

From Objectivity to the Scientific Self

A Conversation with Peter Galison

JASON DE STEFANO

*Peter Galison is the Joseph Pellegrino University Professor and director of the Collection of Historical Scientific Instruments at Harvard University. He is the author of such influential volumes on the history and philosophy of science as *Image and Logic* (1997) and, with Lorraine Daston, *Objectivity* (2007). In addition to his scholarly work, Galison has been involved in the production of two documentary films—*Ultimate Weapon* (2000) and *Secrecy* (2008, directed with Robb Moss)—and collaborated with the South African artist William Kentridge on a 2012 multimedia exhibition, *The Refusal of Time*. He is currently at work on a new book, *Building, Crashing, Thinking*, and a new film, *Containment*, also directed with Moss. Jason de Stefano spoke with Galison in the summer of 2014 about these forthcoming projects, their relation to Galison’s previous work, and the historical, philosophical, and methodological questions that have guided his prolific and influential career.*

JASON DE STEFANO (JD): Throughout your work you have insisted on a reciprocal relationship between the abstract and the concrete, the theoretical and the material. In *How Experiments End* you “looked up” to theoretical physics to ask “what bits of theory shape experimentalists’ faith in a microphysical effect” and “looked down” to the material culture of the laboratory and experimental apparatuses to ask “how . . . the overwhelming histori-

cal expansion of the laboratory from bench to factory affect[ed] the building of a persuasive argument.”¹ In *Image and Logic* you “bring out a continuity of the devices of physics and the changing experimental life that surrounded them.”² Your forthcoming book, *Building, Crashing, Thinking*, will complete the trilogy that began with *Experiments* and continued with *Image and Logic*. However, from what I understand of this project, a somewhat different relation is at issue. Now you are tracking the reciprocity between human subjects and scientific objects—how we make machines and machines remake us, to invoke the subtitle of the seminar you taught at the University of Chicago as the 2012 *Critical Inquiry* Visiting Professor. So my first question is twofold: first, could you outline some of the stakes—be they methodological or historiographical—of focusing on this relation in *Building, Crashing, Thinking*; and, second, would you describe how this shift in focus developed out of your previous work?

PETER GALISON (PG): What interests me most about the relationship between modes and thoughts, abstractness and concreteness, is that it seems to open three modes at the same time. First, at a purely pedagogical level, I find it easier to understand abstractions—for instance, in a political debate or in philosophical arguments—when I know the fundamental and specific concern that propelled the broader argument. That is to say, there’s a pedagogical gain to be had in understanding the specific origin of things that are presented as abstract. That’s the first level of analysis.

The second is philosophical. The kinds of arguments that are presented in philosophy characteristically happen at a very abstract level. But in the first instance, they develop out of specific and material interests. For instance, when the logical positivists argued that concepts should be closely tied to specific procedures, they had in mind, among other things, the victory that Einstein had claimed in understanding the nature of time, simultaneity, and space by making operational what you had to do to establish that two distant clocks were coordinated. In physics, too, and inside the concepts of physics in their philosophical dimension, not just as read by philosophers but as read by physicists like Niels Bohr, Albert

Einstein, Erwin Schrödinger, and Werner Heisenberg, there's often a concern about quite specific and material things that are directly at stake in the broader philosophical claim. And ultimately I think the meaning itself of a theoretical claim is to be got at through understanding a certain degree of material specificity.

The third level is aesthetic. I find it funny, engaging, aesthetically appealing to look very specifically at the metaphors that are constantly being invoked in arguments, claims, or concepts and to see these metaphors not just as explanatory but also as, in a sense, flickering back and forth between the literal and the allusive. So, for example, maybe I'm too easily amused, but I found it very funny that when Einstein talked about clocks and trains in his 1905 paper on relativity and coordinated time, he might have actually been talking about real clocks and real trains. We've had a tendency, not only most of us individually but also as a culture, to deracinate the conditions of reasoning that put these concepts together. So by the time you're teaching physics in the late twentieth or twenty-first century, it sounds as though when Einstein says we need to think about clocks and trains or when Henri Poincaré says we need to think about two telegraphers coordinating their signals in time so that they can map the world, they mean something purely hypothetical. We quickly assume that they, like contemporary Anglo-American philosophers, are talking about purely imaginary scenarios: brains in a vat, Searle's Chinese room, or trolley drivers who must choose to run over three grandfathers or two hopscotching adolescents. As usually invoked, these are deracinated metaphors: hypothetical counterfactuals used in a purely rhetorical or argumentative way. But Poincaré was really in charge of mapping the world, exchanging time-coordinated telegraph signals with his emissaries from Paris in Brazil, for instance, and Einstein really was working in a patent office where they assessed patents about how to coordinate clocks along train tracks. I like that idea. It's funny in a Freudian sense of funny: a collapse of the abstract into the everyday and material. That sudden diminution of the grand into the small works the way Freud says, in *The Joke and Its Relation to the Unconscious*, that jokes often work. I like those jokes. I like that collapse of the abstract into the concrete.

At the same time, I don't think it's just that. I don't think that

abstractions are nothing other than the concrete. But they're also the concrete. So I would say, by way of orientation, that I think of my work as being organized around a pedagogical appeal, a philosophical appeal, and an aesthetic appeal. And then, within that frame, the following sequence of thoughts led me to this question of the construction of the self by objects and objects by the self.

My first book, *How Experiments End*, is about how physicists decide they're looking at a real effect and not an artifact of the apparatus or the environment. Unlike a purely deductive argument, at some point in every experiment you have to say, "This is my conclusion, *ceteris paribus*," though all things being equal is never something you can enumerate completely. So there comes a time when you, the experimenter, have to be able to do something which is not immediately recognizable to purely deductive or syllogistic argument; you have to say something more. You have to say, "For all the plausible accounts of the apparatus or the surrounding environment, I think we've demonstrated x , and this experiment has come to an at least provisional close."

