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THEMATIC SECTION ARTICLE: CONCEPTS OF AGENCY

What Is Agency? A View from Science Studies and Cybernetics

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Abstract

The first part of this essay relates a minimal and primordial concept of agency to be found in science and technology studies to an overall ontology of liveliness. The second part explores the relation between minimal and higher-level conceptions of agency concerning goal-orientedness and adaptation, and moves towards specifically biological concerns via a discussion of cybernetic machines.

Keywords Adaptation · Agency · Cybernetics · Emergence · Goal-orientation · Ontology

Introduction

The first part of this essay elaborates a minimal sense of agency by exploring some key related concepts as they figure in science and technology studies (STS). My example is drawn from the history of physics, but the ontological picture of the liveliness of matter that emerges is general and primordial—something to take into account whatever sort of system, physical or biological, one is concerned with. The second part relates the minimal sense of agency to higher-level conceptualizations that associate agency with purposefulness and adaptation. The aim is to show how a primordial understanding of agency can be extended towards biological concerns, with a consideration of some cybernetic machines as a bridge.

Minimal Agency

Running through science studies and STS is what Samir Okasha (2023, this issue) calls a "minimal concept" of agency, "simply that of *doing* something or behaving."[1] This sounds simple and straightforward enough in itself, but opens up to a set of important and productive issues that I explore here. In STS, the minimal sense of agency functions as a shorthand for an overall ontological vision, a vision of what the world (organic and inorganic) is like: namely a lively place, built up in the interplay of actions and performances.

To put some flesh on this picture we need an example to hang onto, and I can refer here to a typical episode in the history of physics about which I have written at length before—the evolution from the mid-1970s to the late 1980s of a series of experiments aiming to search for free quarks (Pickering 1981, 1995, Chap. 3). The details are not important, but the first step in all of these experiments was to levitate small particles of matter (initially grains of graphite, later small steel cylinders) in a magnetic field. A pair of metal plates then applied a transverse electrical field and the response of the samples was interpreted in terms of their electrical charges—charges of one-third of that of the electron being taken as evidence for the presence of free quarks.

What can we say about this? (1) The world is not a monolithic entity that acts as one. We need to think here of a *multiplicity* of agencies, including magnetic and electric fields as well as the scientists who configured and reconfigured the apparatus, made and interpreted measurements, and so on. (2) Beyond action we need to think about *interaction*

[1] Strictly speaking, I am concerned here with the "posthumanist" wing of STS, exemplified in actor-network theory (e.g., Latour 1983, 1987), Pickering (1995) on "the mangle," Barad (2007) on "infra-action," and the "new vitalism" (e.g., Bennett 2010). The "humanist" wing of STS, typified by the sociology of scientific knowledge and the social construction of technology, focuses instead on specifically human agency understood in terms of human goals and interests.

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and *chains* of actions within this multiplicity. The scientists acted on their material apparatus, setting up some specific configuration, and then observed how that configuration itself would act; electric and magnetic fields acted on the test particles, which acted in turn—floating in midair, moving from side to side (or not).[2] (3) Importantly, some of these chains and concatenations of agency have a looping, re-entrant or recursive quality. Thus, having observed how their apparatus performed in a particular configuration, on many occasions the scientists reconfigured it to find out if it would perform differently. I call this recursion in performance the mangle of practice or, more evocatively, the *dance of agency*, in which all of the partners are liable to transformation.[3] This dance is what plugs scientists into the material world and vice versa (Pickering 1993, 1995). In STS, "agency" as "doing something" thus points beyond itself to what we can call a *performative ontology*, an understanding of being in the world that begins with action, performance, liveliness.

But now we need to turn aside to think about *knowledge* and representation. Scientists do not, of course, assemble the elements of their apparatus at random. Many theories and calculations figured in the quark-search experiments, beginning with the laws of electrostatics as a way of conceptualizing the activity of charged particles in electrical fields. There is therefore a temptation to understand scientific apparatus as congealed theory, ideas transmogrified into metal and glass (Bachelard 1984).

