



Abstract Materialism: Peter Galison Discusses Foucault, Kittler, and the History of Science and Technology

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In this conversation between Peter Galison, professor of physics and the history of science at Harvard University, and Jeremy Packer, associate professor in the Institute of Communication, Culture, Information, and Technology at the University of Toronto, Galison addresses numerous concerns related to the historical analysis of technology. These include the importance of the work of Michel Foucault and Friedrich Kittler to the study of technology and science; the historical roots and continued prevalence of cybernetics on understandings of human-machine interactions; the often competing scientific virtues that drive scientific and technological innovation; and how Galison chooses the foci of his historical enquiries, which he calls “abstract materialism.”

Keywords: Michel Foucault, Friedrich Kittler, media history, history of science and technology

Jeremy Packer:

Hi, Dr. Galison. I really want to thank you for doing this interview.

Peter Galison:

It’s a pleasure to be here.

Jeremy Packer:

I want to suggest that there is a thinly veiled Foucauldianism in much of your work, particularly as it relates to the importance of scientific instrumentation over the course of the last two centuries. Such instrumentation seems to be caught up in various power/knowledge relationships, as well as struggles internal to epistemological debates in the sciences, and as the sciences have been bound up in geopolitical struggle. I have suggested elsewhere (Packer, 2013) that your research into the history of scientific instrumentation and its centrality to the epistemological conditions of modern knowledge production might be gainfully added to a kind of methodological arsenal for the investigation of media from an explicitly Foucauldian foundation. Can you give me some sense as to whether Foucault has indeed been a considerable influence on your work?

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Peter Galison:

Yes. Foucault has been a long-term interest, going back to when I first came to Stanford in 1983. When I arrived, I began a conversation with Arnold Davidson that has continued for decades. I consider him one of the great analysts of Foucauldian thought, one who is really able to situate Foucault in broader philosophical context, both continental and analytic. One of the things that draws me to Foucault is his attention to the material dimension as central to the production of scientific knowledge. Going back further: in Marx's writings, it is the highly material side of his work—attention to the living space of loom workers, to the disposition of tools in a factory—that has drawn my attention. At the same time, I found, back in my early work, the Annales School in France to be tremendously helpful, methodologically: they too had a tradition of using material considerations (delivery of mail, transport, modes of crop cultivation) to study history. Key figures like Fernand Braudel and Marc Bloch drew from Karl Marx and Emile Durkheim and perhaps a wider circle of anthropologists. Bloch's work was stunning to me when he showed how much could be gleaned from the patterns of furrows in the land. But in the Marxist tradition, even as it was transformed and given a structural, anthropological, and sociological take, attention tended to focus more on socioeconomic concerns and not on high culture or science. I remember very well how, when I was a graduate student and postdoc, my methodological allies in social history held science in some disregard; for them, it was the domain of the elites and their focus was not there.

For me, Foucault was crucial for several reasons. While he is often disdainful of overly obedient French Marxists, he clearly absorbed the centrality of material culture to an understanding of history. Simultaneously, he drew extensively from Friedrich Nietzsche's deeply critical stance toward naive history, and drew massively (if largely without acknowledgment) from Martin Heidegger in stepping back from an always-already assumed humanism. Unlike Heidegger, Foucault was interested in knowledge and its relationship to power from very early on in his trajectory. In Foucault's form of historical structuralism, you have these patterns of discourse, and the uses of certain kinds of technology in repetitive and inculcating fashion is something that I found and find riveting.

You find this attention to repetition in the power-knowledge nexus both in the early (disciplinary) side of Foucault and in the later (cultivation) side of Foucault. I would say that for me one point of departure from Foucault has been that I'm often interested in very tangible technologies. These differ from the way that the later Foucault was interested in less material technologies for the inculcation and cultivation of a certain form of self. Foucault wants to fasten onto things like going out in the wilderness, self-isolation, self-deprivation, starving yourself, memory techniques, diary keeping, mnemonic technologies. While I agree that self-deprivation or diary keeping are properly considered as forms of *techne*—as Foucault does—I tend to be interested in more technological technology: things like scientific instruments, coordinated clocks, photographic techniques, all the way up through nuclear and electronic weapons. Perhaps this is in part because my main interest is in the period from the 1890s to the present rather than ancient Rome. But whatever the reason, my attention is overwhelmingly directed toward altogether material technologies.

