Chapter 8

Scientonomy and the Sociotechnical Domain

Paul Patton

University of Toronto

Abstract: The *sociotechnical domain* is the realm of scientists, the communities and institutions they form, and the tools and instruments they use to create, disseminate, and preserve knowledge. This paper reviews current scientonomic theory concerning this domain. A core scientonomic concept is that of an *epistemic agent*. Generally, an *agent* is an entity capable of intentional action—action that has content or meaning due to its purposeful direction towards a goal. An epistemic agent is one whose actions are the taking of epistemic stances, such as acceptance or rejection, towards epistemic elements, like theories or questions. An epistemic agent must semantically understand the propositions in question, and their alternatives, and choose among them with reason, with the motive of acquiring knowledge. The most obvious example of an epistemic agent is an individual human being. Rejecting the network of practitioners view, current scientonomic theory argues that appropriately organized communities of scientists can also function as epistemic agents. Communal epistemic agents are of particular scientonomic importance. Whereas the methods of theory assessment of individual scientists can be idiosyncratic, scientonomic theory contends that the taking of epistemic stances by scientific communities is a lawful, rule-governed process. A second concept of central importance is that of an *epistemic tool*. A physical object or system is an epistemic tool for some epistemic agent if there is a procedure by which the tool can provide an acceptable source of knowledge under the method employed by that agent. The agent is then said to *rely* on the tool.

Keywords: sociotechnical domain; epistemic agent; communal epistemic agent; epistemic tool; social ontology; distributed cognition

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1. Introduction

Scientific change is the process by which the theories accepted by some agent as the best available description of its object, and the questions taken as objects of inquiry, change over time. Scientonomy initially focused primarily on these elements and the process of change itself. However, science is an embodied activity practiced by communities of human beings. They rely on simple and sophisticated tools to conduct research. A number of scientonomic works have begun to explore the entities and relations of what I will here call the sociotechnical domain; the domain of the agents of scientific change and their tools. These works draw ideas from earlier theories of scientific change (Barseghyan, 2015), social ontology (Loiselle, 2017; Overgaard, 2017, 2019; Overgaard & Loiselle, 2016), and the philosophy of cognitive science and biology (Patton, 2019) as sources of inspiration in formulating an ontology of the sociotechnical domain. The body of scientonomic literature reviewed in this chapter offers an alternative to the networks of practitioners view advocated by Bruno Latour and some others (Latour, 1987, 2005; Latour & Woolgar, 1986). It incorporates a robust view of the role of communities, instruments and tools in science, as well as the concept of distributed cognition that has emerged and gained currency in cognitive science and associated philosophy. In a distributed cognitive system, cognitive processes extend beyond the minds of individual agents to encompass tools and instruments, and other agents (Clark, 2001, 2007, 2008, 2010; Clark & Chalmers, 1998; Giere, 2002, 2003, 2004, 2007; Giere & Moffatt, 2003; Palermos & Pritchard, 2016; Palermos, 2011).

2. The Epistemic and Sociotechnical Domains

Scientonomy is a descriptive field that posits that the process of scientific change observes general principles, which it seeks to uncover (Barseghyan, 2015).[1] As a human activity, the production of knowledge can be understood in terms of two closely interrelated domains, which we will here call the *epistemic domain* and the *sociotechnical domain*. Loosely speaking, the epistemic domain is the realm of scientific ideas and the sociotechnical domain is the realm of scientists, the social communities and institutions they form, and the tools and instruments they use in the course of creating, disseminating, and preserving knowledge. The epistemic domain has so far been the principal focus of scientonomy. We will begin by briefly reviewing its main features as

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[1] https://www.scientowiki.com/Scientonomy_(Barseghyan-2015)

they are currently envisioned by scientonomic theory, before turning our attention to our primary topic; the sociotechnical domain.

The *epistemic domain* can be defined as the set of all epistemic elements. Two sorts of epistemic elements are currently accepted within scientonomy; *questions* and *theories*. A question is a topic of inquiry (Rawleigh, 2018)[2] and a theory is a set of propositions (Barseghyan, 2018; Sebastian, 2016).[3] There are three sorts of theories, *definitions*, *descriptive theories*, and *normative theories*. A definition states the meaning of a term (Barseghyan, 2018).[4] A descriptive theory is a set of propositions that attempts to describe something (Sebastian, 2016),[5] and a normative theory is a set of propositions that attempts to prescribe something (Sebastian, 2016).[6] A *method* is an especially notable type of normative theory. It is a set of requirements for employment in theory assessment (Barseghyan, 2018).[7] Theories are related to questions and to one another. A theory is an answer to a question, and a question can presuppose a theory (Rawleigh, 2018). For example, the question 'What is the mass of the electron?' presupposes theories that electrons exist and have mass. The accepted answer to this question is the theory that states that the mass of an electron is $9.1x10^{-31}$ kilograms (NIST, 2018).[8]

The *sociotechnical domain* includes both communities of human beings and the instruments and tools they use to generate and transmit knowledge. From Plato's Academy in Ancient Greece, to the Intergovernmental Panel on Climate Change today, social cooperation has played a central role in the creation of scientific knowledge (Barseghyan, 2015, pp. 43-52; Overgaard, 2017, 2019; Patton, 2019). Tools and artifacts used for observation, measurement, recording, computation, as an aid to reasoning, and as a means to preserve and disseminate symbolically expressed epistemic elements likewise play a central role in the process of scientific change. Tycho Brahe's careful measurements with quadrant and sextants, Galileo's use of the telescope, and the recording of their observations with quill and paper were clearly important to the formulation and acceptance of heliocentric astronomy in the sixteenth and seventeenth centuries. Experiments with giant particle accelerators, calculation and reasoning with pencil and paper, blackboard and chalk, and powerful computers

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[2] https://www.scientowiki.com/Question_(Rawleigh-2018)
[3] https://www.scientowiki.com/Theory_(Sebastien-2016)
[4] https://www.scientowiki.com/Definition_(Barseghyan-2018)
[5] https://www.scientowiki.com/Descriptive_Theory_(Sebastien-2016)
[6] https://www.scientowiki.com/Descriptive_Theory_(Sebastien-2016)
[7] https://www.scientowiki.com/Method_(Barseghyan-2018)
[8] Recently Kye Palider (2019) has proposed another sort of relationship connecting theories with other theories – that of *reason*.

and the dissemination of ideas through printed journals available in libraries were equally essential to the formulation and acceptance of the standard model of particle physics in the twentieth century. Even in the formal sciences, physical tools are essential to all but the most rudimentary mathematical and logical computations because of the limitations of human memory and computing ability (Rumelhart & McClelland, 1986, pp. 44-48; Dehaene, 2011). In what follows, I will review past work towards the development of a scientonomic theory of this sociotechnical domain.

3. Entities and Relations in the Sociotechnical Domain

In order to incorporate the sociotechnical domain of scientists and their tools and instruments into scientonomic theory, we need a guiding ontology that identifies the relevant entities and their relations to one another. Barseghyan (2015, pp. 48-52) considered two levels at which we might look for such sociotechnical entities and relations – the level of the beliefs of the individual scientist and the level of the scientific community and its mosaic of accepted theories and employed methods.