Then in *Image and Logic*, where I was interested in the people who make the instruments themselves—the nitty-gritty of lenses, photography, counts, and statistical simulations—I wanted to know what counts as a good apparatus, what counts as a good experiment. As I pushed on that it became clear that understanding what counts as a valid experiment or what counts as a good instrument implicated at the same time what counts as a good experimenter. The kinds of things that you had to do to conduct a good experiment, to design a good apparatus, fixed at the same time the personhood of the experimenter or the instrument maker. So if you want to do an experiment like the kind that's done at CERN [Conseil Européen pour la Recherche Nucléaire], where you have three thousand physicists working with a billion-dollar device and it takes ten years to do the kinds of experiments that, for instance, led to the discovery of the Higgs particle, then you need a different kind of person with different kinds of values and a different way of integrating yourself and science into this vast team. The kind of person who fits into this apparatus is very different from the solitary observer working in a lab in, say, 1920. I became interested

in this question of what counted as a theorist, what counted as an experimentalist, what kinds of skills were relevant, what kind of compartments could be allowed, encouraged, forbidden.

Then one day, in the fall of 1989, I was in the basement of the medical library at Stanford, and I found something that was very surprising to me. The reason I was down there was that I had come across physics books with titles like *An Atlas of Cloud Chamber Pictures* or *An Atlas of Nuclear Emulsion Pictures*. I didn't know what these things were; that is, I couldn't figure out in what sense these compendia were atlases. But one of them made reference to medical literature, so I went to the library in the medical school to look at what medical atlases look like. It turns out that there are thousands of these things: atlases of the kidney, atlases of the liver, atlases of the eye. And atlases of instruments to study the eye, atlases of electrocardiograms and electroencephalographs, of instruments and instrument outputs, parts of the body, types of bones, X-ray atlases—everything you could want. In fact the atlas genre turned out to be even wider still. There were atlases of crystals and atlases of rocks, atlases of clouds, of plants. These were meant to be considered compendia of the long-term knowledge of different branches of science. They were supposed to transcend any particular theories, to be, in a way, the basic working objects of different domains of the universe. What struck me that day was that these atlases all talked about objectivity and the objectivity needed to produce them. It was fascinating to me that these compendious, long-term volumes speaking scientist to scientist, doctor to doctor, talked about objectivity and talked about it in a way that was quite directive, quite normative, about the right kind of person and the need for a right kind of self-abnegation or self-restraint that would be required to produce these images. It was very much the analogue to, in the work I had done, the question of how to do a good experiment: you had to have the right kind of experimenter. But this was in a way more explicit about the normative features of personhood, of what I came to call the scientific self.

Over the years one of my closest friends has been the philosopher Arnold Davidson, and at that point we had been talking about what Foucault meant by the historicity of the self and about

his work on the hermeneutics of the subject in particular. But it's a theme throughout his work, and he builds on a longer tradition going back through Heidegger to Nietzsche of not treating the self as a kind of eternal human nature that is given once and for all, but rather, Foucault is interested in these ways that we fashion ourselves through spiritual exercises, for example, drawing on the work of Pierre Hadot and others. So one of the questions that I became interested in was how the self was not only reflected in the way these atlases were made but also how the atlases became a form of exercise on the self, a kind of demand on what the self should be like and on the deliberate, difficult task of restraining yourself from improving an image. For instance, the astronomer Percival Lowell had these pictures of Mars, and he wanted to show that there were canals on Mars. He thought, "Well, can't I just fix the images so you can see them better?" He didn't think of it as fraudulent; he thought of it as explanatory. But his editors said, above all, not to do that. If he dared to even touch the images they would lose what the editors called their "autograph value"—"nature's pencil," to borrow Henry Talbot's phrase. You would lose that sense that people had that the scientist had extricated him- or herself from the process and allowed nature to write itself or draw itself, print itself or photograph itself to the page.

Out of this research, Lorraine Daston and I wrote a piece called "Image of Objectivity" that was published in *Representations* back in 1992.³ That was our first collaborative piece on objectivity. Then over the years we were writing both separately and sometimes together on the subject, and I became interested in what it was that made it possible to have this new kind of objectivity, this nineteenth-century picture of objectivity, which meant self-restraint. What switched the epistemic and comportment goals from thinking that the role of the scientist was to intervene as much as possible to improve, isolate, and idealize nature, because who would want any old clover on the page? No, Goethe and his contemporaries wanted the ideal type behind the particular instances. Then, rather abruptly, beginning in the 1830s and 1840s, scientists began striving to remove themselves from the depiction process as much as possible; they aimed to be as anti-interventionist as pos-

sible. I was trying to think what it was about this moment in the 1830s when that shift began to take place and people began to say that we have to control the will, to develop a kind of will-to-will-lessness. And I began to think of this in terms of classical German philosophy and Romantic philosophy—that you couldn’t think of the will as the biggest problem until the will was the central feature of the self. In fact, it’s just at the end of the eighteenth century and the beginning of the nineteenth century that you have a philosophy of the will or a psychology of the will that referred to and altered in some ways the Kantian picture of what the self was. Whether they got Kant exactly right or not, this became a very popular way of thinking. When Arthur Schopenhauer and others talk about will and representation, they think they’re continuing and pushing on the Kantian tradition. Scientists took this will-to-will-lessness very much to heart. It’s a very different picture of the self than, say, in the seventeenth century and early eighteenth century, where you have a bunch of faculties, which included the will, but the will wasn’t in charge. For Descartes reason is or should be in charge, and if there’s a monarch among these subject faculties, that monarch is or should be reason. So this idea that the will is the center of the self is not an eternal picture of the self, and it’s not a commonplace either. Without a will as central to the image of the self, the idea of a will-to-will-lessness wasn’t an appropriate thing to aspire to, and therefore the picture of objectivity that you see written all over the middle of the eighteenth century and even into the later period isn’t there. I developed this argument in a piece called “Objectivity Is Romantic.”⁴