So that's one place where I depart somewhat from Foucault. The other point of departure is that the Foucauldian question, as I understand it, is "How does a certain technology, like self-deprivation, silence, mnemo-technologies, and so on, *form* the self?" "How do these repetitive actions condition a certain form

or concept of the continuity of self, a certain way of relating to other people, the defining relational structures that pick out a certain self?" He sees this form or concept as changing over history.

I'm very sympathetic to Foucault's technology-to-self approach. It's not that I disagree. It's just that I think there is a reciprocal question, which is equally important. And that is, in a sense, a prior one: "What do certain forms of the self make possible in technology, at all?"

Let me give an example, drawn from the long history of the psychology of the inkblot. The idea that "random forms" might tie to the imagination is an ancient idea that goes back to the Renaissance. Leonardo da Vinci urged would-be artists to study these unformed forms: clouds, embers and fires, cracks in the wall. By extracting forms from them (so da Vinci and his contemporaries insisted), you can improve and exercise the faculty of the imagination. Since the time of Galen, maybe before that, it had become a commonplace that we are composed of faculties deeply set in us: the faculty of calculation and memory, common sense and imagination. By the end of the 19th century, there was a pretty common idea that the faculties that composed the self each had a test that would probe its strength.

One such test (of memory) might be how many numbers can you remember? Can you remember 1247? Can you remember 12479? Can you remember 12479113, and so on. Alfred Binet was one of the first great psychological testers. The specific test of the imagination he had in mind was to give somebody a card with an inkblot on it and the subject would ring a bell every time he or she saw something. Couch, house, hat, boy, girl, horse. The more things the subject could see in the card the better or stronger the imagination.

But something happens between the 1890s and the 1910s when Hermann Rorschach, the Swiss psychiatrist, begins to examine these issues, and he says very directly that the eponymous test with these images of blots on them have nothing at all to do with the imagination (Galison, 2004). This is sort of astonishing since only a few years earlier that was the test's entire purpose. Instead, Rorschach says the inkblot card is a way of characterizing perception. So I want to know "what happened?" What is it that made possible the transformation of these blots from being a test of the strength of the faculty of imagination to a test that probes the innermost aspects of our perceptual apparatus? It's not whether you see a cat or a dog. In fact, it has nothing, or almost nothing, to do with content and instead focuses on typical ways in which you organize the field of perception. Do you emphasize blank spaces or gradations and tone? Do you see color first (splattered red) and then only weakly add content (blood)? Or do you see content (a pointy hat) and then comment on color (red)? And whether these sorts of things could be used to characterize really what the personality is made up of: your disposition to see the world in certain ways, not in content, but in its affective and conceptual structure.

What makes possible this shift from test of the strength of imagination to characterization of perception? The answer, I have argued, is the introduction of the unconscious into the idea of the self—a dramatic move away from the self as directed by a conscious, controlling will. This is a radical displacement from the self-directed by an inner king, so to speak, to a self where most of the self is unconscious, like the hidden majority of an iceberg. The (mostly) unconscious self is a condition of possibility for the Rorschach technology to exist at all: we could call it the self a priori.

Once the Rorschach test becomes ubiquitous, becomes a master metaphor that you can find every day in the newspaper, somebody can say, as President Obama says on many occasions, "I am a Rorschach" and expect several hundred million Americans to know what he means. So that then begins to train us up in a certain way of thinking about ourselves. Even people that have no psychoanalytic, psychological, psychotherapeutic background begin to register the idea that we are a kind of magic lantern projecting unconscious wishes and desires out onto the screen of the world. That notion is now widespread. I think the Rorschach test in a way has served as a tool of reforming the self. This move of cultivation of the self, the Foucauldian moment, is the technological a priori. But the first question (what is the self a priori that makes possible certain technologies?) is its complement. This endless cycle that I think drives changes in what the self is—this back and forth—is my major object of inquiry these days.