In privileging knowledge, that line of thought tends to idealism and taken seriously it displaces activity from its foundational position. But it is misleading. It turned out that over time the quark-search experimenters were repeatedly *surprised* by the behavior of the particles they were working with. The test samples acted in ways that transgressed the experimenters' theoretical models of their instruments. And though the scientists eventually modified their understandings, their key response on repeated occasions was just to continue the dance and tinker with their apparatus to find out how it would act when configured differently. At an early stage, for example, they obtained credible results by widening the separation between the plates that maintained the transverse electric field, despite theoretical indications that they should be as close to one another as possible. And I want to emphasize, therefore, that such passages restore the primacy of agency over knowledge. Scientists' knowledge is parasitic on action, entangled with it, "mangled" in practice.

We could rephrase this in terms of *emergence*, by which I mean the appearance of unpredictable performative novelty in the world. Despite a wealth of pre-existing knowledge, scientists (and, by implication, all of us) have to *find out* how this configuration of the world or that will act. Speaking ontologically, then, agency-as-activity is emergent.

Of course, to say this is to set up a puzzle. Scientists are indeed from time to time surprised by the behavior of their apparatus, but often they are not. Over the course of their experimentation, the quark searchers built reliable electric and magnetic levitation systems, and on several occasions they felt confident enough to publish their findings—though more surprises were always waiting down the line. How should we understand that? This is a tricky problem from the present perspective, and my own solution is to add to the ontological picture a notion of *islands of stability*. Much more needs to be said, but the basic idea is that such islands are specific configurations in which the flux of becoming slows down and emergence is, so to speak, backgrounded, so that a dualist separation of people and things can come to the fore (Pickering 2017).[4] These islands are hard to find, rare and precious. They are what both science and our everyday world are built on, and their existence is a sort of ontological discovery. This language of islands is a way of remembering their contingency. We can always fall off them—as when the quark searchers were repeatedly surprised by the performance of their apparatus. And, of course, in many situations, including the overall sweep of scientific research projects, we find ourselves adrift and not at all in control of a reliable world.

Activity, multiplicity, interactivity, the dance of agency, emergence, islands of stability—these are basic elements of the ontology that the minimal notion of "agency" conjures up, a set of concepts for analyzing being and becoming in a lively world. By way of contrast, we can note that this ontology is different from that of the physicists whose work I have been discussing. Physics, and the modern sciences more generally, reifies islands of stability and aims to construct pictures of a fixed and knowable world on that basis. The STS sense of agency foregrounds both the existence *and* instability of these islands *and* the ocean of emergence and becoming they punctuate—locating these islands in a wider frame, putting them in their place, so to speak, and science too.

[2] Latour (1995) offers a nice analysis of how scientists contrive experimental set-ups so that they can act in turn.

[3] On transformation, Latour (2005) distinguishes between "mediators" and "intermediaries." The former transform the elements they link; the latter leave them unchanged and relate specifically to stabilized set-ups (see below on "islands of stability").

[4] Pickering (1995) discusses the "interactive stabilisation" of elements of scientific culture but without exploring its ontological significance. Islands of stability have much in common with Latour's (1987) "black boxes," though my point here is also to remember their instability.

We can continue the discussion from another angle. We have been discussing agency in terms of activity and performance, but it is hard to resist the slide from "agency" to something more specific: "*agent"* as a label for whatever it is that acts. The impulse is to localize agency and specify the units of analysis, and the question that interposes itself here is: do we always need to associate agency with some agent?

From one angle, the answer is no. In research practice, what matters are the specific surprises (good and bad) that emerge in the process of research. These are what researchers have to pay attention to and structure their work around, that give form to the mangle of practice and the dance of agency. But on the other hand, in stabilized situations—islands of stability—it is reasonable to speak of instruments and machines, say, as indeed agents themselves, centers of the action. The various set-ups reported in the quark-search literature were the agents that produced the reported results (an absence of free quarks in the experiments at issue).

Where does this get us? First, we can say that while agency as activity and performance is everywhere, agents are not. They wax and wane, coming into existence and fading away as a function of the contingent stability of the associated material set-ups.[5] It is worth emphasizing this. Much philosophical thought on agency begins with agents and analyzes what can be attributed to them. In contrast, agents are epiphenomena in the present picture; they congeal in fields of action. To identify agency with activity instead of agents is to start from a different place in a broader analysis.[6]

Second, along the same lines, we can say that agents are emergent, in the sense, as before, that their activity can always surprise us—as in the quark-search experiments. In fact, agents are doubly emergent: they emerge in practice and their activity is in turn emergent.