All of this is perhaps a too long way of explaining how I became interested in this idea of changes in the self being necessary for certain scientific procedures, and how certain scientific procedures became training exercises—not spiritual exercises but *scientific* exercises—that cultivated a certain kind of self. It’s related to the Foucauldian project in the sense that these self-disciplining structures cultivate a coherent, memory-based picture of the self. For Lorraine Daston and me, in our book *Objectivity* and more generally, it’s the scientific cultivation, rather than spiritual exercise,

that becomes the focus. And sometimes these procedures are rather complicated, like the production of a scientific atlas.⁵

In the current project, *Building, Crashing, Thinking*, the argument is flipped the other way around. Whereas the Foucauldian project is to show how procedures or technologies shape the self, in *Building, Crashing, Thinking* I'm also interested in the reverse passage, which asks, How does the self allow for or create these procedures?

JD: This "reverse passage" and its relation to Foucault's work is already present in a piece you just mentioned, "Objectivity Is Romantic." There you write about "conditions of possible comportment" and contrast this concept to Foucault's notion of conditions of possibility, specifically conditions of conceptual possibility ("OR"). The physicality and materiality implied by "comportment"—how experimenters restrain themselves, how they work with scientific apparatuses—is essential to understanding what you call the "will-to-will-lessness" that is so central to nineteenth-century objectivity, but it also suggests that Foucault's conditions of (conceptual) possibility remain too abstract, that the Foucauldian project could not adequately account for what you're trying to understand. This comes up again in another essay, "Image of Self," from Lorraine Daston's edited volume, *Things That Talk*. There you say that we can think of the Rorschach test as a technology of the self in a more concrete, material, and more literally technological sense than the sense in which Foucault deploys that phrase. The Rorschach, you say, is "a far less ideal version of Foucault's *souci de soi*."⁶ So I wonder if the difference between the accounts in *Building, Crashing, Thinking* and the Foucauldian account involves, at bottom, your interest in the concrete within the abstract. It seems that in the two examples I've just mentioned and in the way you've already spoken about your forthcoming book, you're talking about *material* conditions—of, for example, being an experimenter in a lab or being the subject of a Rorschach test.

PG: Maybe first I should say that the idea of conditions of possibility seems to me valuable because it doesn't argue for an inevitable or deterministic causality. It says that without *x* condition,

something else could not happen. In a way it's a Kantian idea that is taken up by Foucault in very new ways. For Kant, having a concept of objects in general requires certain things to be in place a priori. You need a notion of extension and space, you need to have some notion of time and continuity, and so on. What Foucault often does is to have a kind of historical a priori. It's not a priori in the Kantian sense—that is to say, it's true forever and it always has been true that any thinking being like ourselves needs to have certain concepts in place before certain other things can even get off the ground. Rather, Foucault doesn't require that the conditions be true forever. He wants to say that for a given episteme, a given period of reasoning about the world around us, certain things need to be in place. And that seems to me helpful. So let's call that a kind of historical a priori. It exists before certain kinds of experience, but it's located within history; it's not transcendently so.

Now to the question that propels *Building, Crashing, Thinking*. I think there are two kinds of a priori. There's an analogue of the Foucauldian question, which is, What is the technological a priori? There are certain changes in the way the self more broadly is structured, which are altered by familiarity with and the ubiquity of certain technologies. Certain kinds of encounters with things that we ordinarily recognize as technological begin to change the self. But, reciprocally, there are certain technologies that aren't even conceivable without the self being in a certain configuration. An example of this is the problem of objectivity, which in its nineteenth-century form required a will-based self. A distributed, faculty-based self was never going to have the problem of the will-to-will-lessness because the will occupied just one among many positions of these faculties ultimately ruled by reason. So there's a kind of historical self a priori: what has to be true about the self in order for a particular technology to exist. And then the reciprocal action is, once a technology becomes ubiquitous, how it reshapes the self. That's the historical, epistemological framework within which *Building, Crashing, Thinking* is structured.

Now to your mention of the Rorschach test. The Rorschach test is the first example of this phenomenon that I look at in the book—the first historically and the first in the book. Put in the framework

that I've just spoken of, we see over centuries an interest in what people often call random forms: inkblots, cloud structures, burning embers, tea leaves. People have been fascinated by formless forms and the things that we see in them, and certainly from the time of Leonardo da Vinci forward, these have been seen by artists and others as a way of exercising, practicing, and cultivating the imagination, of strengthening it as a power or faculty within our psyche. And in the long run from faculty psychology in the Renaissance to deep in the nineteenth century, that was continued in different ways. Leonardo said, "Look at the clouds, look at cracks in the walls and see what you can associate them with, and in this way your imagination will be strengthened. And that will help you as an artist." In the nineteenth century that became a test, not just a way of exercising this faculty but of measuring its strength. And so in this age of testing, the 1880s and 1890s and early 1900s, there was great interest in being able to probe each of the faculties: memory, ability to calculate, ability to grasp a scene at a glance. Each of these had its own test. How many numbers you could remember, for example. Could you look at a geometrical shape and then draw it? How complicated could it be before you would fail to be able to re-create it once it was removed from your sight? The test of imagination was to see how many things you could see in an inkblot. So the idea of inkblots and what one saw in them is very old. But with Hermann Rorschach, we see a very different conception of what the test is about. He said that it has nothing to do with the imagination and is, in fact, a probe of how we perceive the world: not whether we see, for instance, a lamp or a table, but what we pick out of a scene, what's salient to us. Do we pick out the affective elements or the formal elements? Do we see gradations of shading? Do we look at the blank spaces between objects? And what does that tell us about our innermost selves? About depression or proclivity to sociality, for instance—and then encoding these into even broader aspects of the self, what Rorschach called "experience types," *Erlebnistypen*.