Jeremy Packer:

I appreciate the attention given to technology in this instance. Amongst a long list of accusations, a common Marxist criticism has been that Foucault is an idealist. While I don't think that is an entirely fair characterization, to some extent, we can see in the work of Friedrich Kittler a move to demand a technological, material, or media specificity to the production of discourse and potentially then to the production of the self. For instance, to apply this notion to technologies of the self would demand that how one selects and stores one's memories, the degree to which they can be reassessed or processed, depends upon what medium one uses to keep them: a diary, journal, photo album, or Facebook account. In Kittler's formulation then, I think there is a media a priori or a technological a priori, which structures the possibility for the range of potential selves that could ever be imagined, insofar as a given medium is actually being used to do some kind of work on the self. The fact that it's a book in which you keep a diary matters. It stores information in very specific ways. It aids in certain kinds of memory formation, but not in others. It proceeds in a linear fashion and so on.

Peter Galison:

I actually agree with this idea, as you related it, that there is something somewhat idealist about Foucault. Or maybe it is nonmaterialist. There's a way in which if I try to imagine what Foucault is really saying, it's that "you go to the archives" and in the archives what do you really find?

What you really find are statements, *énoncés* (not propositions, which are things that are true or false but raw utterances). Imagine a vast library of little strips of paper, each with an utterance on it—that would be the (Foucauldian) archive. Foucault next says that we must find the underlying, often unspoken ordering principles that govern the combination of these artifacts. So Foucault proceeds in a deeply positivist vein first (what are the statements; what empirically goes with, or doesn't go with, what?). Then there is an historical structuralist move: the articulation of the rules of combination (which is not positivist). For example: What statements do and don't go with statements about God's will in the 16th century? Do statements about God go with a statement about physics in the Third Republic?

So there are certain kinds of utterances that form a structural whole with rules of combination, forbidden association, entailment, and so on. On my reading, those rules constitute what Foucault means by a discourse. In the end, I think that it is these discourses that ultimately govern us. They have material associations in some cases. True, Foucault is interested in material things. But they are material things as

we have them and ultimately as we speak and are spoken through the rules of a historically specific and structured discourse. This is a more elaborate answer, perhaps, than what you had in mind; but if I were to say Foucault had an idealist dimension, it would be exactly insofar as discourse is his last term of analysis. But perhaps we should turn to Kittler?

Jeremy Packer:

For instance, with technical media the sheer volume of statements has grown exponentially at precisely the period at which Foucault's historical investigations end, say 1850, or halfway between Kittler's *Discourse Network 1800/1900*. As Kittler explained, with the advent of mechanical media, statements no longer need to be captured by human perception and stored by a human hand inscribing something onto paper. A rather vast amount of data—visual, auditory, textual, and climatic, etc.—is now being collected, stored, and processed automatically.

Peter Galison:

So I think the three features that characterize Friedrich Kittler's work are his media-specific history, his technological gloss of the Lacanian psychoanalytic system, and his technological critique of humanism.

I am completely sympathetic to the idea of a historical media-specific history and looking at the epistemological aspects that are built into it. In that sense I find myself very sympathetic to Kittler. There's a second aspect of Kittler, which is his view that the Lacanian partition of the psyche into Imaginary, Symbolic, and Real, can be explained by an underlying "technological a priori"—light, sound, and print undergird these psychic categories. More specifically (according to Kittler), film forms the ground for the Imaginary, the typewriter for the Symbolic, and the gramophone for the Real. This seems too complex, the explanation requiring too many gears to get from these specific technologies to the perhaps too arcane categories of the Lacanian system.

The third aspect of Kittler's thought is his engagement with Heidegger's antihumanism. I think that that's very interesting in that he actually shares with Foucault both the repression of the shaping force of Heideggerian posthumanism and his commitment to it. You see at that post-1968 moment a widespread critique of the idea of an a priori, unified, transhistorical, human self, one that can be tracked through Heidegger, Kittler, Foucault, but also Niklas Luhmann and Gilles Deleuze.

There's much to be said about this antihumanism, but perhaps most importantly, it reinforces the idea that the self is something that is in constant and endless historical mutation. It's been a kind of figure of reason-as-king above unruly subjects of desires. It's been an 18th century Kantian and then Neo-Kantian will-based self and psychology of self. It's changed to an unconscious. And this ever-shifting, ever-protean self won't stop changing.