According to Overgaard (2019, pp. 12-64), Barseghyan's levels correspond to two different approaches that have guided research in the philosophy, history, and sociology of science. He calls them the conceptual frameworks camp and the networks of practitioners camp. The conceptual frameworks camp consists of those scholars who regard intellectually and culturally unified communities of researchers as the bearers of knowledge and the units of analysis we must study to understand the process of scientific change. Such communities might include the scientific community as a whole, a particular disciplinary community, or an individual research lab. Many past theories of society, including past theories of scientific change, like those of Kuhn and Lakatos, have been grounded in the conceptual frameworks view (Overgaard, 2019, pp. 12-40).

Critics of the conceptual frameworks camp contend that, when scrutinized carefully, social communities dissolve into a complex hash of unique and distinctive individuals and their relationships to one another, with no clear boundaries to this network of relationships. The concept suffers, it is claimed, from the same problems as essentialist classifications of organisms in modern evolutionary biology (Overgaard, 2019, pp. 32-39; Mayr, 2006; Sober, 2006), which flounder over the unique and distinctive combinations of traits produced by sexual reproduction and the independent inheritance of genes. Rather than being ontologically real features of the social world, communities are artificial illusions foisted onto an unruly world by social theorists.

Having decided that communities do not exist, the networks of practitioners camp focuses on individual scientists and the networks of material and social interactions in which they engage. The most noted such approach is Latour's actor-network theory (Overgaard, 2019, pp. 41-47; Latour, 1987, 2005). Latour's theory supposes an indefinitely large network of actors in which both human beings and instruments and tools play symmetrical roles and possess agency. The claim that tools and instruments possess agency is Latour's way of capturing the causal role that the structure of the natural world plays in science. The network of practitioners framework suffers its own set of ontological and other problems. Overgaard (2019, p. 63) notes that networks incorporating social and natural entities on an equal footing blur the distinction between the social and the natural world. Giere (Giere, 1992; Giere & Moffatt, 2003) has also pointed out that the theory ignores relevant and important ideas deriving from cognitive science. Rejecting what they suppose is a dubious focus on communities and abstract theories, proponents of the network of practitioners approach seek to ground the study of science empirically by the direct study of scientific practice in the laboratory, shifting the focus away from scientific theories. Overgaard (2019, pp. 61-64) takes this approach to be the dominant one in current science studies.

From its beginning, scientonomy, like earlier general theories of scientific change, has been aligned with the conceptual frameworks camp, taking the concept of communities, and what we have called epistemic elements to be centrally important to the process of scientific change (Barseghyan, 2015, pp. 43-52). Barseghyan (2015, p. 43) wrote that "when we speak of some transformation in science, we don't mean that this or that great scientist has changed her mind and decided to accept a new theory or employ a new method, but that the scientific community *as a whole* has rejected some elements of the mosaic and replaced them with new elements". He further argued that the past failure to find a lawful process of scientific change has been due to the historian's tendency to conflate the individual with the social, and to focus on the idiosyncrasies of prominent individual scientists rather than on the behavior of scientific communities as a whole (Barseghyan, 2015, pp. 45-47). Further, he supposed that the behavior of the community is neither determined by elite individual scientists, nor is it the simple summation of the individual views of all the members of the community. He supposed instead that the relationship between the individual and community involved complex social dynamics (Barseghyan, 2015, pp. 48-51).

Subsequent scientonomic work concerning the sociotechnical level has thus focused on justifying the existence of communities as distinct and ontologically real social entities amenable to scientific study. Such a justification was provided by the work of Overgaard (Loiselle, 2017; Overgaard, 2017, 2019; Overgaard & Loiselle, 2016), who drew on the findings of social ontology (Lawson, 2014; Searle, 2006; Tollefsen, 2014; Tuomela, 2002) to argue that what he called *epistemic communities* were both ontologically real and methodologically accessible for study. Overgaard's work was further refined and elaborated by Patton (2019), who drew inspiration primarily from work in the philosophy of cognitive science and biology (Clark, 2001, 2007, 2008, 2010; Clark & Chalmers, 1998; Giere, 2002, 2004, 2007, 2010; Palermos & Pritchard, 2016; Palermos, 2011; Palermos, 2016; Theiner, 2014; Theiner, Allen, & Goldstone, 2010; Theiner & O'Connor, 2010; Wimsatt, 2006, 2007) to formulate the concept of an *epistemic agent*, that may be either individual or communal. I sought to explicate the nature of the emergent relationship between individual and communal epistemic agents. I also explicated the role of scientific tools and instruments as *epistemic tools* (Patton, 2019). Following Clark, Giere and others, I maintained the central importance of distributed cognition in understanding this role. In this chapter, I will review this past work and survey our current understanding of the entities and relations of the sociotechnical domain.

4. Agency, Intentionality, and Epistemic agency

To understand the role of individual human beings, and communities of human beings in the production of knowledge, and to discern whether and how that role is distinct from that played by tools and instruments, we need a definition of *epistemic agent*; the actor in the process of scientific change. We begin with the more general concept of an *agent*. An agent has typically been defined as an entity capable of *intentional action* (Schlosser, 2015). To understand what is meant by intentional action, we must first consider the more general concept of *intentionality*.

Intentionality is the property possessed by representational states that have content or meaning. Such states are *about* something. They refer to an object. Mental states, like perceptual states or belief states, are the classic examples of states that possess intentionality (Dretske, 1981; Jacquette, 2006; Neander, 2012, 2017, pp. 63-82; Dennett, 1971; Millikan, 1984, pp. 85-94; Overgaard, 2019, pp. 65-70). Many philosophers no longer regard them as the only intentional states. Symbols with semantic content, in a medium external to the body, like spoken words in air, text on paper, instrument readings, computer displays, and software code are taken to exhibit intentionality as well (Dretske, 1981; Jacob, 2019). Proponents of the extended mind thesis argue that such symbols, though external to the body, should not be regarded as external to the mind (Clark, 2008, 2010; Clark & Chalmers, 1998). Leaving aside the question of whether or not such items are constituent parts of the mind, proponents of distributed cognition regard them as intentional bearers of cognitive content (Giere, 2002; Giere &

Moffatt, 2003; Rumelhart & McClelland, 1986, pp. 44-48). Other biological states, such as the arrangement of nucleotide base pairs in the genome of an organism, are also said to possess intentionality, since they perform the function of containing semantic information for the system of which they are a part (Dretske, 1981; Fitch, 2008; Godfrey-Smith, 2006; Godfrey-Smith & Sterelny, 2016). This broad understanding of intentionality will be of considerable importance when we turn to the discussion of epistemic tools. The suggested definitions are presented in Figure 8.1.

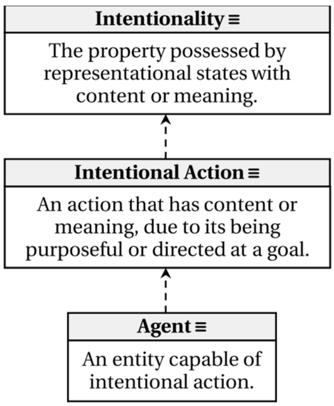

Figure 8.1: The taxonomy of 'intentionality', 'intentional action', and 'agent'

When we say that an agent's actions are intentional, what we mean is that they have content or meaning because they are purposeful, directed towards a goal, or performed for a reason. By some accounts, this is because they are caused by the agent's mental states. This has made the concept of agency problematic for naturalists, since, as traditionally understood, it seems to involve dualistic notions of mental causation that are irreconcilable with physical causation (Jacquette, 2006; Schlosser, 2015). But, a number of authors have proposed naturalistic accounts of agency in which intentional states supervene on appropriate physical states, or are simply a way of interpreting those states. On this account, mental or intentional causation is real, but as a species of physical causation, arising when a physical system has the appropriate special state of dynamical organization, such as that possessed by an organism and its brain in interaction with the world (Dennett, 1984, 1987, 1991, 2003; Fulda, 2016; Giere, 2004; Schlosser, 2015; Walsh, 2012, 2016; Walter, 2009, pp. 239-268; Thompson, 2007, pp. 37-65). More broadly, agency appears to be a universal organizational feature of living systems, evident in the flexible goal-directed behavior of bacteria and other single-celled organisms, as well as in the behavior of the cells that make up multicellular organisms (Walsh, 2015, pp. 208-229; Fitch, 2008; Fulda, 2016, 2017; Walsh, 2016). It has also been argued that a derived form of agency is present in goal-seeking engineered systems as well, with thermostats being a simple example (Dennett, 1987, pp. 37-42).

