Discussion Note: Distributed Cognition in Epistemic Cultures*

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In *Epistemic Cultures* (1999), Karin Knorr Cetina argues that *different* scientific fields exhibit *different* epistemic cultures. She claims that in high energy physics (HEP) individual persons are displaced as epistemic subjects in favor of experiments themselves. In molecular biology (MB), by contrast, individual persons remain the primary epistemic subjects. Using Ed Hutchins' (1995) account of navigation aboard a traditional US Navy ship as a prototype, I argue that both HEP and MB exhibit forms of *distributed* cognition. That is, in both fields cognition is distributed across individual persons and complex artifacts. The cognitive system producing the knowledge is heterogeneous. Nevertheless, in both fields we can reserve epistemic agency for the human components of these systems. We do not need to postulate new distributed cognitive agents, let alone ones exhibiting new forms of consciousness.

Introduction. Karin Knorr Cetina's *Epistemic Cultures* (1999) might turn out to be the last great laboratory study of its kind. It involved over a decade of observations at two different laboratories, one in high energy physics and one in molecular biology. It is difficult to imagine anyone again putting so much time and effort into observing the culture of one scientific laboratory, let alone two laboratories in two very different sciences.

Knorr Cetina's reason for engaging in a comparative study of two different sciences is that her main thesis—scientific fields exhibit distinct "ep-

*Received July 2002

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Philosophy of Science, 69 (December 2002) pp. 637–644. 0031-8248/2002/6904-0009$10.00
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https://doi.org/10.1086/344627 Published online by Cambridge University Press

istemic cultures"—is strengthened if she can show that *different* scientific fields exhibit *different* epistemic cultures. In this note I will focus on just one central difference she claims to find. I will suggest that this particular difference appears much smaller than she claims if thought of in a richer way that merges cognitive with social aspects of scientific cultures.

2. High Energy Physics. Knorr Cetina's first and most extensive case is high energy physics (HEP); in particular, experiments done between 1987 and 1996 at the European Center for Nuclear Research (CERN). The scale of this laboratory is suggested by the fact that CERN's Large Electron Positron Collider, located on the border between France and Switzerland, was 27 kilometers around. This collider has now been replaced by a Large Hadron Collider (LHC) coupled with a very large detector called ATLAS. The ATLAS detector itself is 44 meters wide, 22 meters high, and weighs 7000 tons. The ATLAS project involves hundreds of scientists, technicians, and other support personal.

Among the most salient features of experiments at CERN Knorr Cetina finds are these:

(1) The size and complexity of the instrumentation, as noted above.
(2) The size of the collaboration. HEP experiments may have 1000 participants.
(3) Long duration. HEP experiments typically take several years.
(4) Instability of the collaboration. Partly because of the size and long duration of HEP experiments, participants come and go.
(5) Physical separation of the participants. CERN has around 3000 employees, but most of the investigators in individual experiments are employed elsewhere, typically in universities around the world.

These features form the basis for Knorr Cetina's conclusions about the epistemic culture of HEP. A major claim, the subject of a whole chapter, is that HEP experiments have a "post-traditional communitarian structure." One feature of such structures is that authority is distributed. In HEP experiments, expertise confers authority. But expertise cannot be centralized simply because no one person can know everything that must be known to make the experiment work. So, because expertise is distributed, authority is distributed. Along with authority goes responsibility, which also must be distributed. This distribution of authority and responsibility depends on a high level of trust and cooperation within the community. As one would hope, the rewards, such as they are, tend also to be shared. These features provide most of Knorr Cetina's basis for calling the culture of HEP "post-traditional communitarian."

Of course an experiment has leaders, but these, she says, cannot operate hierarchically. Rather than being "on top," the leaders are "in the middle,"

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coordinating more than directing. The result is what Knorr Cetina calls "management by content." What gets done, and when, depends mostly on the technical problems that need to be solved to achieve the goal of a meaningful and reliable result.

Perhaps Knorr Cetina's most provocative idea is "the erasure of the individual as an epistemic subject" in HEP. One cannot identify any individual person, or even a small group of individuals, producing the resulting knowledge. The only available epistemic agent, she suggests, is the extended experiment itself. Indeed, she attributes to the experiment itself a kind of "self-knowledge" generated by the continual testing of components and procedures, and by the continual informal sharing of information by participants. Email now makes it possible for active participants always to be virtually on site at CERN itself no matter where in the world they are physically located. In the end, she invokes the Durkheimian notion of "collective consciousness."

3. Distributed Cognition. I want to suggest that there is a complementary, *cognitive,* account of these experiments to be found in notions of distributed cognition recently developed in the cognitive sciences. Knorr Cetina, in fact, indirectly suggests this approach. In at least a half dozen passages she uses the term "distributed cognition" to describe what is going on in a HEP experiment. Here are two examples:

> the subjectivity of participants is . . . quite successfully replaced by something like distributed cognition. (25)
>
> Discourse channels individual knowledge into the experiment, providing it with a sort of distributed cognition or a stream of (collective) *self-knowledge,* which flows from the astonishingly intricate webs of communication pathways. (173)

These uses of the expression "distributed cognition" are almost always qualified with expressions such as "something like" or "a sort of." Nor is there ever any further characterization of what distributed cognition might be. Moreover, these uses of the term are neither referenced nor footnoted. And, finally, the otherwise wide-ranging bibliography contains no references to works in which distributed cognition is discussed.