I wanted to know how these blots on paper went from being a specific test of the power of the imagination to being a probe or what people called an X-ray of the soul, of the characteristics of

our patterns of perception. And the answer, it seems to me, lies in a transformation of the idea of the self, from a faculty-based picture of the self, which was a requirement for thinking about the inkblot as an exercise in or test of the imagination, to a self that is more like Freud's topographical model, in which most of the self lies outside of consciousness. Also, the idea of a will-based self is now entirely inappropriate, because the will, or its distant cousin the ego in Freud, is but a thin membrane separating desire from reality. It's not in charge; the ego is no longer master in its own house, as Freud once said in a terrifying remark. In that period, as the unconscious was introduced and developed, it became, by the 1910s and 1920s, a fairly common way of understanding the self, no matter whether people followed Karl Abraham or Jung or Freud. The idea of the unconscious and the thought that it might be significant that you misspoke or that you forgot somebody's name—all the commonplace ways in which the unconscious is invoked in everyday life, even for people who don't subscribe to detailed psychodynamic accounts of action—became very important.

With Rorschach, I was interested in how, in those years from 1910 to 1920, he absorbed and learned to think with the unconscious in his psychiatric work, and how that made possible a very different picture of what these inkblots were. That's an example of this first stage of how a changing idea of self makes possible a new technology. And I take the Rorschach test to really be a technology; not just the plates themselves but also the scoring mechanisms, the way these are tallied, the apparatus that's used, some parts of which are now computerized. It is a technology—one that's produced, distributed, discussed. Reciprocally, once this technology is mass-produced and becomes truly ubiquitous, so that it's a model for artworks, science fiction, cartoons, and it becomes possible for President Obama to stand up in front of three hundred million Americans and say "I am a Rorschach" and expect that we'll know what he's talking about, then it begins to act in the more Foucauldian way. It begins to train us, whether we're one of the millions of people who have taken the Rorschach or whether we're witness to it through cultural productions. It becomes a stand-in for this picture of the self as a magic lantern projecting its innermost concerns

onto the outer world, which we've absorbed. And it would have been unrecognizable as a picture of the self in the seventeenth or even the nineteenth century.

That's the kind of process that I'm interested in: how changing ideas or changing experiences and understandings of the self make possible certain kinds of technology. Then, once certain technologies are spread far and wide and become part of our everyday vocabulary and experience, they teach us how to be.

JD: I want to ask one more question about *Building, Crashing, Thinking*, specifically about the title, which I take to be an allusion to Heidegger's "Building Dwelling Thinking."⁷ We've been speaking about technologies of the self, Foucauldian and otherwise, but I wonder if there isn't also a Heideggerian valence to the notion of technology at issue in *Building, Crashing, Thinking*. How do Heidegger's writings on technology relate to the work you're doing in this book?

PG: I think of Heidegger as both a positive and a negative model for what I want to do. That's why I used and then flipped the title of his work. On the positive side, Heidegger did a huge amount, that's visible if often unacknowledged in Foucault, to make possible the historicization of the self. In the later Heidegger especially, including his writings on technology, he's very concerned with the way in which how the self works in the world has shifted. I find that approach very useful. Even though Heidegger presents epochal pictures that are not as exactly tied as they are in Foucault to the particularities of science and technology, I think that Foucault's sensibility about the changing nature of the self owes a huge amount to Heidegger. And I in turn owe a huge amount to what Foucault did. This idea that the self can be conditioned and the idea of scientific exercises by analogy to spiritual exercises are very important to what I'm trying to get at in this project.

But there's a negative side to Heidegger, too, and I'm not speaking about the political issues that surround what he was up to in the 1930s and 1940s with Nazism. Instead, in a profound way, Heidegger dismisses precisely the kinds of technology that I find most

urgent. He thinks, for instance, and says, that the atomic bomb is not a thing, that airports are not places—they're not things either. The destructive, crashing problems of large-scale technological structures are exactly interesting to me and exactly uninteresting to Heidegger. He dismisses them categorically and philosophically. The kinds of things he sees as worthy of the name are things like a pewter jug shaped to its use by the hand, to pour and contain; his famous hut with the sloped roof built just so to shed the snow, built appropriately into the side of a hill. In a way, perversely and enthusiastically, I find riveting all the things that aren't that. I'm interested in Bauhaus technology, flat-roofed houses, airports and airplanes, crashing airplanes, nuclear weapons, surveillance—all sorts of technological objects that are both more contemporary and larger scale, sometimes constructive and sometimes destructive. It's unimaginable to me to exclude those sorts of things from philosophical or historical analysis. And I'm precisely interested in the questions that they raise.

So Heidegger's title, "Building Dwelling Thinking," is quite important to me because it prompts thinking about space and place, the way our constructions transform place, like when he analyzes the bridge and what it does to space and place. The idea of dwelling in the Heideggerian sense may be less interesting to me because it seems so saturated with what strikes me as a nostalgic picture of what objects or things are or ought to be. And the crashing that I've substituted for that is an acknowledgment that in the centralization that is characteristic of so much of modern society—of cities, infrastructure, highways, and data systems, of power and weapons—the fragility of our expansive systems becomes more visible to us and their nature more apparent. In a way, that's a kind of contemporary version of something that Heidegger was interested in, which is when the hammer handle separates from the head and throws the object into a kind of relief that's not otherwise available to us when we're simply hammering and it's an extension of our hand motion. But on a much larger scale, I'm interested in how we understand the failure of big systems, up to systems the size of the earth: big communicative systems, large-scale nuclear wastelands, the crash of a 747 or a rocket. And what that means

as to how we understand the world around us and what place that puts us in—us both collectively and in the sense of the modern and contemporary self.

