CHAPTER 13

HAPTICS
Haptic Creativity and the Mid-embodiments of Experimental Life

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> "…a subject only becomes interesting, deep, profound, worthwhile when it resonates with others, is effected, moved, put into motion by new entities whose differences are registered in new and unexpected ways."
>
> (Latour 2004: 210)

Henri Bergson's (1991) *Matter and Memory* animates a theory of perception based on 19th-century physiology. In this work Bergson bundles perception and movement together in the nervous tissue of the body, exploring how affect and responsive action are produced through a "kind of motor tendency in a sensory nerve" (1991: 55–56). Through Bergson, and Deleuze's reading of him, we've been lured to attend to the affective sensibilities acquired by researchers at work and play in their laboratories. We've begun to see their bodies as *excitable tissues* for gathering up the energetics and movements of the world, and manifesting these as perception, affect, and action (Myers 2006). In this chapter we find affinities among the practices of biologists who visualize living cells through time-lapse media, and those of geologists who work with data models of earth formations in virtual reality environments. As they work with responsive media, these researchers' articulate gestures and movements remind us of protein crystallographers and biological engineers whose modes of embodiment are continually reconfigured as they build and use models of protein molecules (see Myers 2007 and n.d.). Myers has found that molecular modelers' responsive bodies are attuned to subtle molecular forces and affinities; they hitch rides on the molecular movements they model and allow these intricate forms to inflect

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their gestures and affects. Modelers *transduce* these affects through their body-work and propagate these gestures through performative articulations that excite others into action. In this sense, entire research collectives become *excitable media* with the capacity to collect up and relay nuanced molecular affects. And as we turn our attention to the visualization practices of geologists and cell biologists, we learn new things about excitability and embodiment in experimental practice.

In this chapter, we present our collaboration working as anthropologists of experimental forms of life. We examine fieldsites where practitioners develop and use computerized visualization technologies. In the process we aim to collaborate with scientists and artists as they reflect on their practices and interpret their experiments. In addition to cell biologists, geologists, protein crystallographers and biological engineers, we have worked with PET scan brain imagers (Dumit 2004), dancers and installation artists. Here we focus on two researchers who are involved in intensive investigations with relatively new technologies. One is Dan Hijiko (pseudonym), who inquires into cell movement through live-cell imaging, and the other is Dawn Sumner, a geologist who engages her data in a 3D immersive environment known as the CAVES, for "Computerized Active Visualization Environment."

We have conducted an extended set of interviews with Dan at the east coast research university where he works. We observed his public talks and his contributions to meetings with interdisciplinary researchers, as well as his classroom lectures in biological engineering courses and in a course that Joe teaches on comparative visualization techniques called "Visualization Across Scientific Disciplines." In each case we were interested in Dan's approach to visualization and how he acquired his skills working with organisms, instruments, data, and stories.

We currently spend time with geologist Dawn Sumner as she engages her data in the KeckCAVES (http://keckcaves.org) 3D immersive environment at the University of California, Davis. This interdisciplinary collaboration between earth scientists and computer scientists aims to develop new visualization techniques to improve scientific interpretations. KeckCAVES provides an environment for collaborative research, teaching, education, and mentoring in the use of interactive visualization methods for understanding geological processes and human interactions with the natural environment. Its core facility is a CAVE, which consists of 3 walls and floor with stereoscopic displays providing full 3D images, head-tracking to render perfect stereo for the viewer, and a six-degrees-of-freedom (6-DOF) tracked input devices for interaction with the data. According to its users, research in the CAVES has already transformed the geologists' practices and insights, but this transformation has been difficult for them to express in their scientific publications.

Rather than enumerating the differences between these sites, the distinct kinds of instruments, data, questions, and objects that circulate within them, we are interested in affinities. The two practitioners in this study are constantly reworking their technologies while they develop and test their hypotheses. Both engage their technologies to get entangled *kinesthetically* and *affectively* with their data. In practice, they transform these technologies into *responsive media*, and in so doing, they maximize their opportunity for what we are calling "haptic creativity." Each fieldsite teaches us new things about experiment, and holding them together we can begin to observe more generally the morphing modes of embodiment and excitability that constitute experimental forms of life.