Barseghyan (2018) was the first to introduce the concept of an epistemic agent in scientonomy, and a definition and theory was formulated by myself (Patton, 2019). My definition of epistemic agent is grounded in the general definition of agent explained above. Under that definition, an agent can be seen as an entity capable of perceiving its environment and acting within it with a motive or in pursuit of a goal, choosing among multiple courses of action to best fulfill that goal. For an epistemic agent, the relevant environment consists of epistemic elements, which, as we have noted, include theories, questions, and methods. The epistemic actions of an epistemic agent are the taking of epistemic stances towards these elements, such as accepting or pursuing a theory, or employing a method. To qualify as an epistemic agent, the agent's goal in doing so must be to acquire knowledge of the world (Figure 8.2).

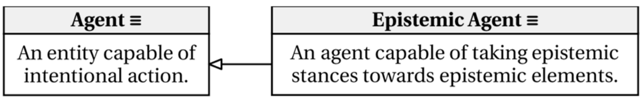

Figure 8.2: The definitions of 'agent' and 'epistemic agent'

Thus, a random number generator, selecting among various versions of string theory proposed by physicists is not an epistemic agent. To constitute an exercise of epistemic agency, an agent's taking of an epistemic stance must be an intentional action, and for this to be the case, two conditions must be met: 1) the agent must have a semantic understanding of the propositions that constitute the epistemic element in question and its available alternatives, and 2) the agent must be able to choose among the available alternatives with reason, and for the motive of acquiring knowledge. In scientonomic terms, the normative epistemic strategy which an agent deploys in assessing a theory is the agent's *method* (Barseghyan, 2018).[9] When fabricating and planting the fossils, the perpetrator of the Piltdown Man hoax, most likely Charles Dawson (Donovan, 2016), was not acting as an epistemic agent since he almost certainly did not accept the theory that forgery was a valid route to knowledge of human evolution. Epistemic agency involves the employment of the norms of epistemic honesty one accepts (Goldberg, 2016). When astronomer Arthur Eddington made his careful and meticulous observations of stars near the sun in the sky during a solar eclipse, he was acting as an epistemic agent. This is

[9] https://www.scientowiki.com/Method_(Barseghyan-2018)

because, under the method he employed, Einstein's theory of general relativity was more likely to be true if its unexpected novel prediction that the gravitational field of the sun bends starlight were correct, and because Eddington employed the rigorous standards of observation, measurement, and epistemic honesty that he accepted as necessary for astronomical observation (Isaacson, 2007, pp. 255-262).

Who or what can be an epistemic agent? Scientonomy takes epistemic elements to be propositional. It has, so far at least, also taken propositions to be sentential; that is, they are expressible by a sentence or sentences of a natural language, mathematics, or logic. Thus, non-linguistic animals and pre-linguistic human infants can be ruled out as epistemic agents, since they lack the requisite ability to semantically understand sentential propositions. This leaves the most obvious example of an epistemic agent as the typical individual human being. Such an individual can, given appropriate education and training, understand the propositions that constitute an epistemic element, and its alternatives. They can choose among these alternatives with reason, with the goal of acquiring knowledge of the world. It should be evident that individuals may vary, one from another, in the degree to which they satisfy the definition of an epistemic agent. Their degree of semantic understanding of the epistemic elements in question, for example, may vary with experience, education, and professional training. The sincerity of their commitment to the goal of acquiring knowledge of the world may also vary, as indicated by their adherence to norms associated with epistemic honesty.

5. Communities as Epistemic Agents

Whenever epistemic elements are explicitly stated as sentential propositions, they can be shared with other epistemic agents. While typical individual human beings clearly do satisfy our definition of epistemic agent, the point of central importance for scientonomy is whether or not communities that include multiple individuals can do so. In order to claim that communal epistemic agents are ontologically real, we must show that they satisfy the conditions for epistemic agency in their own right, as distinct from the individual epistemic agents which they include as constituent parts. If they do really exist, then any account of scientific change that left them out would be seriously deficient. Further, they, and the circumstances which bring them about, must be amenable to empirical study through historical or sociological research. I will argue here that they do exist and are amenable to empirical study, drawing primarily on the scientonomic work of Overgaard (2017, 2019). The idea of social communities as ontological elements and as agents has been developed in depth by social ontologists (Lawson, 2014; Searle, 1995, 2006; Tollefsen, 2014; Tuomela, 2002), and has been applied to the concept of epistemic communities by a number of authors (Overgaard, 2017, 2019; Palermos & Pritchard, 2016; Palermos, 2016; Theiner & O'Connor, 2010; Tollefsen, 2004, 2006).

The taxonomy diagram in Figure 8.3 presents definitions and relationships associated with epistemic communities as formulated by Overgaard (2017, 2019).

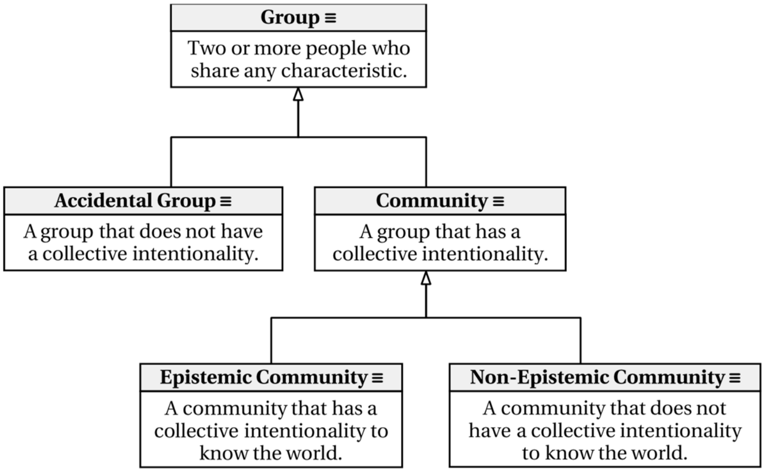

Figure 8.3: The taxonomy of 'group', 'community', and 'epistemic community'

A *group* consists of two or more individuals sharing any characteristic. The set of people with blue eyes who are fans of the Green Bay Packers football team is an example. Groups may be defined, essentially arbitrarily, based on any collection of traits. *Accidental groups* are those groups that just happen to contingently share some collection of traits. Members of such a group need not necessarily be agents. Social ontologists distinguish a *community* as a very special sort of group consisting of agents that share a *collective intentionality*, that is, that are organized to jointly pursue a collective goal or purpose (Overgaard, 2017, 2019).