JD: This seems to be precisely the impetus behind *Containment*, the documentary you've been working on with Robb Moss. Its subject, nuclear waste and the various methods, projects, and sites for containing it, is a problem that is at once technological, scientific, and political but whose sheer physical and temporal scale makes it extremely difficult to visualize. I think this is equally true of your previous documentary, *Secrecy*, but by way of talking about *Containment* I wanted to ask about the kinds of challenges that you've been confronted with regarding how to visualize the problem of nuclear waste containment. And, in turn, what has film given you in this project that a print project would not? How do you engage with these historical objects differently when you're working in film versus print?

PG: I'd say you are exactly right that when I'm interested in things like objectivity, time, secrecy, or the distant future, I'm trying to get at them through concrete, visualizable situations in this characteristic way that I've been developing from *How Experiments End* forward. In *How Experiments End* and *Image and Logic* I designed the images so that you could read the books through the images as side narratives or another dimension of the narrative. In *Objectivity* this is even more the case. The objectivity at issue is objectivity through images, and images produced through procedures. One of the targets of the book was that Lorraine Daston and I wanted people to stop thinking of objectivity as coterminous with science or exactitude or correctness. We also wanted to show how it had a particular meaning along with particular practices, and that objectivity did *not* enter with Descartes, Galileo, and Newton. They had no interest in objectivity as such; in fact, when Descartes uses the term he more or less means the opposite of what we would mean. So I wanted to know how objectivity could be given a philosophical, scientific, and pedagogical understanding through procedures used to make things that people dubbed objective—and those things were, in the first instance, images.

Images have been very important to me throughout my work, and I was interested in film for a long time. I particularly wanted to know how to think of film in terms that connected to the work I was doing in the history of science. I had written about the moral-political debate among scientists in the late 1940s and early 1950s about whether they should build the hydrogen bomb. It really split the community; people who had been very good friends and colleagues, like Edward Teller and Hans Bethe, stopped talking to one another. It led to the Oppenheimer security “trial” in 1954, which further split the scientific community. It led to the creation of the Livermore Laboratory in competition with Los Alamos and drove a kind of internal arms race within the United States. It had huge consequences. And among the leading scientists of the day, there was a wide rift. Some thought the H-bomb was necessarily a weapon of genocide. Oppenheimer believed that. Fermi thought that. Bethe thought that. Others like Teller, Pitzer, Alvarez, and Lawrence thought that if the United States didn’t build the hydrogen bomb, the United States and its allies would lose the Cold War and much of Europe would be enslaved by the Soviet Union. There were opposite pictures of apocalypse on both sides. This work became the basis of my first film, *Ultimate Weapon*, which I made with Pamela Hogan. When making the film, I started by thinking that I could just do what I did in the text, only film it. But that worked terribly. As a historian, or a philosophically informed historian, you could ask, What are the periods, why did people seem to flip-flop the way they did, how do we understand this? In other words, you could periodize the events: 1942 to 1949, 1949 to 1954, and so on. But organized in that chapter form, it was a kind of illustrated lecture, not a film. So I really struggled with figuring out what worked in a film and how to use the moving image to get at something.

For instance, there was a film made shortly after World War II in which Oppenheimer and his colleagues acted out the making of the atomic bomb, like a simulacrum of their own lives. I thought I could use that in this film. And the Atomic Energy Commission was making films about the detonation of atomic weapons, including the hydrogen bomb. The AEC would then show that to Congress; they were classified, then later released to the public. Films were

being used to make a form of history, as well as to make policy, to get funding. That became part of the way I thought about making the film. In film, the density of visual information allows you to get at things unavailable in print. Print can be better at a kind of analytic parsing, but it's not because I think that print does concepts and film doesn't. I think that film does concepts through this kind of specificity of image and tone. I was interested in exploring that.

Then in *Secrecy* there was a new challenge, which is how in the world we could make a film about secrets if your subjects can't talk about them and your viewers can't see them. In a way, understanding what secrecy does to people, how it actually acts in the world, how secrets are held, how they're resisted, how it's decided what should be secret—I think there's a dimension to it that's not captured by a purely analytic approach. You have to see in people's faces what carrying, protecting, and disclosing mean. During filming I was very struck by how people understood the connection between different kinds of secrecy. I was curious whether people thought, for instance, that biblical, sexual, and national security secrets had anything to do with one another. Or did they think such things linked only by crazy association. One of the things that really struck me was that everyone, from senior people at the NSA and CIA interrogators to journalists like Barton Gellman, who's now very well known for his role in the Snowden leaks, all saw immediate connections between different kinds of secrecy. Mike Levin, who's from the NSA, opens the film by saying, "Secrecy is like forbidden fruit. You can't have it; makes you want it more." To understand that association, which seems to me fundamental to understanding how secrecy functions the way it does in our world, is to understand secrecy's force. It's a place where metaphor functions in this deep way, not just in a purely expositional way. It's less like the rhetorical trolley problem and more like Einstein's trains or Poincaré's maps. If you see how deeply people feel about secrecy, then you can understand why, say, Congress believed secret information that turned out to be wrong about Iraq nuclear weapons and didn't believe the non-secret UN report, which in fact turned out to be correct. But that sense that the secret is valuable, that it's hidden and therefore superior, attractive, seductive, is, I think, cru-

cial to understanding secrecy's political function. Film allows you to understand this.