In our work with these researchers we pay attention to how they produce, play and replay time-lapse movies and explore 3D models at different spatial and temporal

scales; we keep pace with them as they keep pace with phenomena that unfold at different tempos and rhythms; and we stay with their prevarications, repetitions, and hesitations as they try on different narrative forms to render time-based events sensible. We also pay close attention to how, in their responsive experimental environments, they explore new analogies and metaphors in an often-playful manner.[1]

What we find in both sites are experimentalists caught up in prolonged encounters with their data, instruments and stories. They are in the midst of things: caught up in moments of not yet knowing. The relations between scientist and object loop in the form of ongoing, iterative, overlapping becomings. By beginning our accounts from inside their experiments it is possible to show how these experimentalists' data, instruments, and bodies and identities are continually reconfigured within their apparatuses. We show how these researchers spend significant portions of their time figuring out *what it might be possible to know* in the context of their experiment. What we offer, then, is an anthropological phenomenology of those sometimes fleeting, sometimes prolonged moments that arise in the middle, mid-thought or mid-gesture. This paper thus tracks this constantly morphing tangle of bodies, instruments and objects that we call the *mid-embodiments of experimental life*.

Leaning Into The Data

> *"Is not being moved, or rather, put into motion by the informants exactly what we should mean by an enquiry?"*
>
> (Latour 2005: 48)

Dan Hijiko, a cell biologist and biological engineer, stands up in front of an audience made up of an odd assortment of anthropologists, historians, nuclear engineers, physicists, architects, and life scientists. We are all participating in a series of NSF-funded workshops examining how computer visualization has changed the dynamics of different professional fields including biology (see Turkle et al. 2005; Turkle 2009). Dan is here to talk about his contributions to innovations in light microscopy and cellular dynamics. Like many of his colleagues, he uses confocal microscopes to image living cells in their three-dimensional thickness and to follow them through time; and like others, he homes in on particular molecules of interest by tagging them with fluorescent proteins that light up under ultraviolet light. He stands in front of a screen illuminated by a looping time-lapse video of a large, seething cell pulling itself across a sheer surface. It is a macrophage: a white blood cell whose actions are central to the body's immune response.

The cell is translucent against a mottled grey surface. As its leading edge extends, it reaches outwards and pulls itself along with a rippling motion forming protrusions and invaginations. The cell pullulates with activity: a thin layer at its leading edge billows and bubbles, while the material in its middle ingathers and swarms in eddies. As the cell pulls itself forward, it leaves long strands of its body tethered to the surface. These get stretched to a thinness and then rapidly indrawn as the cell advances onwards. Dan sets up his talk for his audience: "This is a story about how our bodies develop – during development, during embryogenesis. It is a story of how cells move. And cell movement is very like a rock climber, where the rock climber inches his or her way up a rock face, usually by fingertips creeping up some sheer rock wall."

As he begins to tell the story, he lifts his arms high up above his head, and rises up on his toes. The camera-person recording this performance has not anticipated the largesse of Dan's movements and his arms extend right out of the video frame. Dan suspends himself here as he continues to describe how the rock-climbing cell gets its grip: It is "stabilized by some little purchase on some little deformity on the surface." He comes down from his perch and presses his hands, palms down, to create an image of a stable surface. "And that's basically how a cell moves."

The cameraperson clues in to the dynamics of Dan's movements and starts to follow him as he tacks back and forth from his computer where he is running a PowerPoint presentation, to the projection screen. Dan moves to the screen: "You can see it here in these videos. Where, this is a cell moving forward. It pushes its membrane out as the macrophage advances forward." With his eyes fixed on his audience, he stands next to the projection screen and stretches his arms out in the direction of the cell's movement, moving with the cellular motion to emphasize the push of the membrane.

He releases this gesture to continue: "But in order for motion to occur there has to be some sort of friction generated. And here you see at the leading edge of the cell are these zones of dots which continually appear as the cell moves forward." He sweeps his left arm upwards to show his audience where to look. "And these dots are basically adhesions that the cell makes literally pulling itself forward as it's moving."

