing, transposing, interpreting, imaging and, most importantly, constituting the nervous system in organisms. To get a sense of how diverse these sciences are, we can simply draw up a small list of some of them: for example, neuroanatomy, behavioural neuroscience, computational neuroscience, neuroethnology, molecular neuroscience, systems neuroscience, developmental

neuroscience, and so on. These all designate various specialities within neuroscience but also, sometimes vastly different methods, philosophical approaches and indeed ways of realising the brain as organ, system, structure or entity. Within or across any of these specialities, competing and dissonant approaches to how the nervous system is seen to function exist. A decade, indeed more than a century, of practice and research in neuroscience has only multiplied the neural as a vast field of unknown quanta and qualia.

It seems important to emphasise this point, although neuroscientists and especially neurologists – those practicing a branch of medicine that deals with disorders affecting the nervous system of, mainly, human organisms – will happily admit that they only know how 10% of the brain works. It is important to emphasise this because 'neuroscience' – when it appears in discussion in the media, but also within public and academic intellectual debate – outside the neuroscience context, can often appear like the incontrovertible truth about: thought, consciousness, interiority and sometimes even all of (lived) experience. Neuroscientific 'results' are dragged, kicking and screaming, into the debate about how, for example, 'youth' are being rewired by online gaming or surfing the web. Often, these results are backed up by the power of the neuroimage, which seems to causally locate social, emotional or cognitive behaviour 'in' some specified red area in the brain. In our popular imaginary, neuroscience has become the new genetics.

Rather than engage in 'big' brain issues here, such as consciousness or the neural correlates for behaviour, I have chosen to collect a range of articles that address a quite specific topic within neuroscience: the role of

sensorimotor activity in perception. In fact, this is a huge topic; it covers a range of specialisations within neuroscience – some of these include neuroanatomy, behavioural neuroscience, neuroethology – but it also covers the space where neuroscience crosses disciplines. Because this topic deals with perception, it necessarily deals with the question of how perception is experienced…and not just experienced for humans but also for other kinds of living beings. This, then, raises two important philosophical and ethical issues: what do we mean by experience and the perception of experience, on the one hand, and how are we to think about and access nonhuman life's perceptual apparati and experience(s)? Indeed, in attempting to address these issues some neuroscientists have worked with philosophers, and have even become philosophers, in order to produce neuroscience.

At the micro level, then, the role of sensorimotor activity in perception as a topic for neuroscientific research renders neuroscience as a diverse, contested and highly interesting field for nonscientists. Rather than acting as the substrate proof of some social or cultural issue for nonscientists, looking at sensorimotor experience and its function within perception demonstrates how neuroscience can do something else. It can pose difficult and taxing questions and problems about how 'life' experiences. This Living Book is an attempt to bring together both landmark articles and current neuroscientific studies that foreground the role of motor and sensory experience and the place of these in the generation of human and nonhuman perception. Certainly the articles I have selected are oriented less toward the idea that the neurosciences provide proof that these kind of activities do have neural correlates and more toward demonstrating how relations between

the neural and perception can be construed. The collection, then, is a way of indicating that while the neurosciences certainly foreground the sensorimotor system and its role in generating perception, sensory and motor experience cannot be reduced to the firing of neurons. Even neuroscientists who look for the neural correlates of action or how neurons respond to sensory material do not necessarily pose sensorimotor experience reductively. They may in fact deploy a systems approach in which neuronal clusters operate in distributed networks and in relation to other aspects of perception (representational aspects, for example).

I have included articles, or where articles are not possible links, that show the question of how we perceive is an area of active contestation for neuroscience. We should therefore speak of neurosciences instead. This is important for nonscientists to remember: neuroscience is not a homogeneous domain that somehow proves that we are ruled by our neurons as we move and engage in and with the world. However, it should be noted that the range of articles, and the way I have posed their relationships with each other in this Living Book, favours a particular approach to sensorimotor experience, which has come to be known as the 'enactive perception' approach (Thompson, Palacios, Varela, 1992: 2). This approach is highly contested within neurosciences' studies about perception and often comes up against what is known as the 'representationalist' approach (Gallese and Keysers, 2001). Put broadly and briefly: the enactive approach understands the organism with a nervous system and its environment to be co-determining. This means that perception occurs as a generated or enacted activity out of the relation between what the environment offers the

animal and what the sensorimotor system of the animal brings to the environment. The representationalist approach, on the other hand, sees perception as, for the main part, a mode of representation that arises (often in a systemically complex manner) out of interactions between neurons in and across the animal's nervous system. This seemingly makes the representationalist approach internal to the animal's nervous system. However, recent neuroscientific research on mirror neurons has complicated this attribution, as mirror neuron research has developed evidence that perception (and other cognitive activities such as language) may also depend upon interaction with another's nervous system. Representationalist approaches therefore are also dealing with the questions of what experience is – is it neurally distributed across self and other? for example – and with whom else experience might be generated.