Jeremy Packer:

I would like to add a fourth Kittlerian trajectory into our conversation, one that I believe also has quite a bit of overlap with your own work, and that is the centrality of warfare to the development of technology for military strategic ends. Some people have accused Kittler of placing too much emphasis upon the role of war as an historical mover, calling it his "military a priori" (see Winthrop-Young, 2002). Such criticism

suggests that there is a teleological advancement from one media to the next in an ever-escalating struggle, which ultimately ends at the computer during World War II in order to predictively manage ballistics and break codes. You've also written about the role of cybernetics, computation, and ballistics in the creation of what you've called "a new ontology of the enemy" (Galison, 1994). How would you characterize your own sensibility regarding the determinative power of struggle or military struggle in terms of technological development?

Peter Galison:

Well, there are two ways in which it might be represented. One is a generalized picture that knowledge develops through struggle. This is more than just warfare, but a generalized conflict we can see in Nietzsche's image of clashing swords of conflict that only momentarily and in a fragmentary way illuminate what's going on. You can see it in an agonistic field that Bruno Latour talks about, for instance. I think it is quite common to think about fighting as a driving force that actually is the default stage of human interactions. I do not share this view; in my work, novel forms of collaboration play altogether as large a role as conflict.

The other is the content or subject matter question, which is to what extent is war the driving force of technology, and is it the site where we need to examine all of our interactions and development of modern society? So, one is a methodological precept about epistemological struggle: that agonistic or confrontational situations are the only final or motor force of development. The other is specifically about war, as in violent confrontation, among nations and peoples. I think that the former, the idea that it's important to look at scientific controversies and conflict, is a very helpful precept because it throws light on what is contested and what isn't. If you have two different experiments in dispute, you can actually see what the pieces of knowledge are that are in question and that are commonly assumed. Not everything, as we've known for a long time in the philosophy of science, as Popper would have liked it, is up for grabs simultaneously. Even back in 1962, Thomas Kuhn said, "Well, that's just not true, you wouldn't be able to do any science at all if you were simultaneously questioning that two and two is four or that oil floats on water, and at the same time trying to resolve a detailed question on fluid dynamics."

I think methodological conflict can be very useful, and I certainly use it a lot of times, and I encourage my students to use controversy as a way of getting at things. On the other hand, that's not the only form of interaction that people have, and I would say that an equal part of my work is about different forms of collaboration: the idea of a trading zone, how people can disagree about fundamentals and nonetheless find localized common ground (for instance, see Galison, 1997). That is often very important in understanding the emergence of new disciplinary structures, new kinds of knowledge—computer science, biotechnology or geometry, or any of the other fields that have hybridity in their name.

Even the things that we consider pure disciplines, like pure math, are actually a hybrid of things that were historically very different. I want to know how they came to collaborate, sharing piecewise connections while disagreeing about foundations: for instance, how Descartes made analytic geometry tying traditional synthetic geometry to a new grasp of polynomials that was dramatically new. Understanding those combinations of things is not just an understanding of the conflictual agonistic field. I think that is what I think about that.

In terms of the specific accusation that Kittler somehow pays too much attention to war: As you know, my work has also often been about weapons, radar, etc.¹ I think that it's been very important for the history of physics to recognize the military character of much of modern science: to recognize the importance that warfare played in the material structure, the training, the societal status, the funding, everything. I think to ignore the Cold War (for example) is really to put your head in the sand about the 20th-century evolution of physics. People used to narrate these histories as if war was a pure distraction because the topic of weapons was very different from the topic of fundamental science. For instance, people would say: "cosmic ray physicist Bruno Rossi was working on cosmic physics until 1939 and then he had to go away for the war and he resumed in 1946." That kind of the structured story with a hole in the middle of the narrative makes no sense. Understanding why it was done in the war depended on what was kept in the report, how it transformed in scale, in scope, in collaboration structure, in government grants, and the whole apparatus of science. And afterward, when it resumed, it actually was taking on the old subject matter, but transformed by new forms of instrumentation and new technologies, including financial technologies, grant technologies, as well as a new status for the sciences.