Collective intentionality is not simply shared intentionality. A group of parents that share an intention to raise their children do not share a collective intentionality because they each direct similar intentional actions separately towards their own children. A football team or a symphony orchestra does share a collective intentionality because the intentional actions of individuals make distinctive coordinated contributions towards a singular collective goal--such as winning the game or playing the symphony. The sharing of a collective intentionality is not merely an incidental or accidental feature of membership in a community; it is the *essential* feature of membership, by which members can be distinguished from non-members.

Overgaard (2017) defines an epistemic community as one that has a collective intentionality to know the world. More specifically, an epistemic community may seek to answer a particular question, or set of questions that have been accepted as legitimate topics of inquiry (Rawleigh, 2018). Those questions might, for example, be those delineating a particular scientific discipline (Patton & Al-Zayadi, 2021). Members of that particular epistemic community can be identified by their coordinated efforts with other members of that community to answer that question or those questions that are the particular object of that community's collective intentionality. The members of a research group might coordinate their actions to perform an experiment aimed at answering a particular question, with each making their own distinctive contribution towards its success. The outcome might be a single co-authored published paper containing a theory which answers the question at issue, and is accepted by the entire team.

Just as individual agents can be constituent parts of an epistemic community if they perform a distinctive coordinated role within the collective intentionality of that community, so can other epistemic communities (Overgaard, 2017). Thus the scientific community of the modern world shares a collective intentionality to know the world by answering all those questions it accepts as legitimate topics of inquiry under its demarcation criteria. Particular disciplinary communities play distinctive specialized roles in fulfilling this larger goal (Patton & Al-Zayadi, 2021). The community of physicists deals with those questions generic to the behavior of matter and energy, the astronomical community answers those questions dealing specifically with celestial objects, the geological community with those questions dealing specifically with the constituent parts of the Earth and other such planetary bodies, the biological community those questions distinctive to living systems, and the psychological community those questions specific to the mental processes and behavior of living systems. Such a hierarchy of communities and subcommunities continues to the level of individual research laboratories and their members. A hallmark feature of collective intentionality is a *division of epistemic labor* in which different epistemic agents perform distinctive specialized roles towards the fulfillment of a goal that no one person could possibly possess the skills, education, and training to accomplish by themselves.

For an epistemic community to qualify as an epistemic agent in the sense defined above, it must be capable of taking stances towards epistemic elements. Those stances must distinctively belong to the communal agent itself, rather than to its constituent agents, taken separately. There are good reasons for supposing that an epistemic community can possess some properties that belong distinctively to it, rather than to its constituent individual agents taken separately. Systems with multiple interacting parts, if those parts are appropriately organized in relation to one another, exhibit *emergent properties* that are the product of that organization rather than of any of its constituent parts, taken separately (Bedau, 1997; Kim, 1999; O'Connor & Yu Wong, 2015; Wimsatt, 2006, 2007, pp. 274-312). Such properties belong to the system as a whole rather than to any of its parts.

Wimsatt (2006, 2007, pp. 274-312) defined the emergent properties of a system as those that depend on the way its parts are organized. An *aggregate system* is one whose parts do not bear an organized relationship to one another. The parts all play similar roles and can be interchanged or rearranged without any consequence. The properties of the whole are an additive, statistical consequence of those of its parts. There are no emergent properties. A jumbled pile of mechanical parts is an example of an aggregate system. Its properties, like its mass or its volume, are just the sum of the masses and volumes of its parts.

A *composed system,* on the other hand, is one that possesses emergent properties due to the way in which its parts are organized in relation to one another. A clock assembled by arranging mechanical parts in the proper causal relationship to one another is an example of a composed system. The clock's ability to indicate the time of day is an emergent property, because no part of the clock possesses that ability on its own. The parts are organized so that there is a division of labor among them, and each plays its own distinctive role in the production of the emergent property. As we have seen, collective intentionality requires that a community be organized in such a way that each individual agent plays a distinctive role in the fulfillment of the community's shared goal. Thus, communities, including epistemic communities, seem likely to possess emergent properties belonging specifically to them (List & Pettit, 2006, 2011; Overgaard, 2019; Palermos & Pritchard, 2016; Palermos, 2016; Patton, 2019; Theiner, Allen, & Goldstone, 2010; Theiner & O'Connor, 2010, Wimsatt, 2006, 2007).

To satisfy our definition of an epistemic agent, an epistemic community must be organized such that its decision-making processes lead to epistemic stances that are emergent properties of the community as a whole, rather than the simple aggregate of the decisions of its individual members. Given the properties of epistemic communities as we have outlined them, this seems quite likely to be the case. The individual agents that make up an epistemic community can, by definition, semantically understand epistemic elements. Because they will each have at least somewhat different areas of expertise, they will each bring a different area of semantic understanding to the decision-making process of the community as a whole. Different agents, for example, will be better equipped to assess different premises of an argument. Interactions among such diverse individuals with different areas of expertise would seem to ensure that the views of individual community members are influenced by others, leading the community to take epistemic stances that are distinct from those the same individuals might take if left to their own devices. We will discuss below the concept of authority delegation, in which different epistemic agents are recognized as possessing different areas of expertise in a division of cognitive labor.

In an analysis of legal decision-making, Tollefsen (2004) outlines a simple scenario in which the decisions of a committee might be viewed as emergent and belonging to the committee rather than to its individual agents. The members of a committee are asked to assess each of the premises of an argument separately. In such a case, the conclusion reached by the committee, though following logically from the premises, might not be one that any individual would agree with. Given that different members of an epistemic community will bring different levels of expertise to different premises of an argument, and will be influenced by an awareness of the expertise of others, such scenarios seem an almost inevitable feature of such communities.

Tollefsen's investigations of legal decision-making demonstrate that the weakly emergent properties posited here are in no sense mysterious. Their occurrence in epistemic communities can be investigated empirically in much the same way that Tollefsen did for legal communities. Regardless of the details of the social mechanisms by which they arise, communal epistemic agents are a plausible foundation for scientonomy (Barseghyan, 2015, pp. 48-51; Overgaard, 2019; Patton, 2019, see Figure 8.4).