For example, in *Secrecy*, which is a more visually articulated film than *Ultimate Weapon*, we wanted to use animation. When people were talking about forbidden fruit we could flow out of real-time interviewer footage and into this woodcut-like animation that Ruth Lingford did for the film. That's a way that the imaginative space of film opens things up. A silent, woodcut-like animation is a long way from print. It's using the medium of film to do something that it does very well, which is adjoining the affective, the conceptual, and the associational. Film moves by different logics than print.

JD: In what you've been saying I hear resonances with a quote that I recently read in an interview you did with *Public Culture*. You said, "I think that what people can't understand in a specific way, a specific, tactile, or visible way, is often out of the possibility of real political engagement."⁸ For me, this politicization via visualization is one of the most crucial aspects of, for instance, watching *Secrecy* or reading your piece "Removing Knowledge," where you can see on the page your estimate of the volume of documents classified by the US government. What is *Containment* trying to visualize, to concretize, in order for it to have a political potential that it might not otherwise have had?

PG: So if I say, for instance, that there's nuclear waste, or even if I give you a number—for example, there are 220 million-gallon tanks of high-level liquid waste—you don't know where they are or what they are like. Our experience of it as a problem is different if you can visualize it. You might ask, well, what is a million gallons? But if I say, picture a tank that's the Capitol dome upside down and filled with nuclear waste—that's a million gallons. Then if I say that this stuff has the consistency of peanut butter, and there's this sludge that would kill you if you drove by it, that's a very different picture. Or, rather, you *have* a picture, whereas you didn't have one before. And if I say it's sitting in or above the water table on the Savannah and Columbia Rivers and some of it

in Hanford has been leaking into the Columbia River, and meanwhile you also see images of this, then suddenly its removal from the domain of abstract discourse to a place, size, and consistency, to a tactile and visual form, begins to create the conditions under which you can actually get going with a political argument about what you want to happen to it or what amount of resources we're willing to devote to it. Part of this concretization of abstraction is a way of bringing things back to their human dimension, to the real. There's a risk with abstraction: when something becomes deracinated in the sense that I mentioned earlier, it can get lodged outside politics, outside reason. It can move outside being a matter of concern to us. That's a consistent theme of what I'm interested in, especially in the film work: to take questions that have a scientific, public, political dimension and to use film to bring those questions into the national discourse through a visualization that makes them concrete. Brecht once talked about the need to give things names and addresses. To me that seems important; without names and addresses, things slide out of our awareness, or if they're in our awareness, then they slide out of our ability to judge whether they're worth engaging with, whether we should care. Robb Moss and I were trying to make secrecy a bigger topic of discussion at a time when it really wasn't. We didn't know anything back then (of course) about the Snowden or Assange cases, but it was already clear that there was a corrosive quality to the vast extension of secrecy. It wasn't, however, a matter of disclosing a particular secret. In neither my written nor my film work am I trying to say, for instance, "This (secret) jet can go to 48,000 feet and travel at 720 miles per hour." That's not the point. The point is to ask, What is the secrecy apparatus, its purpose, procedures, effects? What does that mean for us? What does it mean for deliberative democracy? What do we need in order to bring things into the discourse? We need specificity and tactility of knowledge.

JD: William Kentridge, speaking about *Refusal of Time*, the exhibition on which you and he collaborated, has said, "One of the things that artists do is to take things we know but can't see and make them visible."⁹ This sounds very much like what you've been

saying about the importance of visualization in your work. Indeed, I would say, adopting a phrase of yours from “Objectivity Is Romantic” and *Objectivity*, that visuality is a particularly important epistemic virtue for both you and Kentridge. Did you find yourselves agreeing about the epistemic, affective, and other roles of visualization generally and of images and representation specifically? How is the kind of knowledge production you’re after in an aesthetic work different from a historical or analytic work?

PG: When we began talking, one of the things Kentridge said right from the start was that he didn’t want to do an illustrated science lecture. I said that’s good because I don’t want to be a science adviser on an art project. That out of the way, we began from two starting points. One is that we both like making things visible, albeit in different ways. The other is that we were both fascinated by this moment in late-nineteenth- and early-twentieth-century technological culture when technology wore its function on its sleeve, so to speak. You didn’t have to pry open a black box to fix a car. And in a computer, even as late as the 1940s, there were switches and telephone relays. There was a new epoch of technology opening up, but it had a kind of visibility that you can’t find in contemporary technology.

Kentridge read my book *Einstein’s Clocks, Poincaré’s Maps*, and I went to see his exhibit that was opening at the Museum of Modern Art then, and we began to talk about time and how a collaboration might work. One episode that figures importantly in the book and that he liked very much was the idea that people were pumping compressed air underneath Vienna and Paris as a way of coordinating clocks. I thought this was very funny, in the way that I thought Einstein and train stations were funny. So we began to think about that, and what I’ve learned from the work with William is to go farther along the associative lines, by a long shot, than I had done before. In *Secrecy* we were already using animation to go past anything that I could write about. But William pushed really hard on that, as he does in all of his work. Learning to be freer, in a way, to allow the associations to move, grounded in but not bounded to this idea of different times: coordinated time, pumped time, Einsteinian time, black hole time—going way out from there.

I wasn't trying to monitor it for expositional completeness. *Secrecy* is trying to go back and forth between bringing issues to understandability and exploring the psychological interior states that are associated with it, as well as the political consequences. So it's constantly on a kind of knife-edge between these different registers. In the artwork, by contrast, we begin in but travel away from a chronological, expositional, pedagogical understanding.