Third, agents have a fractal structure, built up in a regress of sub-agents. The quark-search experiments, for example, included two subsystems—the magnetic levitation system and the electrical measurement system—and these subsystems were, of course, themselves decomposable in terms of power supplies, measuring devices, electrical circuits, and so on. In a sense, this returns us to a notion of agency as diffuse and not precisely locatable. We understand the action of machines in terms of more primitive assemblies, but that understanding is always revisable in practice, as already discussed, returning us to the primacy of action over representation.[7] This, then, is how to think of agents, as contingent fractal islands of stability in the flux of becoming.

My goal in this section has been to explore the ways in which a minimal and very simple sense of agency as "doing things" in fact adumbrates a rather rich and challenging ontological vision of how the world is, a vision quite different from that of familiar sciences like physics (and of modern commonsense). I have laid out some of the key ontological concepts—including multiplicity, interaction, emergence, islands of stability, the ebb and flow of agents and their fractal structure—that in different ways (and by different names) have proved fruitful in STS, empirically and philosophically. In the next section I relate the discussion to higher-level conceptions of agency and more specific concerns of biology and philosophy of biology.

Goals and Adaptation

> *Our terrestrial world is grossly bimodal in its forms: either the forms in it are extremely simple, like the run-down clock, so that we dismiss them contemptuously, or they are extremely complex, so that we think of them as being quite different, and say they have Life. Today we can see that the two forms are simply at the extremes of a single scale. The Homeostat made a start at the provision of intermediate forms.*
>
> Ross Ashby, *Design for a Brain* (1960, pp. 231–232)

> *Having decided (heaven forgive me, but it is my conviction) to follow in Darwin's footsteps, I bought his autobiography to get some hints on how to do it.*
>
> Ross Ashby, notebook entry, 29 June 1945 (p. 1956)

The minimal sense of agency is primordial, to be found everywhere. In this section I want to move towards more distinctly biological concerns. A preliminary point is that even the minimal conception of agency speaks directly to topics of biological interest: an ontology that emphasizes liveliness (rather than the statics of physics) is obviously a good place to start thinking about living organisms; the evolution of species is surely an instance of the dance of agency between species and their environments (Ziman 1996); the waxing and waning of agents likewise connects directly to life and death as a property of organisms; organisms and

[5] This is presumably why Latour (1987) refers to "actants" rather than "actors" in his articulation of actor-network theory, and perhaps why the acronym ANT is now preferred.

[6] Thus the classical humanist understanding of agency begins with a notion of humans as a certain kind of preformed willful agent.

[7] This line of thought is a performative translation of the so-called Duhem-Quine thesis. In its classic form, the thesis observes that when prediction fails it shows that something has gone wrong somewhere in the theoretical network behind the prediction but without specifying which elements require revision. In the quark-search experiments, the inference was often that some subsystem was not performing as expected without identifying which.

species are islands of stability in the flux of becoming. But still, discussions of agency in philosophy of biology often seek to clarify what is distinctive about living organisms and we can think about that now. I want to consider two aspects of agency often associated with biological systems: purposefulness and adaptation. My aim here is not to specify these ideas of agency further, but to see how the minimal notion connects to them. My strategy is a familiar one: to begin with a discussion of machines and then to relate that to biology (e.g., Barandiaran et al. 2009).

A first candidate for the specialness of the living might be goal-orientation.[8] One might imagine that an important contrast between biological agents and inanimate matter is precisely that the former but not the latter have goals and purposes. This contrast certainly holds up in respect of assemblages of inanimate matter like the quark-search experiments just discussed: the physical apparatus of these experiments indeed had no intrinsic goal, it simply did something. In the dance of agency with the physicists, all of the purpose was on the human side: the scientists *wanted* the apparatus to work to produce knowledge and they acted accordingly.