I think that's why it's typical, and I think it's very important to understand the development of science and all of these demands. Whether it's cryptography, Erwin Schrödinger's new way of understanding what is life, a million questions that develop in quantum electrodynamics—the purest of the pure sciences after World War II, though Feynman and Schwinger were working on war projects—understanding the relationship of that is crucial. War in the mid-20th century was a transformative moment of sciences across the board, whether it's medicine, physics, or various branches of mathematics. But again I would say, not every science is a war science, and not every transformation of science is a war transformation.

I've done work on other kinds of things that are not fundamentally war technologies and have been quite different. The Rorschach test example that I discussed earlier is not fundamentally a war technology, though the war expands the reach, scope, and use of psychological testing (see Galison, 2012). But for a Swiss psychologist in 1910, war is not the main topic. It is necessary to recognize it as a historical corrective and to understand what it means for the United States to be spending half a trillion dollars a year in a war economy. To ignore that and its effect on science and technology is really crazy. But I don't like the idea as a methodological precept that assumes the only form of human interaction is conflictual or that war is the only thing driving things forward. Much recent technology, even military technology, comes out of the commercial ventures. Silicon Valley has its roots in war technologies, but to say that Silicon Valley is mostly about war technology today would be a tremendous error. It would be wrong not least because during the later Cold War (after the 1970s) many big technology companies realized that they were too vulnerable to fluctuations in military expenditures. They began to think about consumer products—even the military began to acquire more material from the commercial sector rather than having it purpose designed and built. Mainframe computers issued from security demands, to be sure, but personal computers were not developed fundamentally as war machines.

¹ On weapons, see Galison, 1998; on radar, see Galison, 1997, chapter 4, "Laboratory War: Radar Philosophy and the Los Alamos Man."

Jeremy Packer:

Let me redirect this slightly to address the relationship between dominant epistemologies and their relationship to military struggle. In your essay "The Ontology of the Enemy," you suggest that cybernetics produced a new ontology of the enemy, which was a man/machine enemy or a cyborg. This was based on Norbert Wiener's work on ballistics prediction during World War II that suggested the only way to predict, and hence counteract, the enemy was through the computational analysis of the observable actions resulting from humans and machines acting together. This kind of predictive assessment carried forth throughout the Cold War and led to all manner of war games that could only be played out via vast forms of computation. Your work seems to suggest that there is a relationship between epistemological convictions and the kind of enemy that one can imagine and hence counteract. I want to ask if that is indeed the case, and if so, do we have a new ontology of the enemy and what kind of epistemology might that result from?

Peter Galison:

I wrote that piece right around the end of the Cold War, in 1989–90. I was already interested in this question of how experiences of technologies could shape the notion of selfhood and then how a certain notion of selfhood could open up new kinds of technologies. The World War II war situation was grim: Wiener and of course his British colleagues were desperately hoping to save England from defeat by shooting down the Nazi planes then showering England with the Blitz. Obviously you couldn't actually have access to the words, much less the intentions, of the pilots. The bombers' lives depended on *not* speaking on the radio. For the anti-aircraft crews, the experience of the enemy pilot was reduced to the enemy's speed, direction, characteristic patterns of turning, altitude changes—just radar-tracked movements that Wiener came to believe could be characterized, and [he] shows they can be characterized by a kind of learning machine that would take these frequencies and make a prediction about where the pilot would be 10 or 20 seconds in the future. That was the goal. In the event, they never got that far. But for two seconds the predictor predicted with uncanny precision.

That wartime experience gave rise to Wiener's notion that feedback based prediction *was* intention, that intention had no extra, subjective aspect, since behavioral data was all you had access to. For the cyberneticians, intention really was nothing other than the input/output relations.

Jeremy Packer:

Do you think that the remnants of the cybernetic imaginary are still present in the dreams of big data? It seems that one of the problems that was endemic to cybernetics was the ever-expanding growth in any given system. There seems to be a constant need for more data to be collected via an ever-growing number of feedback mechanisms. It seems that behind the investment in the Internet of things, as well as any number of media that ubiquitously collect data, lurks the dream of increasingly more accurate prediction and ultimately the dream of control. There may be no way to access the psyche or understanding intention, but if given X prompt via some interface, we can expect to get Y response. It seems to me that is ultimately Google's operative logic. They don't care who's behind the screen. All they want to know is that if this data goes in, that data will come out. Is this still the model you are pointing out, but no one is calling it cybernetics anymore?