JD: Much of your work focuses on collaborative relationships in the history of science. In *Image and Logic* you trace what you call subcultures of theoretical physicists and experimentalists, the logic tradition versus the image tradition, and there develops a kind of sociology of these subcultures. But collaborations have also been important to the production of your work, and we've spoken of a number of these: *Objectivity* with Lorraine Daston, *Secrecy* and *Containment* with Robb Moss, *The Refusal of Time* with Kentridge. So I wonder if you've ever stepped back at moments during these projects and thought about your own subjectivation, as it were, as a scientific—or other—kind of self. It would seem that the processes of self formation that you've tracked in your work and that we've been speaking about would have to be present in the making of that work as well.

PG: They are, and I think of them often. What's been important to me in the collaborations with all of these people has been learning a kind of discipline of letting an idea develop, of not stopping it, and of seeing where it goes. Now, this requires a lot of trust in the collaborator, and the dynamic is certainly different in these situations than, for instance, at CERN, where there are upwards of three thousand collaborators, most of whom one never meets, let alone having the same kind of interface. But in Robb Moss, Pamela Hogan, William Kentridge, and Lorraine Daston I have collaborators from whom I've learned that in order to advance sometimes, you need to try things out. And what struck me so strongly, especially in the film and art collaborations, is that once you try it, there's actually very little argument about whether it's working or not.

Early on, Robb and I would get into arguments all the time,

but we learned to stop trying to resolve our differences of opinion through statements alone and would instead just try out our ideas on the screen. I also saw that very much in the collaboration with Kentridge. We tried a lot of things that didn't work, but they weren't an argument once we tried them; they were apparent. And sometimes they would lead to something else. In the Kentridge piece, for instance, I wanted some way of visualizing the falling of information into a black hole, and I thought we could use Morse code and embed it into the music somehow. I spent a lot of time talking with composer Philip Miller about how we might do that, and he had some ideas. But then we found out that Stockhausen had done something like this, and besides it didn't sound that great the way we were doing it—but there was no argument once we tried it. Then I was looking at a player piano in Kentridge's Johannesburg studio and noticed that the roll of music looked like dots and dashes. So I thought we could use that as a form of encoded information, as a visual stand-in for information. I showed that to William, and he said, Why don't we project light through it, onto a screen? So we did that, then reversed the film so the light was falling instead of rising, then inverted the color, black for white, and it was beautiful.

In short, collaborating has also taught me to quiet my own sense that I can anticipate how something will work before we try it and to allow a kind of experimental openness in the work. I think that's part of what a collaboration has to be. Then, when working by myself, I've tried to be more open to that. Another thing about the collaborative structure, especially for work in the arts like the Kentridge collaboration, is that even after something passes the test of the makers thinking that it's working, you then have to show it to other people. In the written world we sometimes do that, but sometimes we don't. We have our writing groups, or we try something out as a paper. But in film you *really* must see it with people in the room, and you can feel when people are attentive and when they're not. Then something that's true of both the written and the visual work is when somebody says, "When you did *x*, you could have done *y*." Which is to say, recognizing that there's a problem, and the solution that's being offered might not be at all what you

want to do, but what you must do is recognize that something went off the rails at that point.

JD: Was there something in *Building, Crashing, Thinking* that you thought would work—for instance, how to present a certain argument or how to narrate an event—that then just did not the first or second time around?

PG: I'm now doing a final set of revisions on the *Building, Crashing, Thinking* manuscript, and there have been many things that I've learned about it. For example, in the study of the Rorschach, I noticed that the text oscillates back and forth between the present and Rorschach's time, and it seemed to me to not work. Especially since it's the first substantive chapter after the introduction, it's very important that people see the structure of the argument: how it was that Rorschach was brought into a picture of the self different from the one he was trained in by associationist psychiatrists, like his teacher Eugen Bleuler, and into the fold of a (broadly speaking) Freudian picture of the unconscious. I think that the experience of teaching the course at Chicago and speaking about the structure, working out how to put the argument in a schematically clear form, made it much more evident that I needed to see how Rorschach was treating his patients, how he was treating their diagrams and drawings and paintings, in the ten years before he introduces the test. So I've been working through that much more carefully, chronologically, and seeing the unfolding of this at first Freudian picture of the unconscious and how it functioned, then how that was linked to how Rorschach was treating his patients' drawings and images—sometimes cartoons, sometimes paintings, sometimes little schema—and being in an ambient culture of others who were interested in making the “art of the insane,” as they called it, into a very significant piece of diagnostic psychiatric culture. Then that would make sense of how he thinks about the inkblots when he comes back to them in 1917. Those ideas are there in the piece that I did for *Things That Talk*, but they're not clear enough. That piece doesn't show how he got plunged into this psychiatric milieu and then pulled out

the Freudian dimension to make the test something that would become a kind of lingua franca for psychiatry more generally, usable by people from Bleuler and Carl Jung to Karl Abraham or Freud and others. Being able to show this in the book is the result of having tried it out and of having tried, very deliberately, to make this structure of the self a priori and the technological a priori clear in their directional, reciprocal action. That's an example that I think is very central to the project.

JD: It's been twenty-seven years since the publication of *How Experiments End*, in which you first outlined your plan for a three-volume project that continued with *Image and Logic* and is now nearing completion. What suggested itself that early on and then continuously through your career that there should be these three volumes that, although they each stand alone in their own way, are meant to fit together into one collected work?