But we can go beyond the concerns of STS and make things more complicated by getting rid of the humans and thinking about purposeful nonhuman systems. The postwar science of cybernetics is important here because it centered precisely on purposive action, and from the start it explicitly eroded the contrast between the animal and the machine (Rosenblueth et al. 1943). The foundational machine in the early development of cybernetics was the servomechanism (Galison 1994), the domestic thermostat being the simplest example. Three points about thermostats need to be noted. First, the thermostat is a machine which indeed has an intrinsic goal: to keep the temperature in a room constant. Second, it achieves this by an artful inner concatenation of components: a temperature-dependent element (often a bimetallic strip) which operates an on-off switch that controls the heat supply. Thirdly, these components *together with the environment* form a closed loop: the thermostat controls the heat supply which determines the temperature in the room, which acts back on the thermostat, in a regularized dance that I call a *choreography of agency*.[9]

The overall plan of goal-orientation is, then, an appropriate inner organization of parts coupled to an environment so as to create a closed loop in the dance of agency—here of a multiplicity of minimal nonhuman agents acting together, and jointly constituting a purposive higher-level agent (the thermostat). Various observations follow. First, this is how the discussion of minimal agency can connect up to an understanding of higher-level purposive agents. We do not have to choose between these senses of agency; we need instead to grasp the relation between them. Second, evidently not all assemblages of minimal agents have this recursive character—as I said, the quark-search experiments did not. So this sense of agency as goal-orientation applies only to special arrangements of minimal agents. We could think of such arrangements as a special kind of self-stabilizing, dynamic, or even “organic” island of stability, in contrast to the brute “mechanical” stability of machines like the quark-search set-ups.

And third, of course, organisms, too, are purposeful entities, so this discussion of cybernetic machines shows how the minimal conception of agency can cross over into topics of specifically biological interest. Gregory Bateson (2002), for example, identified “mind” as a property of re-entrant looping structures, and argued that such structures are to be found throughout nature. Humberto Maturana and Francisco Varela’s (1980) image of autopoiesis is likewise one of inner biological organization “structurally coupled” to a surrounding milieu.[10] We could also make a link to Jakob von Uexküll’s concept of Umwelt here: servomechanisms respond not to their environments tout court, but to the specific features to which they are coupled—the thermostat and its ambient temperature—just like von Uexküll’s famous ticks (Pickering 2021).

So, this is how minimal agents and goal-oriented agents stand in relation to one another, with the latter as a special arrangement of the former, and how the present discussion can travel from physics via a particular class of machines into the biology of living organisms. But what about emergence? I suggested before that agency is emergent, so how does this manifest itself in goal-oriented assemblages? In the case of the thermostat—imagined as a stable and generally reliable object—all of the emergence is on the side of the environment. The weather can always surprise us, and the thermostat simply does its best to cancel that out. But more complicated cybernetic machines internalize emergence, so to speak; they model agency as emergent.

As a first example, consider the robot “tortoises” built by the English cybernetician Grey Walter in 1948 (Walter 1953; Pickering 2010, Chap. 3). The tortoises were small mobile robots which dodged round obstacles while locating and homing in on lights. Walter (1950) described them as “an imitation of life.” Like the thermostat, they were

[8] Okasha (2023, this issue) discusses three conceptions of agency in biology that go beyond the minimal one, all of which hinge on goals and purposes.

[9] For choreographies of agency involving our relations with the environment, see Pickering (2019, 2022).

[10] “A living system defines through its organization the domain of all interactions into which it can possibly enter without losing its identity only as long as the basic circularity that defines it as a unit of interactions remains unbroken” (Maturana 1970, quoted in Froese and Stewart 2010, p. 29).

goal-oriented machines, but, unlike the thermostat, Walter reported that their behavior was itself emergent, surprising him to the point of incomprehensibility when equipped with a learning circuit known as CORA. A new aspect of the agency of machines, and no doubt organisms, which we could call *inscrutability*, surfaces here, which I have not seen discussed explicitly in the literature. I think of this as the cybernetic discovery of complexity (Pickering 2010): even a few simple minimal agents acting in relation to one another can generate an effectively indefinite range of performances.[11]

From a different angle it is interesting to think about another cybernetic machine, the homeostat, built by another British cybernetician, Ross Ashby, also in 1948 (Ashby 1960; Pickering 2010, Chap. 4). The homeostat was an electromechanical device that explored its environment (modelled by more homeostats) via the currents it emitted and responded to whatever currents came back to it—another dance of agency. Its purpose was to achieve equilibrium in this process by randomly reconfiguring its inner circuitry (changing the values of resistors) until the currents tended to zero, so that the dance became a choreography of agency.