A major shift in the neurosciences' theorisation of perception occurred with the 1959 publication of 'What the Frog's Eye Tells the Frog's Brain' (Lettwin, Maturana, McCulloch and Pitts). This detailed study of how a frog's visual system sees only movement in its environment, challenged an entire scientific and philosophical paradigm of the structure and relations between sensation, perception and world. In living organisms with a visual system, eyes had been thought to be sensory organs receiving material from the world – light – and then transmitting this information to the brain. It was the brain that organized and interpreted this information, and then told the eye what it was seeing. Lettwin *et al* instead proposed to study a frog's eyes as part of a system that worked to actively organize vision. The eyes of the frog are unlike human eyes; they anatomically constitute a single visual

system from retina to colliculus (the superficial layers of the brain stem). The human visual system, on the other hand, is a double system, which allows for different kinds of movements by the eyes in relation to the sensory world. For example, human eyes can follow the movement of others in their environment in order to fixate upon the object moving, whereas the frog's eyes remain stable. This singular visual system involves a coupling of the frog with its environment resulting in it only perceiving the movement of moving prey/food. The eye-environment coupling tells the frog's brain what the frog needs to perceive, in the sense that it provides an already systemically and actively organized frog visuality for the frog's brain.

We should keep in mind that while this is sometimes interpreted as a constructionist argument, constructionism should not be here posed as some simple opposition to biological causation or neural correlationalism. It is not that the frog simply constructs its perceptions but, rather, that perception, such as vision, is an active system that involves relations of coupling between an organism and its environment. This coupling, or co-determination, actively generates perception by calling upon the pattern of relays that develops between sensorimotor experience and the neural system of the animal. This has emerged as the 'enactive approach' to perception, a branch of thinking in neuroscience (Varela, Thompson, and Rosch, 1991) that also crosses into philosophy. Enactive perception is something that living organisms do rather than simply have.

Important aspects of the enactive approach are: a) that organisms generate their own cognitive processes; b) that the nervous system is autonomous as a system, its

systematicity generated recursively through relays and feedback in the organism's sensorimotor activities; but that the preceding is therefore c) an embodied system coupled with the organism's environment; and that consequently d) the organism's cognition will be generated out of this embodied, coupled and most importantly relational system of closed sensorimotor system and open environment-system (see Thompson, 2005). Although initiated by the neuroscientific research in 'What the Frog's Eye Tells the Frog's Brain', the enactive approach has also been developed by interdisciplinary collaborations between neuroscientists and philosophers, such as the longstanding research collaborations of Francisco Varela and Evan Thompson (for example, Thompson, Palacios and Varela, 1992: 2). I have therefore included an article by Evan Thompson, the philosopher, 'Sensorimotor subjectivity and the enactive approach to experience', in this collection as his work has indeed become part of the 'neuroscience' of enactive perception. This article clearly outlines the place sensorimotor experience occupies in a system of ecological relations in the enactive approach.

But I have also included another article on colour vision by Thompson. Not only does this develop an enactive approach to colour; it demonstrates the importance of comparative animal studies in neuroscience for understanding perception. Perception is here understood as something that an animal does in its environment rather than something that an animal receives externally from its environment and then internally processes. The importance of both a comparative and environmental approach to the neuroscience of perception is still playing itself out in more recent studies. For example, included in the section 'recent studies on aspects of sensorimotor

experience in the perceptual systems of humans and nonhumans', is a link to a free access article published in 2008, 'What the bat's voice tells the bat's brain'. With obvious resonances to the earlier 1959 article, the authors here stress the importance of undertaking neural recordings of data of mammals while they are behaving in their natural environments: 'We believe that future recordings of neural activity from the free-flying bat, while it engages in the full suite of rich natural behaviors, will yield data that will contribute not only to our understanding of what the bat's voice tells the bat's brain, but also more broadly to our understanding of the behaving brain across species' (Ulanovsky and Moss, 2008). The bat's voice, flying, brain and environment is an ecology that enacts perception.