PG: I've done a series of pieces on the way theory functions in physics, and I've come to think that these are probably more directly the third part of the trilogy. That work deals with questions like how Fineman's work on the atomic bomb at Los Alamos reshaped his idea of what physics should be about, whereas most people would say that Fineman just had years of distraction at Los Alamos because the nucleus really had nothing to do with how electrons work and with his famous and Nobel Prize-winning work on quantum electrodynamics. But to the broader question of how I understand the relation between *Building*, *Crashing*, *Thinking* and my work more broadly, I would say the thing that's constant is that I love the sudden juxtaposition of the abstract and the concrete. I think it's funny, interesting, politically useful, aesthetically intriguing—much more than a kind of Platonic picture of a rough-hewn circle in the sand, then ever more refined instantiations until we have the Idea of the circle, or the opposite, namely, that we start in abstraction, abstract mathematical physics, then applied physics, chemistry, biology, and so on. To me that seems neither amusing nor true. That's constant, although its form has changed somewhat. Moreover, I would say that all of my projects have

come from thinking of these ideas in physics, then how they move outward. Physics has this strange path through the long twentieth century that took it into deep relationship with philosophy and technology, then through the atomic bomb into matters of national defense and national security more broadly. Physics is about electricity, magnetism, and power, but it's also about nuclear weapons, the nature of causality and simultaneity, determinism, who we are, where the universe comes from, and where it's going. It's an oddly multivalent site of culture. It *is* a site of culture, and being able to explore these various radii emanating out from it is what has interested me so strongly over all these years.

JD: We've spoken at length about your contributions to the history of physics specifically and of science in general, and of the particular historical methodology that has developed over the course of your work. But there is no doubt that this work has also informed and in many instances specifically engaged with abstract, theoretical discussions in philosophy and the sociology of science. Your most expansive historiographical work, *Image and Logic*, finishes with an extended discussion of Kuhnian paradigm shifts, logical positivist and antipositivist accounts of periodization, and your own, alternate account of how knowledge has developed over time in the field of particle physics. Your notion of trading zones, which developed out of this discussion, has been taken up by scholars across a range of disciplines in the humanities and social sciences. Nevertheless, the theoretical aspects of your work are always tied to the concrete and the historical. This is of course in line with everything you've said about the importance of the material and the visualizable in your work, but there also seems to be an underlying insistence on historiography over theory.

PG: If you want to understand what I think about these things, I would say the same thing about the objects of my inquiry, which is to look at the specificity embedded in the ideas. When I talk about an account of periodization, it comes out of looking at experimentalists, instrument makers, and theorists each having their own rhythms, changes, break points, and so on. I think you can

go far in theory without obscuring the connections of the abstract and the specific, and that's what I'm after—both in my own work and in accounts of what's going on in the culture more broadly. You know, sometimes people will say to me, "I'm using the trading zone in this way, say, to understand soil scientists and farmers," or "I'm using it to study urban design. Can you adjudicate whether I've used it correctly?" In every way the position of Method Judge is not one I want to occupy. I see theory as a form of tool that helps us understand things. I don't see it as a kind of intellectual property that needs to be monitored and regulated for correct use. In fact, I learn from the way people carry on with my ideas. That's how I'm interested in other ideas, too. Whether it's Michel Foucault or Arnold Davidson, Hilary Putnam, Gilles Deleuze, or Martin Heidegger, I want to use others' ideas to better understand the world unfolding around me. Of course, there are moments when the goal is different from that, and it really is to give the most in-depth, coherent, or contextual understanding of where a set of ideas is embedded. That kind of *exposition du texte* is fine, but in my working mode that's not my primary objective, and it's certainly not, in reverse, my goal when others want to use my work.

JD: So then the lesson is in fact quite characteristic of your work. Just as abstract versus concrete is a kind of false dichotomy, so too is theory versus history or theory versus historiography a false choice.

PG: Yes. It would seem a priori unlikely that there was a sharp boundary between theory and history or, say, between theory and literature that didn't hold in the place where theory has its greatest purchase—namely, theoretical physics. My experience is seeing theoretical physics and experimental, instrument-based physics as each having a certain quasi-autonomy but being tied through these trading zones to each other and to the world in different ways. Theoretical physics is tied on one side to math, on another to instrument making and technologies. So it seems unlikely that when the humanities or the humanistically inclined social sciences turn to terms like *theory* that they would find a total autonomy not otherwise present. Again, if I'm trying to understand what Lévi-Strauss

is talking about, for instance, or Saussure, Deleuze, or Foucault, I often want to know the cases in the first instance before them. Over and over again that seems to me a useful place to begin. Looking for the practices that lie behind something that seems even relatively abstract, like the Rorschach inkblots, is helpful because people don't start in the abstract. I am interested in historiographical and theoretical issues of a historically embedded epistemology. But I think that the way to these abstractions is through the specific and the material. That collision draws out how we think and who we are.

Notes

1. Peter Galison, *How Experiments End* (Chicago: University of Chicago Press, 1987), ix.
2. Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997), xix.
3. Lorraine Daston and Peter Galison, "The Image of Objectivity," *Representations* 40 (Autumn 1992): 81-128.
4. Peter Galison, "Objectivity Is Romantic," in *The Humanities and the Sciences* (Philadelphia: American Council of Learned Societies, 1999), 15-43. Hereafter cited as "OR."
5. Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007).
6. Peter Galison, "Image of Self," in *Things That Talk: Object Lessons from Art and Science*, ed. Lorraine Daston (Cambridge, MA: Zone, 2004), 258.
7. See Martin Heidegger, "Building Dwelling Thinking," in *Poetry, Language, Thought*, trans. Albert Hofstadter (New York, 1971), 143-59.
8. B. R. Cohen, interview with Peter Galison, *Public Culture* 26, no. 1 (2014): 91-92.
9. William Kentridge, *The Refusal of Time*, promotional video, Metropolitan Museum of Art, <http://www.metmuseum.org/exhibitions/listings/2013/william-kentridge>.