Four points about the homeostat follow. First, as just stated, it was another example of a purposeful, goal-oriented agent. Second, the pursuit of its goal was an emergent process, randomly moving through possible configurations. We could say that the homeostat was itself a model of emergence, confronting us directly with emergence in action.[12] Third, we could note that the upshot of this search process was *adaptation*, the achievement of a stable relation between the machine and its environment. The homeostat thus illuminates an even higher-order conception of agency, going beyond simple goal-orientation to active search and adaptation.[13]

And fourth, of course, the homeostat model of search and adaptation carries over directly to biological phenomena. A research psychiatrist by profession, Ashby built the homeostat in his spare time as a way of understanding the brain as an organ, not of cognition, but of performative adaptation.[14] At the same time, he saw in the homeostat a model of biological evolution, another open-ended search process (e.g., Ashby 1952, 1960). The homeostat shows us, then, a route to build up from a minimal conception of agency through goal-orientation to adaptation in both the machine and the organism.

Conclusion

In the first part of this essay, I explored the ontological space mapped out in STS around the minimal sense of agency as "doing something." STS is about relations between people and things, while in the second part we have been concerned with things amongst themselves. I have tried to draw inspiration from cybernetics in connecting the minimal conception of agency to higher-level conceptions that include goal-orientation, inscrutability and search—beginning with a subset of machines and then noting how the analysis transfers over to distinctly biological topics.

To conclude, I should notice that the slide from machines to organisms is contentious. Many authors, including those cited above, are happy to make it. Others, like Daniel Nicholson (2013, 2018), want to make a sharp difference between organisms and machines. It seems to me that some of these distinctions are overdrawn. It is, for example, hard to agree with Nicholson's blanket assertion that "the most significant difference between organisms and machines is that the former are intrinsically purposive whereas the latter are extrinsically purposive" (2013, p. 669)—it seems forced to say that thermostats, robot tortoises, and homeostats do not have intrinsic purposes.

Other candidate distinctions are harder to contest, especially the idea that organisms are self-organizing systems existing far from thermodynamic equilibrium, while machines, including the cybernetic ones just discussed, are not (e.g., Nicholson 2018). Whether such distinctions are important must depend on one's aims in making them.[15] I cannot take this line of thought further here, except to note that self-organization itself has been another distinctive topic of cybernetics (von Foerster 2014), and that the key inorganic system to think about in this connection might be the "threads" and "whiskers" that Stafford Beer and Gordon

[11] See also Stuart Kauffman's (1971) discussion of "articulation of parts explanation" in biology. In mathematics, the parallel to this is the emergent behavior of simple cellular automata: Wolfram (2002). We could note that the original theoretical model of autopoiesis was a cellular automaton: Varela et al. (1974).

[12] In fact, the homeostat had 25 possible inner states, so its search space has to be seen as a sawn-off version of emergence, pointing towards open-ended search but not getting there. Ashby's archetypal set-up consisted of four interconnected homeostats, collectively spanning 390,625 states. This finitude of possible states implies the limit on a system's adaptability that became known as Ashby's Law of Requisite Variety (Ashby 1956).

[13] The contrast here is with the "passive" adaptation of the thermostat to whatever fluctuations impinged on it. A thermostat responds to its environment; a homeostat interrogates it.

[14] This emphasis on the brain as performative is one of the points of divergence between cybernetics and symbolic AI, which emphasised instead representation and cognition.

[15] Froese and Stewart (2010) argue that Maturana's conception of autopoiesis cannot identify what is singular about organisms because of its origins in Ashby's work, which in the end amounted to a general and nonspecific theory of everything (Pickering 2010, Chap. 4). Bich and Arnelios (2012) dispute the centrality of Ashby's work and ascribe a rather different intellectual context to Maturana's ideas.

Pask experimented on in the late 1950s and early 1960s—electrolytic metal dendrites that indeed organized and recreated themselves in far-from-equilibrium conditions (Pask 1960; Cariani 1993; Pickering 2009, 2010, Chap. 7).

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