To show how the cell pulls itself forward, he again stands parallel to the screen and extends his arms and hands out in front of his body. But this time he situates himself directly in the beam of light emanating from the LCD projector. Looking into the light, towards his audience, he extends his arms out and up, and ripples his fingers to follow the direction of the cell's movement. He casts a dancing shadow on the screen. Like his looping video, he repeats his shadow puppet show as he talks, and even turns his head to take in the full effect as his arms and hands animate the pull of the cell's adhesions.

As he pulls his body into play to dance with the projected light, he makes visible the otherwise invisible integuments that entangle him with his data, his instruments and the stories he tells. Indeed, in this performative medium he is able to articulate quite effectively just how he is entangled inside of his inquiry into cellular life. This demonstration shows his audience how he leans into cell movement and how he gets swept up – *kinesthetically* and *affectively* interpolated – into a story of cells as rock climbers whose finger-like adhesions fumble to get a grip on some sheer surface. Dan, the cell, and the rock-climbing story all gain purchase in this performative moment. And as such, the otherwise hidden aspects of this experimental form of life come into view.

We begin our analysis from the premise that there is more going on in this scene than one charismatic scientist trying to persuade his lay audience through theatrical gestures. In other words, we push past the assumption that this scene can be interpreted through theories that analyze scientific truth-making as a self-consciously staged performance (See Herzig 2004; Hilgartner 2002; Mol 2002). Historians of science pay extraordinary attention to carefully choreographed scientific demonstrations and public displays as they try to make sense of how scientists corral assent and secure validation for their experimental findings. Their analyses of "gentlemanly modesty" or theatrical bravura have brought renewed attention to bodies, gender and affect in scientific truth-making (e.g. Shapin 1994; Shapin and Schaffer 1985). And

yet, feminist theorist and historian of science Rebecca Herzig (2004) has shown how these analyses have tended to take for granted the bodies of the scientists and the materialities of their experimental apparatuses. In the process, scientists' bodies are treated as an ontological ground and self-evident source of agency. With Herzig, we are on the lookout for ways of theorizing performances, like Dan's, in ways that make visible how bodies and materialities are precisely what is *in formation* and at stake. We look to feminist science studies scholar, physicist, and philosopher Karen Barad's (2003, 2007) renewed approach to *performativity* and the ongoing materialization of bodies and meanings in science. Barad models science as an "intra-active" practice through which matter and meaning, subjects and objects, experiment and phenomena are always in the making.

For example, in a performative reading, the looping video cannot be treated as a stand-alone representation of the cell; in addition to the laborious experiments that were able to materialize cell movement in video, this clip is just one part of a wider scene that includes Dan's stories and movements, the projected light, the screen, and the audience. The overall effect is a performative rendering: an *enactment* of cellular life (Barad 2003; Mol 2002). This approach helps us see how, in this elaborate dance with his data, Dan is becoming a scientist, the cell is becoming an object, and the rock-climbing story is becoming a scientific hypothesis, all right before our eyes.

Moreover, through this frame, we also begin to appreciate the shifting, tentative, and precarious nature of the scientist, his object, and his story. In this performance, Dan is both inside and outside the story he is telling; he is simultaneously the observer, the rock climber, and the cell. The stories, like the rock-climbing cell and the others we discuss in this paper, gain their purchase, their foothold, only fleetingly. For example, the rock-climbing cell is a story that never makes it into print. In an early publication, Dan tells another story to animate the cell at a molecular scale. He homes in on and traces the relationship of tiny dots and blobs at the membrane surface calling them "mother" and "daughter" adhesions. Eventually this story too falls by the wayside, replaced in later publications with other terms and stories. In this sense, Dan's cell stories are labile and shape-shifting: the characters in the story keep morphing; the scale keeps telescoping; the subjects and objects vacillate. He shows us how his stories loop from a space of unknowing into insight, and how new stories and new insights are constantly in the making. We treat Dan's stories, therefore, not as descriptions of phenomena, so much as interventions through which new phenomena are materialized.

