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Is ‘the brain’ a helpful metaphor for neuroscience?

Fred Keijzer

Abstract

Brette criticizes the notion of neural coding as used in neuroscience as a way to clarify the causal structure of the brain. This criticism will be positioned in a wider range of findings and ideas from other branches of neuroscience and biology. While supporting Brette’s critique, they also suggest the need for more radical changes in neuroscience than Brette envisions.

Brette’s analysis and critique of neural coding provides an important challenge for neuroscience. He shows how neuroscience’s reliance on neural coding brings in an external scientist’s perspective that searches for correlations – encodings – between environmental features that are recognizable by us and neural events made recognizable for us through psychophysical experiments. In this analysis, he argues that finding such correlations between the ‘outer’ and the ‘inner’ world is of dubious value when it comes to clarifying how nervous systems causally function in organizing behavior. In addition, he stresses the need to maintain the representational sense of the coding metaphor, for example “as a form of normativity realized by anticipatory properties of internal processes.” In this response, I will argue that the issues related to the causal operation of the brain are much more general and pervasive than Brette acknowledges here and that, as a consequence, his commitment to representations becomes problematical.

This wider range of problems becomes visible by highlighting another metaphor, ‘the brain’, a concept widely used – including by Brette – to designate the target of neuroscience. ‘The brain’ may seem a neutral, descriptive term, but just like ‘neural code’ this concept comes with a range of ready-made assumptions, associations and theoretical commitments that deserve scrutiny.

First, ‘the brain’ refers only to the central, and not the peripheral, nervous system; second, ‘the’ suggests a human brain instead of central nervous systems more generally; and third, ‘the brain’ usually refers to nervous systems as a mental or cognitive control system that consists of an inner information-processing device, linked to the outer world via its sensors and effectors acting as input-output devices. Overall, the phrase ‘the brain’ is associated with interpreting nervous systems in relation to humans, to mind and to agency.

Using ‘the brain’ to designate the domain of neuroscience is widespread, but it is actually quite strange. It restricts neuroscience to a single (or a few) animal species and comes with a specific and limited focus on what nervous systems might do. It is a bit like developing an account of computation based on a particular computer game. Instead of a human- or mind-oriented view on neuroscience, we require a neuroscience view on neuroscience. I will discuss several issues where the difference plays a role.

Large parts of (cognitive) neuroscience still rely on a clear conceptual separation between neurons and other bodily cells, but this *brain-body dualism* is becoming increasingly problematic. For example, many of the molecular ingredients of neurons go back to unicellular ancestors (Sebé-Pedrós, Degnan & Ruiz-Trillo, 2017); the evolutionary differentiation of neurons from

other cells involved a gradual functional segregation (Arendt, 2008); and non-neural cells are still involved in electrical signaling, for example in development (Levin & Martyniuk, 2018). Brains are clearly specialized parts of the animal body rather than something of a completely different order.

It is therefore better to talk about ‘nervous systems’ (plural), a phrase that easily accommodates the millions of different types of nervous system organization in existence and refers to whole systems instead of only the central parts. It also applies to relatively ‘simple’ nervous systems that enable fine-grained studies how relatively small collections of neurons can accomplish sophisticated behavior (e.g. Marder, 2012; Bargmann & Marder, 2013; Liu, Yang, Wu, Duan, Soucy, Jin & Zhang, 2018).

Focusing on nervous systems more generally provides a different context for neuroscience, which is more concrete than the abstract tasks devised to address behavioral and cognitive questions. Nervous systems are intrinsically active systems that integrate and balance behavioral and perceptual, as well as physiological and developmental processes (Jékely, Godfrey-Smith & Keijzer, 2015). To understand how nervous systems actually work, a more inclusive view of the various functions of nervous systems is required.

A general neuroscience perspective also takes the peripheral nervous system as an integral part of nervous system functioning. This provides a corrective for the inner-outer dichotomy that looks plausible in a mental context as well as for visual and acoustic input. However, the dichotomy dissolves when it comes to touch and its dependence on self-initiated activity, peripheral nerves, proprioceptive feedback, and the biomechanics of the body itself (Chiel & Beer, 1997; Tytell, Holes & Cohen, 2011; Turvey & Fonseca, 2014). The point can also be made conceptually: the inner-outer dichotomy fits the philosophical notion of mind, but nervous systems are not minds and instead perfectly coextensive with the world, just like the bodies they innervate and the interactions with the world they enable. We do not need to interpret nervous systems as if they are material minds.

To reinforce the last point, it helps to look at recent work on the evolution of the first nervous systems (Kristan Jr, 2016). We usually take our own macroscopic view of a world full of trees and animals as basic. From an evolutionary perspective, it is not. Accessing the world at a macroscopic level is a complex achievement that only came about when certain unicellular organisms turned into animals with their nervous systems and complex senses like touch and eyes (Keijzer, 2015). Intriguingly, in this context the intuitive idea that nervous systems are at heart input-output devices must be questioned as nervous systems may – at least initially – have acted mostly as internal coordination devices by providing multicellular muscle control (Keijzer, Van Duijn & Lyon, 2013; Keijzer & Arnellos, 2017) rather than responding to external stimuli.

To conclude, Brette’s critique of the coding metaphor as used in neuroscience is spot on and he makes this problem visible in a specific and careful way. However, outside the research field discussed by Brette, many other considerations detract from the idea of neural coding. This wider context furthermore suggests that neuroscience needs ideas that take in, but go beyond viewing the brain as a dynamical system and stressing the centrality of perception-action loops. Similarly, hanging on to representational theorizing is not an obvious way to deal with the many issues raised by a neuroscience view on neuroscience.

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