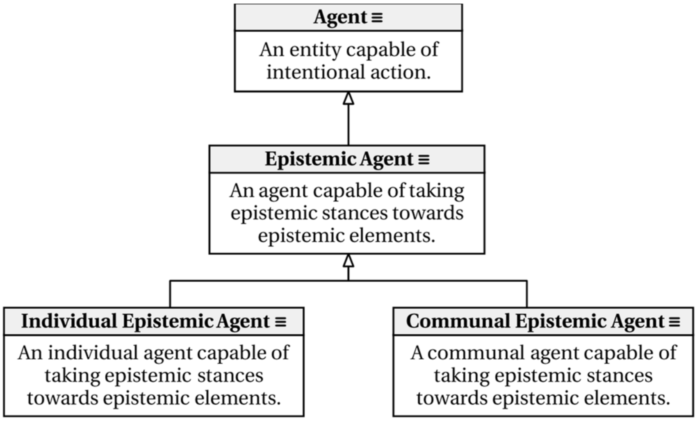

Figure 8.4: The taxonomy of agents

6. The Distinctive Importance of Communal Epistemic Agents

In order to grasp the distinctive importance of communal epistemic agents to scientonomy, it is helpful to consider both their similarities to individual epistemic agents and their fundamental differences, relying, in part, on some ideas from cognitive science. There are some important ways in which the two kinds of epistemic agents bear a closer resemblance to one another than one might, at first, suppose. Fitch (2008) has argued that the living cells that make up individual epistemic agents themselves exhibit a rudimentary form of intentionality and agency, which he calls "nano-intentionality". This nano-intentionality is manifested in the ability of cells to rearrange their own structure in response to damage, nutrient distribution, and other factors of their environment. Fitch regards cellular nano-intentionality as the foundation for the intentionality exhibited by multicellular organisms, including the epistemic agency of human beings. The functionalist view of mind sees cognition as an emergent consequence of the organized causal interaction among elements that are not themselves cognitive (Bechtel, 1988, 2008; Clark, 2008; Levin, 2018). The epistemic agency exhibited by individual epistemic agents is thus a species of collective intentionality, emerging from the organized interaction of vast numbers of individual elements, each possessing only nano-intentionality and together constituting a composed system which exhibits epistemic agency as an emergent property. Investigating the dynamical mechanisms by which epistemic agency arises from the interactions of simpler elements is the subject matter of cognitive neuroscience (Bechtel, 2008; Clark, 2015).

While individual and communal epistemic agents may resemble one another in that both possess cognitive processes emerging from their composed organization, there are few good reasons to suppose they are similar in many other respects. For example, social scientist Karin Knorr-Cetina (2009) has proposed that communal epistemic agents are similar to individual epistemic agents in possessing their own consciousness. This doesn't seem particularly likely given the profound disanalogies between these two sorts of cognitive systems. It also is unclear how one might recognize consciousness in such an unfamiliar form. While the similarities of the two kinds of systems should be noted, their dissimilarities are also profound, and as we will see, critically important to a scientonomic theory of the sociotechnical domain.

An individual epistemic agent consists of a vast number of interacting living cells, in particular, the 86 billion nerve cells, or neurons, of the human brain (Azevedo et al., 2009; Herculano-Houzel, 2009), each of which communicates with as many as ten thousand others by way of patterned discharges of neurotransmitter substance, a relatively simple sub-symbolic vehicle of cognitive content (Bechtel, 2008; Dretske, 1981). By comparison, communal epistemic agents consist of vastly smaller numbers of individual elements. The largest such community known is the global scientific community of the modern world, which is estimated to consist of 7.8 million individual researchers (UNESCO, 2013), a number four orders of magnitude smaller than the number of neurons in the brain of a human individual. The most salient differences, however, concern the nature of the interactions between the elements.

Cognitive scientists once supposed that the inner workings of the individual mind were much like those of the outer world of symbols and formal, rule-based logic that humans have communally fashioned. Cognition was taken to be the inner manipulation of symbols in accordance with rules, as in formal logic, or the function of a digital computer (Fodor, 1975; Newell & Simon, 1976; Putnam, 1960; Turing, 1950). This view of the mind has been rejected. Beginning in the 1980's cognitive scientists began to attend to the architecture of the brain and to study the behavior of simulated networks of neurons (Bechtel & Abrahamsen, 2002; Churchland, 1989; Churchland & Sejnowski, 1992; Dayan & Abbott, 2001; Rumelhart & McClelland (Eds.), 1986). By the end of the century, cognitive neuroscientists saw the mind/brain as a dynamical system whose neural parts were engaged in nested loops of interaction among themselves and with the body and the world (Beer, 2000; Clark, 2015; Friston, 2003; Friston et al., 2017; Hohwy, 2013; Kelso, 1997; Rabinovich et al., 2006; Varela, Thompson, & Rosch, 1997). The partially analog, dynamical and sub-symbolic neural processing which forms the inner workings of individual agents mediates their sensorimotor interactions with the world and their inner cognitive workings, as well as their interactions with one another that do not involve symbolic language.

The exchange which takes place between the individual epistemic agents that make up a communal epistemic agent are of a fundamentally different nature than those occurring between the constituent neural and cellular parts of an individual epistemic agent that has been less frequently recognized. Scientonomy defines epistemic elements as propositional and stateable in sentences of natural language, logic, or mathematics, or as graphical diagrams. These forms of expression, as we have seen, appear not to reflect the inner workings of the mind, but rather the manner in which the outcome of those workings is expressed publicly. The emergent cognitive decision-making processes of communal epistemic agents arise in a very different way than do the inner workings of the individual mind. They emerge by the exchange of symbolic epistemic elements among limited numbers of individual epistemic agents assisted in their decision-making by propositional reason. The concept of epistemic communities as distributed cognitive systems has been explored by a number of researchers, including, notably, Fleck (Fleck, 2012, 1986), Giere

(Giere, 2002, 2004, 2007; Giere & Moffatt, 2003), Theiner (Theiner, 2011, 2014; Theiner, Allen, & Goldstone, 2010; Theiner & O'Connor, 2010), Palermos (Palermos & Pritchard, 2016; Palermos, 2011, 2016), and Patton (Patton, 2019).

From what we have seen about the distinctive cognitive properties of individual and communal epistemic agents, it would not be at all surprising to find that the epistemic stances of communal epistemic agents have new properties that are not present in those of individual epistemic agents. There are good arguments that such distinctive properties do exist. Longino (Longino, 1990, 1996, 2019) has argued that when communities have normatively appropriate structures, critical interactions between individuals holding different points of view and influenced by differing contextual biases mitigate the influences of their individual subjective preferences. This allows communities to obtain a level of objectivity in their taking of epistemic stances that is seldom possible for individual epistemic agents.

Similarly, Barseghyan (2015, pp. 43-52) has noted that the methods of theory assessment employed by individual scientists are often idiosyncratic, and attempts to identify a lawful process of scientific change through the study of individual scientists have not proved successful. Paul Feyerabend's conclusion that scientific change is not a rule-based process, for example, was based largely on his studies of Galileo's personal epistemic practices. He suggests that a lawful process of scientific change arises from the non-aggregative properties of communities of the sort developed in much greater detail here, and elsewhere in the literature of group cognition as noted above. Current scientonomic theory posits that the taking of epistemic stances by communal epistemic agents is a lawful, rule-governed process, and a number of laws of scientific change have been identified by Barseghyan (2015, pp. 123-243) and other scientonomic authors (Fraser & Sarwar, 2018; Patton, Overgaard, & Barseghyan, 2017; Sarwar & Fraser, 2018). These laws, described by scientonomy, can be understood as implicit norms of rationality employed universally by communal epistemic agents. It should be stressed, however, that the goal of scientonomy is not to prescribe epistemic norms, but rather to empirically describe the norms actually employed by communal epistemic agents. The posited laws are amenable to empirical testing against historical evidence. We envision such testing as a central activity of what has been called observational scientonomy (Barseghyan, 2018).

7. Authority Delegation

We have already developed the idea of communal epistemic agents as composed systems in which different constituent agents play distinctive roles in a division of epistemic labor. The concept of authority delegation was formulated by Overgaard and Loiselle (Overgaard & Loiselle, 2016; Loiselle, 2017) to describe the relationship of interdependence between such epistemic agents having different areas of expertise. They supposed that this relationship was applicable to both communal and individual epistemic agents (Figure 8.5).

Authority Delegation ≡
Epistemic agent A is said to be delegating authority over question x to epistemic agent B *iff* (1) agent A accepts that agent B is an expert on question x and (2) agent A will accept a theory answering question x if agent B says so.