Peter Galison:

I think there is an aspect of it that is an extension to today's world of divining through data what people will do or buy—called predictive analytics, today a gigantic and growing industry.

It made perfect sense for a ship trying to escape a torpedo during World War II to act as if this self-correcting device had intention. The uncanny analog for us today is having an online corporation tell you that you will like this movie, that book, and finding you do.

Even in our most intimate moments, where we don't suspect that big data can get at us, correlations and predictable analytics intervene. That unnerving sense, that uncanniness, of algorithms—in the previous case electro-mechanical structures—doing things that we thought only a person could do, is striking. There are aspects of this that are military and military intelligence. You know that when you go to the airport your security check begins well before you come into the airport. They are looking at all sorts of correlations, built on your demographics, online behavior, actual travel, perhaps financial interactions. In a more lethal form those sorts of signals, aerially monitored, and human-sourced correlations are used in targeting drones (so-called signature strikes), where distant targeters select whom to hit based on observed behaviors, without knowing the name of the person in the crosshairs.

Jeremy Packer:

The issue is no longer necessarily one of known affiliation, but rather pattern recognition and security expectations according to some risk analytic.

Peter Galison:

That is a different kind of enemy. It's not an enemy identified by uniform. It is not an enemy identified by party affiliation, ideological predilection, or leadership role. A group of grown men walking together in a certain area, perhaps carrying things and communicating with a particular cellphone, at a certain time of day can become a target. Signature strikes do begin to redefine how we understand the ontology of the enemy.

Jeremy Packer:

I'm going to shift gears quite a bit and ask you to speak about your work with Lorraine Daston (Daston & Galison, 2007) in *Objectivity*, wherein you chart the sometimes radically changing notion of objectivity and the ways in which it has become the dominant scientific virtue. What other forms of scientific virtue might you and Dr. Daston propose? Do others exist that may not be as susceptible to commercial, militaristic, or even nationalistic imperatives?

Peter Galison:

Lorraine Daston and I come at these questions with somewhat different orientations, but I think one area that we are completely in accord about is that virtues in an ethical sense and scientific virtues, in an epistemic sense are historical. There is no sanctified hard core that picks out the essence of science. Science is a chain of sometimes-changeable scientific virtues and sometimes we value some over others. One of the things that really drove us early on in the project was the sense that in ethics we know that virtues conflict all the time.

Nobody thinks that political ethics or political morality, or even individual morality, always align. The whole subject of ethics plays on the fact that we often find that virtues conflict. Plato said something borrowed should be returned. In the *Nicomachean Ethics*, Aristotle says (in better chosen words), "Don't be ridiculous, Plato. If someone lends you a knife and then goes crazy, you don't hand them back the knife. That would be immoral, right? They could hurt themselves or they could hurt somebody else." The history of ethics is essentially a history of trying to cope with our conflicting notions of the good. How do we balance a democracy against the protection of minorities? We're always in that situation in politics—Lorraine Daston and I argue that in science we are too. Sometimes pedagogical clarity or exactitude may work against explanatory virtues.

In *Objectivity*, we were interested in objectivity; objectivity can come at a cost. Other virtues could be in conflict. The weird and fascinating feature of the history of epistemology in science is that we often treat it in this Panglossian way, as if all the virtues line up. As if we can have the most accurate, robust, objective, pedagogically useful images all at the same time. We can't. They actually pull in different directions, just as explanation and predictions, as the philosopher Nancy Cartwright often has effectively argued, pull in different directions. Invoking Newton to account for the attraction of the moon and earth can be very explanatory, $1/r^2$ times the product of the masses, but in real life the rules that you use to adjust the spacecraft's motion when it is passing between the Moons of Jupiter and Jupiter may much less refer directly to Newton's law as such, to mnemonics and heuristics.