My suggestion is that Ed Hutchins' account of navigation aboard a traditional US Navy ship, presented in *Cognition in the Wild* (1995), provides a prototype for constructing a cognitive account of HEP experiments. Of course there are glaring differences between these two cases. The structure of the culture aboard a Navy ship is anything but "post-traditional communitarian." Nor could the lines of communication on a Navy ship be described as "intricate webs." Nevertheless, I think that both situations provide examples of distributed cognitive systems in action.

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4. CERN and the *Palau.* I will limit my attention to a few features of Hutchin's work that might have some counterparts in HEP experiments. Knorr Cetina distinguishes between laboratories and experiments. Laboratories are places where experiments take place. It is primarily experiments, not laboratories, that produce new knowledge. Of course, since experiments use laboratory equipment, parts of the laboratory become parts of the experiment. Likewise, in Huchins' example we should distinguish between the ship and navigation. It is navigational practice, not the ship, that produces the knowledge needed to guide a ship into port. But of course some parts of the ship are also parts of the navigational process.

Both navigation and experimentation are examples of *collective cognition,* which is a special case of distributed cognition. Collective cognition is ubiquitous, although apparently little studied until very recently. Collective cognition occurs whenever two or more people combine individual knowledge not initially shared with the others. Thus, together they produce a cognitive output, some bit of knowledge, that neither could produce alone.

In the case of traditional pilotage, the location of the ship relative to a landmark on the right and the location relative to a different landmark on the left are determined by two different people. Neither learns what the other knows, but both communicate their knowledge to others who can then determine the location of the ship. HEP experiments are more complex and involve many more people, but the collective nature of the knowledge production is similar. Many different people perform different tasks based on what may be known only to themselves, but if everyone does the right things at the right time, the experiment can be run successfully.

Hutchins urges that collective cognition be studied in its own right because it has features not found in individual cognition. Some of these features are just those noted by Knorr Cetina: the distribution of authority, responsibility, and reward, and the need for high degrees of trust and cooperation. None of these features are present in individual cognition. Nevertheless, no matter how important the collective aspects of cognition in HEP experiments, these seem to me not to be what is distinctive about such experiments.

Hutchins argues that cognition can be distributed not only among individuals, but also among individuals and *artifacts.* For example, in determining the location of the ship relative to a landmark, a sailor uses an alidade, an instrument adopted from surveying. With an alidade, a sailor can determine the relative location of the landmark to an accuracy of within one degree. That is to say, the cognitive system consisting of a sailor plus an alidade has an accuracy of one degree. Sailors alone, using only their eyes to determine the angle of a landmark relative to the ship's bow, would be doing well to get within five degrees with any reliability.

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Here is a summary description of collective and distributed cognition.

> *Distributed Cognition:* A situation in which one or more individuals reach a cognitive outcome either by combining individual knowledge not initially shared with the others or by interacting with artifacts organized in an appropriate way (or both).
>
> *Collective Cognition:* A special case of distributed cognition in which two or more individuals reach a cognitive outcome simply by combining individual knowledge not initially shared with the others.

These descriptions are not intended as definitions. I don't think such concepts can usefully be defined by strictly necessary and sufficient conditions.

Hutchins' example can be scaled up for HEP. Imagine a run of the LHC with the ATLAS detector. Suppose there were at this particular time 100 people operating the equipment. They each perform their assigned tasks using their specialized knowledge of the capabilities and current state of the machines. The desired result is, say, data from which the mass of the Higgs boson could be determined. This is a task that no number of people could perform by themselves. Highly specialized machines are also required. So we attribute the cognitive capacity to acquire the desired data to the whole system, people plus machines organized in an appropriate way. The cognition is in this way distributed.

5. The Cognitive and the Social. We are now in a position to reconcile at least some of the apparent conflicts between cognitive and social accounts of the sciences. The traditional navigational system aboard the *Palau* and a HEP experiment are both cognitive systems. They both produce desired knowledge by carefully distributing the cognitive task among humans and artifacts. The tasks and the artifacts required are of course very different. But so is the culture and social structure. Navy culture is hierarchical and the social organization of the navigation team has a top-down command structure. If Knorr Cetina is right about HEP, the culture is communitarian and the social structure of the experimental group exhibits "management by content."

Nevertheless, we do not have a sharp divide, let alone conflict, between cognitive and social accounts of these activities. In both cases, the culture and social structure are part of the respective cognitive systems. They determine *how* the cognition is distributed. To know how a cognitive system works one has to know about the culture and social organization as well as about the capabilities of the people and the artifacts. Distributed cognitive systems are heterogeneous (Giere 2002).

6. Mind and Consciousness. Recall that Knorr Cetina suggested taking the experiment itself as an epistemic subject, the thing that knows, and she

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was even tempted to ascribe a kind of distributed *consciousness* to this distributed subject.