Figure 8.5: The definition of 'authority delegation'

As mentioned earlier, epistemic agency can vary as a matter of degree. Agents can vary in the degree to which they semantically understand the theory being assessed and its alternatives. They can also vary in their devotion to the goal of pursuing knowledge, as reflected in adherence to norms associated with epistemic honesty (Machado-Marques & Patton, 2021). Authority delegation reflects an assessment of such matters. The concept is reducible to theories and the stances of agents towards them. Overgaard and Loiselle used examples drawn from art-related agents (Overgaard & Loiselle, 2016; Loiselle, 2017), as indicated in Figure 8.6.

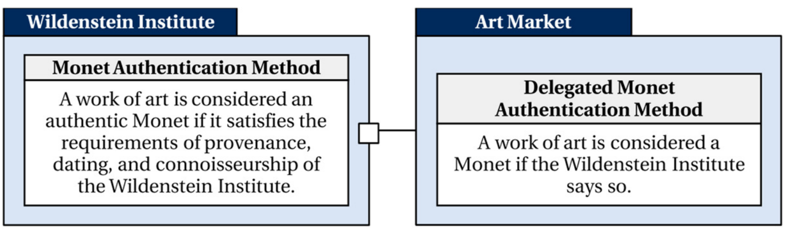

Figure 8.6: A diagram showing a case of authority delegation

The diagram indicates the employed method of the art market community and that of the Wildenstein Institute. The square symbol represents authority delegation. Loiselle noted that the art market community – the community responsible for buying and selling works of art – accepts the theory that the Wildenstein Institute is an expert on determining the authenticity of Monet paintings. Delegating to the Wildenstein Institute is thus its employed method, deduced from that theory, of accessing the theory that some particular painting was a work of Monet. The Wildenstein Institute's authority rests on its ability to justify its own employed methods for assessing the authenticity of a Monet painting, and its application in individual cases, in terms of the accepted theories from which it was deduced. Its authority also rests on the acceptance of the theory that its assessments are in accord with norms associated with epistemic honesty, and will not be swayed by non-epistemic factors, such as the offer of a bribe.

In populations of living organisms, traits are inherited in an independent and largely uncorrelated fashion, making each a unique individual and defeating all attempts to forge essentialist biological categories based on constellations of essentially shared traits. Differences in biology, environment, and upbringing likewise make each human being a unique individual, and make social scientists understandably leery of essentialist categories. But epistemic communities are not the product of undirected biological or social processes. They are intelligently designed social artifacts assembled for the purpose of pursuing knowledge. The assessment of theories regarding authority delegation by epistemic agents who semantically understand the theories they are assessing is one part of this design process. As in the design of a complex technological system, there are many designers and their actions may not be entirely coordinated with one another, but there is nonetheless a design process. Epistemic communities can thus be successfully identified as such based on the shared essential trait of collective intentionality. Note that not all members of such a community need to be aware of this collective intentionality in order to participate in it through their epistemic actions. In order to act as intelligent designers of such a community, however, it must be the case that at least some of its individual members harbor at least a partial semantic understanding of their creation. It is entirely possible that different designers of such a community understand different specialized aspects of its organization, and that the design of the community is itself an exercise of communal epistemic agency.

Since historical records reflect the designers' understanding of their own creation, the empirical study of epistemic communities does not seem to involve special difficulties. Membership in a community can be recognized by such things as the garnering of a faculty appointment in a particular discipline, membership in professional societies, and attendance of conferences. The professionalization of science is a phenomenon that began in the eighteenth and nineteenth centuries. The nature of communal epistemic agents prior to that time is an important matter for historical inquiry. Community acceptance of an epistemic element can be assessed, for modern communities at least, by noting the contents of textbooks, encyclopedias, and university curricula. Membership in a research group can typically be determined by co-authorship of published papers.

8. What are Epistemic Tools?

We have so far reviewed the role of epistemic agents in current scientonomic theory. I have argued that communal epistemic agents exhibit a kind of emergent distributed cognition that is distinct from the cognitive activities of their constituent individual agents taken separately. This is because communal epistemic agents are composed systems organized so that their constituent epistemic agents take on distinctive roles in a division of epistemic labor. This division of labor is as specified by systems of authority delegation. We now turn to a consideration of the role of tools and instruments in the scientonomic theory of the sociotechnical domain. The first discussion of the role of tools and instruments in scientonomic theory was authored by myself (Patton, 2019). Here, I will review the new sociotechnical elements introduced into scientonomic theory by my work with an attention to the role of tools and artifacts in distributed cognition.

Tool use occurs in a variety of animal species (Bentley-Condit & Smith, 2010). Following primatologist Jane van Lawick-Goodall, we can define tool use as the use of an external object as a functional extension of a body part in the attainment of an immediate goal (van Lawick-Goodall, 1970). In the cases we are concerned with here, the immediate goal in question is the acquisition, dissemination, or preservation of knowledge, and the tools we are concerned with are therefore called *epistemic tools* (Patton, 2019).

The simplest type of epistemic tool is a found object. Suppose that I encounter a pit. The bottom of the pit is hidden in darkness. I wish to answer the question 'How deep is that pit?'. Fortunately, I accept several theories that may be helpful in answering this question, which I represent diagrammatically in Figure 8.7.

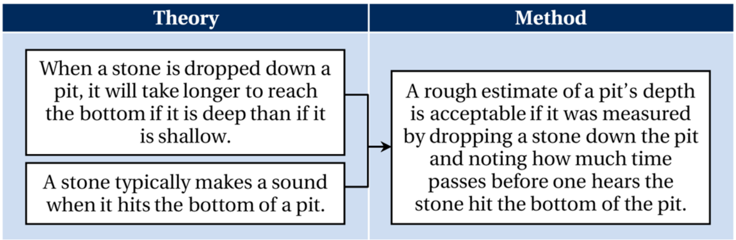

Figure 8.7: A theory-method diagram showing how an employed method is shaped by accepted theories

The theories assert a lawful relationship between the behavior of a stone and the depth of the pit. If they are correct and the lawful relationship does actually exist, then the behavior of the stone carries semantically meaningful information about the depth of the pit, and is a source of knowledge about it (Dretske, 1981, 1983). Using the theories, I formulate the method as stated in the diagram. In accordance with the law of method employment (Sebastian, 2016), the method is a deductive consequence of the theories. Under this method, dropping a stone down the pit, and noting the time interval between the release of the stone and the sound of its impact with the bottom is a normatively appropriate procedure for answering my question. The stone's role in a procedure that is a normatively appropriate way of answering a question given the agent's employed method is what makes the stone an epistemic tool (Patton, 2019).

According to Barseghyan (2015, pp. 7-8), employed methods of theory assessment form a hierarchy from abstract and general to concrete and specific. It is the more concrete levels of this hierarchy that specify epistemic tools and procedures for their proper use, by which acceptable answers to questions may be obtained. The resulting definition of *epistemic tool* is presented in Figure 8.8 (Patton, 2019).

Epistemic Tool ≡
A physical object or system is an epistemic tool for an epistemic agent *iff* there is a procedure by which the tool can provide an acceptable source of knowledge for answering some question under the employed method of that agent.

Figure 8.8: The definition of 'epistemic tool'

On scientonomic diagrams, epistemic tools are depicted by the symbol presented in Figure 8.9.