We know the fundamental laws of electricity, but when we are repairing a radio you don't use those. You often have little rules of thumb, and you design something that involves hundreds of thousands of printed circuits. You don't go back to the fundamentals of quantum mechanics each time. All this is to say that in *Objectivity*, Lorraine Daston and I were certainly not arguing against objectivity. Instead, we contended: here's an important scientific virtue that is not definitional of what science is, because science has had and still has other fish to fry. Scientists want prediction. They want explanation. They want pedagogical clarity and precision, accuracy, quantification, and much more. We are all for calling Newtonian celestial mechanics good science, of course, but Newton's many ambitions (quantification and prediction, for example) and his hopes did not include the achievement of a self-abnegating, 19th-century objectivity. Nor is science in the late 20th century about the 19th-century notion of objectivity—that somehow hands-off judgment-free self-abnegating visual records of things is not the ambition of people even prosecuting the same disciplines in 2015.

Your broader question is "Are there other aspects of the ethos of science that we think are good?" And I would say that there is in fact a deeper issue here, which really is important. I don't know that Lorraine Daston would disagree, but let me just speak for myself. Our knowledge is constantly buffeted by and constructed out of—and uses and is used by—all sorts of things from commercial consumer electronics intelligence efforts, to the personal ambition of a mathematician in a math department somewhere, to application for warfare, and intercompany competition for market share—science exists in the world. But that is not to say that it is invalid or it's just a cork in the ocean, floating up and down every time a wave goes by. And I think that's very important. It's easy to think that either science is an autonomous cloud floating above the vicissitudes of human existence or it's nothing but a cork riding up and down on each

passing wave of all-too human activity; especially as science begins to occupy the very important role that it begins to play in the 19th century forward.

Science is not without its own weight, conditions of explanation, and acceptable forms of argumentation and so on that are not just instantly responsive to this or that whim. The Republicans may not like global warming; they have both houses of Congress; they might get the presidency; and it could be argued, they have the majority of the Supreme Court, but they can't change the fact that global warming is correct. I don't think that the recognition that science exists in the world, it borrows from the world, it reshapes the world around it, is constantly part of our economic, military, social, intellectual, cultural, and philosophical struggles—that doesn't mean that it's just a cork.

I would be sad if people came away thinking that we were saying that objectivity is nothing. It's a scientific virtue in a complicated, constantly reformulated set of other epistemic ratios. Lorraine Daston has a very nice article where she talks about how curiosity was a sin before it was a virtue. At a certain point it becomes a virtue if a scientist is curious, that's a good thing, but that wasn't so in the Renaissance.

Jeremy Packer:

Okay. I appreciate that explanation of the multiple demands and stressors that situate objectivity as a specific virtue of science amongst other competing virtues. I am still curious as to what other virtues you see as being particularly valuable.

Peter Galison:

Pedagogical utility is a virtue. Quantitative analysis is a good thing. Prediction is a good thing. Some branches of science emphasize that more than others. Evolutionary biology is a central part of our scientific understanding and has been for a century. But evolutionary morphological biology is not a predictive science—we have no idea what the descendants of elephants will look like in million years. But evolutionary biology *is* a very explanatory one. Synchronically, we often will value in some domains, some epistemic virtues, above others. That is interesting. That tells us that science is more a set of, in Wittgensteinian terms, family resemblances than it is something that has a set of necessary and sufficient conditions that pick it out, only that thing.

Jeremy Packer:

Fair enough. I would like to ask one last broad question. How do you go about formulating a new project? What are the considerations that drive you to answer new questions or investigate new topics? It seems to me that your two recent documentaries address highly politicized and timely subjects, government secrecy in your 2008 film *Secrecy* and nuclear waste in your 2015 film *Containment*. However, it's not always clear that this has been the case in your written work. I'm wondering if you approach these two kinds of projects differently in terms of subject matter, possibly due to the intended audience, or whether each medium better presents itself to different kinds of inquiry. Or do you see both your written work and your films answering the same sets of questions, but in different ways for different audiences?

Peter Galison:

I would say the single strand that cuts through all my work is commitment to what I've called abstract materialism: the sudden juxtaposition of very abstract and very concrete things. I find these confrontations endlessly fascinating, this idea that there is an epistemology to a Geiger counter, or that there is something to be understood about our human condition in nuclear sludge, or that there are procedures about national security secrecy that call up sexual and Biblical secrecy. Or that scientific objectivity has to do with procedures of picture making. Or that Einsteinian relativity might be tied up with altogether real and altogether metaphorical trains, telegraph operators, and map makers (see Galison, 2003). The reason that I find these confrontations interesting has different dimensions.