Here she clearly assumes that, if knowledge is being produced, there must be an epistemic subject, the thing that knows what comes to be known. There is ample motivation for this assumption in folk psychology, which is decidedly individualistic, where knowing requires a subject with a mind, and where minds are typically conscious. These same ideas have permeated philosophy since the seventeenth century. But Knorr Cetina's deep understanding of the organization of experiments in HEP makes these assumptions problematic in that setting. Feeling herself forced to find another epistemic subject, she settles on the experiment itself.

Similarly, because the traditional epistemic subject is a *conscious* subject, Knorr Cetina is tempted to assign to the experiment itself an extended form of consciousness. Speaking of stories scientists tell among themselves, she writes:

> The stories articulated in formal and informal reports provide the experiments with a sort of consciousness: an uninterrupted hum of self-knowledge in which all efforts are anchored and from which new lines of work will follow. (178)

And on the following page, she continues:

> Collective consciousness distinguishes itself from individual consciousness in that it is public: the discourse which runs through an experiment provides for the extended "publicity" of technical objects and activities and, as a consequence, for everyone having the possibility to know and assess for themselves what needs to be done. (179)

Again, Knorr Cetina is not alone in making such connections. Philosophical commentators on distributed cognition such as Andy Clark (1997) have also been tempted to speak of distributed minds, minds encompassing artifacts as well as humans. Nevertheless, I do not think we are forced to make these moves. We are developing a science of cognition. In so doing we are free to make *cognition* a technical scientific concept different from everyday notions.

Cognitive systems are, of course, human creations, products of human agency. But we can refrain from ascribing agency to anything other than the human components of such systems. Nor need we endow such systems as a whole with knowledge, belief, or any of the other mental states we associate with individual human minds, particularly not with consciousness. The reason for calling these systems cognitive systems rather than, say, transport systems or agricultural systems, is that they produce a distinctly cognitive product, knowledge. But without the human interaction, there would be no knowledge, just a complex physical process. This is

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not to say that we humans are anything other than complex physical systems. We are just a particular kind of physical system, one that can know about other things and even be consciously aware that we know these things. The ATLAS detector is not that kind of system.

What, then, would be a good cognitive scientific way to characterize the result of a HEP experiment? My suggestion would be to *depersonalize* the characterization, so that we would say things like "This experiment has shown that. . . ." or "This experiment leads to the conclusion that. . . ." And to whom is it shown? Who draws the conclusions? The scientists whose professional job it is to do these things. Who else? The rest of us learn it second or third hand on their authority. These more impersonal forms of expression free us from the need to find a special sort of epistemic subject. Individuals cannot *produce* the knowledge in question, but they can in a completely ordinary sense consciously come to *know* the final result.

7. Molecular Biology. Turning finally to Knorr Cetina's comparison of HEP with molecular biology, she argues that molecular biology laboratories exhibit a two-level structure. The lower level consists of individual researchers each working on their own project. The upper level consists of the whole laboratory usually managed by a single director. For Knorr Cetina, the individual nature of the lower level has important theoretical implications. She writes:

> This is perhaps molecular biology's first most important difference from experimental high energy physics: in the molecular biology laboratory, the person remains the epistemic subject. . . . The laboratory, experimentation, procedures, and objects obtain their identity through individuals. The individual scientist is their intermediary—their organizing principle in the flesh, to whom all things revert. (217)

Accordingly, the chapters on molecular biology contain no mention of distributed cognition. Here I think Knorr Cetina assumes that *distributed* cognition is the same as *collective* cognition, terms she seems to use interchangeably. This identification eliminates the possibility that a *single* person operating with a piece of instrumentation can already be an example of distributed cognition where the cognition is distributed between an individual person and an instrument.

Nevertheless, such small-scale distributed cognitive systems are ubiquitous in molecular biology laboratories. For example, she discusses the use of autoradiographs, sheets of X-ray film exhibiting lanes marked with patterns of black and white bands. These bands are produced by inserting radioactive markers in segments of DNA or RNA, and then coating the film with strips of a gel containing the marked segments. According to the

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conception of distributed cognition I have employed, an individual scientist using this technique is already a distributed cognitive system. An individual acting alone, even one holding a DNA sample, cannot produce the information contained in the patterns of bands on an autoradiograph. Not to recognize this possibility is not fully to understand the power of distributed cognition.

8. Conclusion. *Epistemic Cultures* is a powerfully persuasive book. Here I have questioned only Knorr Cetina's claims about the cognitive structures found in these two fields. The cognitive powers of both fields depend upon distinctive distributed cognitive systems. Yet in both, I have argued, we can reserve epistemic agency for the human components of these systems. We do not need to postulate new distributed cognitive agents, let alone ones exhibiting consciousness.

Now I do not believe that there is an objective fact of the matter as to which ways of thinking about these issues are correct. As Knorr Cetina herself has shown, our ordinary ways of thinking about knowledge break down when applied to some areas of modern science. Our problem is to decide which way of thinking about these sciences provides the best overall theoretical perspective on modern science. And this decision can only emerge within the science studies community from continued discussion of empirical studies such as those Knorr Cetina has provided.

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