Figure 8.9: The diagrammatic symbol for depicting epistemic tools

9. The Diversity of Epistemic Tools and Their Role in Distributed Cognition

There are many kinds of epistemic tools. A found object, like the stone, is the simplest example, but epistemic tools are often manufactured artifacts designed to perform their epistemic function. Some of these artifacts simply extend our perceptual capacities. According to accepted acoustic theories, the stethoscope augments the capabilities of the human ear, allowing its user to hear faint sounds within the human body. There are procedures by which a skilled user can garner knowledge suited to answering a variety of questions about health and disease which will be acceptable under the currently employed methods of modern medicine. Windows, mirrors, microscopes, telescopes, and a blind person's cane also augment their users' senses.

Much as dropping as stone down a pit creates conditions that allow an epistemic agent to learn the depth of the pit, many other epistemic tools, such as an alchemist's furnace or the Large Hadron Collider, create special conditions or situations useful for scientific inquiry. The Large Hadron Collider, for example, is designed to accelerate beams of subatomic particles to speeds close to that of light and then cause the particles to collide with one another. According to the employed method of subatomic particle physics, data obtained from appropriate observations of such collisions are acceptable for testing the predictions of physical theories such as the standard model of particle physics (Mann, 2019).

It was once the case that spoken language was the only means by which propositions could be formulated and communicated. Human memory was once the only means by which they could be preserved. One subset of epistemic tools consists of those that represent propositions symbolically in a stable physical medium external to the body. This affords a number of means of cognitive enhancement, the simplest of which is the stable preservation of epistemic elements over time and their faithful transmission to other agents. The first such external representations were graphical (Donald, 1991, pp. 269-333). The oldest known human graphical markings where engraved on a rib 200,000 years ago. Graphical markings on bone or ivory did not become prevalent until 40,000 years ago. Various forms of writing and mathematical notation began to appear around 5000 years ago, and the phonetic alphabet, which allowed the graphical recording of spoken language, appeared about 3000 years ago. Clay tablets, written text on parchment or paper, hard drives, memory sticks, and various other data storage and transmission technologies allowed the creation and spread of symbols encoding the propositional knowledge of their authors.

This sort of epistemic tool, in which a physical medium external to the body is used to record symbols which convey epistemic elements, is a very important class of epistemic tool. However, such tools differ in important respects from our earlier examples, and this warrants further discussion. In Dretske's theory (Dretske, 1981, 1983), worldly events contain intentional semantic information about other worldly entities or processes because of their reliable causal relationships to them. An agent can extract this semantic content if their theories provide prior knowledge of these causal relationships. But while such causal relationships may account for the intentional content of the behavior of the stone about to the depth of the pit, or of subatomic particles in the Large Hadron Collider about the regularities posited by the standard model, written symbols don't typically stand in direct causal relationships to the entities or processes to which they refer. The semantic intentional content of such symbols is said to be conferred instead by the relationship in which they stand to an agent or agents who have knowledge of the meaning of the symbols (Jacob, 2019; Nanay, 2006). Given this significant difference, it's worth asking whether our current scientonomic definition of epistemic tool (Patton, 2019) is still applicable to them. By providing a scientonomic analysis of a simple representative example, I will show that it is. Consider a shopping list written with a pencil on paper. The diagram below shows that given accepted theories about shopping lists and written text, and employing a method deduced from them, a shopping list can provide an acceptable source of knowledge for answering a question, as required by our definition of epistemic tool (Figure 8.10).

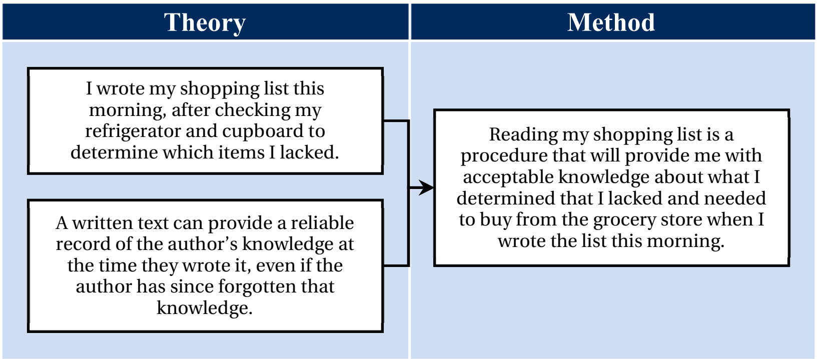

Figure 8.10: A theory-method diagram illustrating how a method can be employed that would allow a shopping list to provide an acceptable source of knowledge for answering a question

Additional features of our definition are probed by another example. In a pioneering work, Clark and Chalmers (1998) asked us to imagine a man, Otto, who carries a notebook with him to remember appointments because he is afflicted with Alzheimer's disease. A woman, Inga, uses neurons in her brain to accomplish the same purpose. They argue that since Otto's notebook performs the same function for him as Inga's neurons do for her that Otto's notebook should be considered a constituent part of his mind. Giere (2007) has advocated the more modest claim that Otto and his notebook form a distributed cognitive system. While accepting that Otto and his notebook form a distributed cognitive system, I wish to point out that the extended mind thesis conflates two different levels of cognitive organization. Because of this conflation, Otto's notebook satisfies our definition of an epistemic tool whereas Inga's neurons do not.

Inga's use of her neurons is not due to her own agency. It is due to the operation of learning processes that are sub-agential constituent parts of her and of which she is unaware. It is also due to evolutionary processes operating over a vast span of time prior to her existence. Because the functional role that Inga's neurons play in her ability to remember appointments is not due to her own agency, it cannot be said to be due to even the implicit acceptance by her of a theory or theories, or of any method deduced from them. This is why her neurons do not satisfy our definition of an epistemic tool. Otto, on the other hand, established his relationship to his notebook purposefully, as a whole behaving agent acting to solve a problem of which he was aware (perhaps with the guidance of other agents, such as his doctor, to which he delegated authority under theories he accepted). He could thus be said, at least implicitly, to semantically understand and accept a theory similar to the one which underwrites my use of the shopping list in the earlier example, from which a method follows under which the notebook is an acceptable source of knowledge. This is why Otto's notebook does satisfy our definition of an epistemic tool.

External representation in a stable physical medium is more than just a means of enhancing memory, it also is necessary in order for a human agent to perform any but the very simplest mathematical or logical computation. As we saw above, the sub-symbolic parallel distributed processing characteristic of the human brain is not well suited to the step-by-step manipulation of symbols according to rules (Rumelhart et al., 1986, pp. 44-48). Most people are lousy at doing math and logic in their head (Dehaene, 2011, pp. 104-128). Our capacities for doing so are vastly enhanced through the use of an epistemic tool like a pencil and notebook or a blackboard and chalk. These tools provide the needed external memory store for human epistemic agents to perform complex multistep symbolic computations (Clark, 2008; Clark & Chalmers, 1998; Dehaene, 2011; Giere & Moffatt, 2003; Rumelhart et al., 1986; Theiner, 2014). The great theoretical physicist Richard Feynman believed that his work took place, quite literally, on paper (Clark, 2008, pp. xxv-xxvi).