Like much neuroscience, this approach to perception is fiercely contested. It is only fair that I therefore also include examples of opposing and differing approaches. But rather than present these debates as if they occupy two divisive camps, I have tried instead to indicate, by choosing certain authors and articles, a more complex relation. Representationalism is often seen as the approach that offers a directly opposing viewpoint to the enactive one. And indeed in the article by Vittorio Gallese and Christian Keysers, which construes the mirror neuron system as representationalist, it would be easy to identify work on this controversial topic as largely fitting into that camp. Broadly speaking, representationalism with respect to perception, is the idea that perceiving arises – and in the mirror system we are talking about the self's perception of others' action, expression and language –as a complex mapping or representation, epiphenomenally out of the interactions of firing neurons. At the basis of the

perception-representation, then lie the neural correlates of such mappings. However, much research and hypothesizing around the mirror neuron system, a relatively new area of neuroscience, also attempts to locate mirror neuron's in specific areas of the brain (Rizzolatti, et. al, 1992; Buccino, G. et. al, 2001). This takes correlational approaches to their extreme and makes it difficult to reconcile the fact that the mirror neuron system must at least account for two animals (mirror neurons have also been 'found' in macaque monkeys as well as humans) interacting. As Antonio Damasio and Kaspar Meyer have suggested, mirror neurons must be understood from a systems viewpoint (Damasio, Antonio and Kaspar Meyer. 2008). Damasio's work, nonetheless, remains strongly representationalist and his neuroscientific research consistently searches for the neural correlates of both perception and behaviour.

It should be clear by now that many of the debates that grip neuroscience have direct crossovers into, and overlap with, debates that extend historically back to at least the seventeenth century within the arts and humanities. It is not my intention to rehearse those debates around subjectivism-objectivism, self-other, mind-body and so forth here. But what I do want to note is that these debates in both neuroscientific and, especially, within the creative and performing arts are very much alive today. I have included both a link to an article by the philosopher Alva Noë and a link to an online conversation between Noë and the choreographer William Forsyth. Together, these provide a conceptual context for how and why ideas about perception as process and action – rather than as a respresentation of the world inside the head – motivate and excite contemporary artists.

I have also included germinal neuroscience articles and recent follow-up studies on, microsaccades or tiny, involuntary eye movements occurring in humans and a range of other mammals (cats, primates) during prolonged visual fixation. This is a newish and unresolved area of research into the neuroscience of perception. The exact function of microsaccades is not known except that they make an important contribution to maintaining visibility. One reason they provoke excitement is that they demonstrate that perception, or at the very least visual perception, in a range of animals is not singly modal. That is to say, if our eyes are actually moving in order to visually perceive, then vision is in some way intimately dependent upon the kinaesthetic. The notion that animals possess separate senses, and separate sensing systems, is really up for grabs. Moreover, vision itself becomes a much more complex process of perception than what we might call the old snapshot conception of vision, where the human eye, for instance, receives minute inverted images of the world but nonetheless processes the world in three dimensions (Noë, 2004: 36). If vision takes microsaccades to happen then looking is no longer receiving visual stimuli but the animal's visual-motor relations actively generating the visible field.

Recent areas investigated in neuroscience and by neuroscientists, philsophers, and, I think, increasingly artists, whose entire practices deals with perceiving, changing and actively inventing the perceptual, signal a shake-up. We might soon find ourselves having to talk about perceiving as a plurality of sensorimotor experience and of a perception of some thing as always also a perception with somewhere. That is, of course, as

long as we don't try to keep all this dynamic stuff just inside our heads.

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Articles

Nervous Perception: Germinal Articles in Neuroscience on Sensorimotor Experience

J. Y. Lettvin, H. R. Maturana, W. S. McCulloch, and W. H. Pitts
What the Frog's Eye Tells the Frog's Brain

Evan Thompson
Sensorimotor Subjectivity and the Enactive Approach to Experience

Evan Thompson
Colour Vision, Evolution, and Perceptual Content

Alva Noë
Experience Without the Head

Vittorio Gallese and Christian Keysers
Mirror Neurons: A Sensorimotor Representation System

Susan Martinez-Conde, Stephen L. Macknik and David H. Hubel
The Role of Fixational Eye Movements in Visual Perception

Aspects of Sensorimotor Experience in the Perceptual Systems of Humans and Nonhumans

Nachum Ulanovsky and Cynthia F. Moss
What the Bat's Voice Tells the Bat's Brain

Jaime A Pineda
Sensorimotor Cortex As a Critical Component of an 'Extended' Mirror Neuron System: Does It Solve the

Perception and Sensorimotor Experience from Neuroscientfic, Philosophical and Creative Practices

Attributions

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Link to Garrison Institute Interview with Evan Thompson, http://www.youtube.com/watch?v=dmwm8tFnmNk (2011). This is a freely accessible interview on YouTube with Evan Thompson on the contribution of phenomenologies of experience to the neuroscience of perception.

Link to Neuroculture.org, a freely accessible website that provides examples of artists and scholars working at the intersection of art and neuroscience. Many of these works are critical of the hype surrounding neuroscience, others actively explore the relations between neuroscience, art and perception.