At its simplest level, abstract materialism is pedagogical. I think mostly when we speak in abstractions, we often have in mind something very concrete, and we suppress that concrete referent for various reasons. It feels more high tone to speak in abstraction without a call-out to things. It feels more general and therefore gives us a kind of power over situations that are not present if we act as if there was no specificity to our concepts. But there is a pedagogical utility in being able to actually show the concreteness behind the abstraction or that lies inside and actually saturates the abstraction.

A second dimension of abstract materialism is political. If we talk about nuclear waste or secrecy in general, it can seem as if we can't get at these topics at all, they are nowhere. Ungrounded talk pulls these topics outside of our ability to discuss, much less change. It seems to me a kind of political prerequisite for any kind of engagement to understand the concreteness of these things. Take nuclear waste. Where is it? What is its texture, volume, toxicity? Take high-level weapons waste, produced in producing tens of thousands of nuclear warheads over the course of the Cold War. There are 177 million gallon tanks in Hanford, Washington, and in Savannah River, South Carolina. A million gallon tank might be pictured as a volume the size of the capitol dome stuck into the ground. They are filled with a mix of liquids and sludge the consistency of peanut butter. When you start to get specific about it and confront its materiality; when you begin to picture locations, people, apparatus; when it becomes visual in its representation, we can talk and eventually act. So, I think there is a political, as well as a pedagogical, notion. This visual, material, specific side of abstract materialism undergirds my interest in using film to complement my writing.

I find abstract materialism to be philosophically interesting because I think that we tend to think in one of two ways. Either we reason with Plato, that is, we start with very material circumstances, and then through a series of abstracting moves, we pass, like the constrained slave, from the projection on the wall, to a grasp of the puppet casting the shadows, to the imagination of pure form. Or, we go the other way: we start with abstractions in mathematical physics, and they become experimental physics, and then applied physics, through chemistry, biology, and then eventually down to the factory floor. Both of these pictures strike me as mistaken. A lot of times it's not ladders of ascension to declension, but instead the sudden collision of the very abstract and very concrete. When Einstein is talking about trains or Poincaré is talking about telegraph operators making maps, they are engaging in both literal and metaphorical activities; they are reasoning about the material and the abstract simultaneously. It is this immediate presence of abstractions in the concrete operations of our lives that I find both evocative and philosophically interesting. It goes against this very long, even ancient tradition of thinking that there is a

gradual set of steps, like a stairway to heaven, from the triangle in the sand, to the triangle in the sky. Or the ivory tower opposite, from triangle in the sky to the shop floor.

Explanatory clarity, political engagement, philosophical alternative—the fact that all cross in the materiality of abstractions makes them into a kind of philosophical joke. By this I don't mean a "joke" as a stand-in for "unimportant." I find it funny and wonderful in an elevating sort of way that something as abstract as the reformation of space, time, and simultaneity had to do with things like sending a telegraph signal from Paris to Recife in Brazil to try to determine its longitude.

Politically, aesthetically, pedagogically, and with a unifying sense of philosophical humor, I find this very appealing. There is a moment in *Einstein's Clocks and Poincaré's Maps* where I described this attempt to pump time underneath Paris and Vienna with compressed air. I thought that was hilarious. True, I am easily amused. But I thought the idea that you would pump simultaneity in metal pipes underneath Paris was tremendously amusing. When I worked on this project with South African artist, William Kentridge, one of the things that helped get us going was this idea of the concreteness of this thing that was so abstract. Drawing grand abstractions into the earth, into their immediacy.

This very Victorian moment of pumping compressed air (steam punk epistemology?) became the launching point for an art installation that tacked back and forth between big abstractions and the altogether concrete things that made up "the Refusal of Time." I like that. I like to choose projects where that unexpected, sudden, immediate, confrontation between abstraction and concreteness takes place. Those are places I like to dig. I find them, for all these reasons, from the philosophical and political to the aesthetic, to be endlessly riveting.

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