The contention that a human agent with a pencil and notebook, performing a mathematical computation, or making a shopping list, constitutes a distributed cognitive system is a highly reasonable one. The mathematical notation and physical diagrams in Feynman's notebook bore intentional semantic content for him. A variety of other physically comparable arrangements of graphite on paper would not. If Feynman's notebook were taken from him, he would have suffered a deficit in his mathematical cognitive abilities, just as surely as he would suffer some other sort of cognitive deficit if his brain were damaged. Feynman and his notebook formed a composed cognitive system in which each component performs a distinctive and complementary function in a division of cognitive labor. Feynman brought to the system a variety of capacities including pattern recognition, semantic understanding, creative insight, and agency. The notebook is capable of none of these things, but brings to the system a capacity that Feynman lacked, namely stable symbolic memory storage. Together the system had emergent cognitive abilities that either component, alone, lacked.

A pencil and paper provide an external memory store that allows a human agent to manipulate symbols according to rules. Computers perform the rule-based symbol manipulation itself. Computers clearly satisfy our definition of an epistemic tool, as there are a plethora of questions for which a computer, used in accordance with an appropriate procedure, can supply an acceptable source of knowledge under a method deduced from a theory appropriate to the question at issue. It would be possible, in principle, to describe the behavior of the computer purely in the language of solid-state physics. But such a description would leave one completely in the dark about why the machine is organized the way it is, rather than in some other way. This ontologically real state of organization can only be grasped by taking what Dennett (1987) called the design stance. A computer is carefully designed so that its inputs and outputs, and everything that happens in between, can be interpreted in a semantically meaningful way by human agents such as programmers or users, as the manipulation of symbols in accordance with rules. This special purposeful state of organization is what makes the aid that the computer provides cognitive rather than simply mechanical. The fact that the computer's rule-based symbol manipulation is quite different from the brain's sub-symbolic dynamical processing does nothing to weaken the claim that the computer and its user together constitute a distributed cognitive system. Such distinctive and complementary capacities are precisely what we might expect in a composed system with its division of cognitive labor.

Some symbolic epistemic tools, such as scales, thermometers, and voltmeters, are designed to produce mathematical symbols representing quantities as their output, thereby permitting quantitative measurement. A voltmeter's output, for example, may be read as the proposition that "this battery generates a voltage difference of 10 volts". Note the semantic content of such readings may be underwritten by Dretske's causal semantics (Dretske, 1981, 1983) since the position of the voltmeter's needle or the digits of its digital display are causally linked to the electrical potential difference between the positive and negative terminals of the battery. The semantic content of the symbols, as discussed above, requires another sort of explanation.

In many modern epistemic tools, quantitative measurement, digital computation, and a semantically interpretable output are combined. Consider a modern DNA sequencer (Heather & Chain, 2016; Hutchinson, 2007). When a prepared sample of DNA is inserted into such a machine the machine determines the order of the four nucleotide base pairs in the sample. This sequence carries the genetic code. The design and use of such a device draws on accepted theories from varied fields, from solid-state physics to molecular biology. The machine reports the base pair sequence as a text string on a computer screen. This output is full of intentional content for a molecular biologist with the appropriate knowledge. Note that the individual user of such a complex epistemic tool is almost certainly not familiar with all of the theories from which its acceptability as a means to acquiring reliable data is deduced. Its use thus typically involves authority delegation to communities familiar with those theories.

10. Epistemic Tool Reliance

Relationships of authority delegation link individual and communal epistemic agents together into larger communal epistemic agents, specifying their division of epistemic labor. What specifies the relationships between epistemic agents and epistemic tools? From what I have said above, it should already be evident that it would not be plausible to suppose that epistemic agents might delegate authority to epistemic tools. Our definition specifies that authority can only be delegated to an epistemic agent deemed to be an expert on some topic *x*. An epistemic agent, in turn, must, by definition, have a semantic understanding of the propositions that constitute the epistemic element in question and its available alternatives, and choose among them with reason. Such an agent, for example, should be capable of justifying its epistemic stances in terms of the relevant employed methods of the community, responding to all objections. It should be obvious, for example, that a voltmeter can't justify the claim that 'this battery generates a voltage of 10 volts'. That role could only belong to an expert familiar, to at least some degree, with the workings of the voltmeter.

The question of whether or not individual or communal epistemic agents ever delegate authority to epistemic tools can only be answered by empirical study of current and historical instances. The challenges typically confronting the users of an epistemic tool can be grasped by considering an incident from the history of radio astronomy (Burke-Spolaor et al., 2010; Gibney, 2016; Petroff et al., 2015). Human-made and natural interference, from varied sources, is a frequent problem for radio astronomers, requiring them to make interference sources a topic of inquiry. Given theories about such interference sources, astronomers can deduce methods of data assessment from them. Such methods ensure that only data derived from astronomical sources is accepted and data derived from interference is rejected. On numerous occasions, astronomers at the 64-meter diameter radio telescope dish at the Parkes Observatory in Australia detected a particular type of fast radio burst which they dubbed a *peryton*. Although these bursts resembled other bursts thought to be of astronomical origin, they also showed some features that, under accepted theories, were tell-tale signs of terrestrial interference. Five separate published research papers focused on identifying the possible source of the interference. A variety of possible theories, including lightning storms or other atmospheric phenomena were assessed and rejected. In the end, the theory that the radio bursts were due to a microwave oven in an observatory lounge became accepted. New methods and norms followed aimed at preventing astronomers from confusing microwave ovens with astronomical signal sources in the future (Patton, 2019).

In Patton (2019), I considered a number of possibilities and could find no instances that could be regarded as the delegation of authority to epistemic tools. As the *peryton* incident indicates, authority delegation seems instead to be to the expert users of the tool in question. Such experts are intimately familiar with theories of the use and pitfalls associated with the tool, and with the methods deduced from them for assessment of data derived from it.

Generally speaking, current and historical epistemic tools do not possess the cognitive wherewithal to be the objects of authority delegation as we have defined it here, since they cannot semantically understand a theory and its alternatives, and choose among them with reason. Cognitive scientists, neuroscientists, and their philosophical allies seek a naturalistic understanding of semantic understanding in terms of the structure and function of brains, and the relationship between organisms and their environment (Morgan & Piccinini, 2018; Neander, 2012). Semantic understanding of propositions is today considered a grand challenge by computer scientists (Embley, 2004). But while such technologies may be on the horizon, they have not yet, to any significant degree, been achieved.

Under our theory, epistemic tools do not possess the properties needed to be the objects of authority delegation. I have reviewed some empirical evidence that they are not, in fact, objects of authority delegation (Patton, 2019). I have therefore proposed a new relationship between epistemic tools and epistemic agents (Patton, 2019). This relationship is epistemic tool *reliance*. It is based on the relationship between epistemic tools and the concrete requirements of an employed method, as already explained. The definition of the term is presented in Figure 8.11.

Tool Reliance ≡
An epistemic agent is said to rely on an epistemic tool *iff* there is a procedure through which the tool can provide an acceptable source of knowledge for answering some question under the employed method of that agent.

Figure 8.11: The definition of 'tool reliance'

Note that, like authority delegation, epistemic tool reliance can be accounted for reductively in terms of acceptance of theories and employment of methods.

11. Conclusion

We have reviewed briefly the entities and relations currently posited by scientonomic theory for the sociotechnical domain. The sociotechnical domain consists of the set of all epistemic agents and epistemic tools. Epistemic agents are of two sorts, individual epistemic agents and communal epistemic agents. The definitions of each are summarized in the diagram. Two sorts of relationships are posited. The relationship of authority delegation exists between epistemic agents, and the relationship of tool reliance that exists between epistemic agents and epistemic tools. I have argued here that the elements of this proposed theory are amenable to empirical testing, refinement, or revision on the basis of historical and sociological research.

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