Dan shows us how scientific storytelling is a process of inserting and orienting oneself inside a phenomenon, and playing through possible narratives. As Dan's fingers crawl with the cell as it pulls itself across the screen, he is instructing his audience in how to see and how to feel cell movement. In a performative reading, he is both attuning our attention and materializing new phenomena. But he is also experimenting. By trying on the movements of cells and rock climbers, he is feeling his way into cell movement and so testing his hypotheses. In other words, his stories are not just images or thought experiments, they are kinesthetically and affectively informed *body-experiments* on their way to becoming scientific hypotheses (see Myers 2007 and n.d.). He moves his body to learn to ask new questions and grope towards insight. In the process, the story and the looping video begins to pull him in as much as they pull in his audience.

Rather than treating his gestures as stage-managed choreographic moves, we pay attention to how he innovates through his movements. He is not rehearsing well-known concepts; Dan is in this moment creating new insight through his kinesthetic stories. Rather than resembling a choreographed score, this performance is closer to a movement practice known as "contact improvisation," where two or more dancers engage in a tacit conversation, experimenting with the push and pull between bodies, and playing dynamically with tension, weight, and gravity. It is a viable metaphor to capture the improvisational play as bodies (human, nonhuman and machine) and meanings get made inside experiments. This is an example of the improvisational, exploratory aspect of scientific experiments that we call *haptic creativity*.

Dan is clearly *moved* by the moving cell that he is tracking, and also by each story that he is telling. Entrained to these subtle movements, he has learned how to *move with and be moved* by cellular life. Through intensive training, his body has become an *excitable tissue* capable of sensing and transducing the molecular practices of cells (Myers 2006). And his animating gestures have become means through which he can both conduct body-experiments to hypothesize about how cells and molecules move, and to propagate cell-inspired stories to his colleagues and students. As he shares his insight with this audience, we in turn *must move with and be moved by him* in order to learn how to see and feel how this cell moves.

Experimental methods

> *"In science, if you know what you are doing, you are not at the cutting edge. So, if you are at the cutting edge, you don't know what you are doing. You don't know what you are going to find. You don't know what the nature of the problem that is sitting in front of you truly is. And you need to develop ways to refine the problem. And that often involves technology. I mean there is a classic feeling among cynics in science that goes: 'That which is doable is not worth doing. And that which is really interesting and worth doing is not doable.' Well the idea is to make the really interesting doable by bringing to those problems the new technologies and the new thinking. And not to be discipline bound. To be able to transcend the different disciplines. And it also makes science fun."*
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> (Nobel Laureate Richard Axel, X-ray crystallographer, Columbia University, Interview available for view on the website for the 2009 documentary *Naturally obsessed: The making of a scientist*, see http: // naturallyobsessed.com)

Experimentation is a risky enterprise: experiments do not promise ease and assurance; they are unpredictable, uncharted "labyrinths" (Rheinberger 1997: 74). For Hans Jörg Rheinberger, experimentation is a tacit, embodied practice of "groping" through dark spaces of not knowing. Experimenters must be agile as they navigate between extended periods of disorientation and moments of insight. In this process, new objects, new questions, and new modes of experimentation come into view. Nothing is stable, including the end products of experiments: scientific images, models, and animations are themselves open reading frames, and enlist many in locally negotiated and contestable interpretations (Lynch and Woolgar 1990).

We want to understand how Dan Hijiko and Dawn Sumner inhabit their computationally responsive instruments and navigate their labyrinthine experiments. Take the

by now well-known example of the "Visible Human Project." This was a data-set built up from the sequential imaging of thin cryosectional slices through a frozen cadaver (see Waldby 2000). These images were stacked, coded and adjusted in order to reconstitute a three-dimensional data-set that could be accessed as a virtual body. Computer scientists, animators and medical professionals are using the data to render bodies virtually and make available digital surrogates for anatomical investigations. This data set has been mined and reconstituted for various training purposes using a range of interactive modalities (Johnson 2007; Prentice 2005). In the mode of the 1966 classic *Fantastic Voyage*, viewers can fly through the recesses of a virtual body on guided tours that take the form of, for example, a virtual colonoscopy. The Visible Human can be sliced and sectioned, or its layers peeled back to generate different ways in. This virtual body can be worked over with multiple logics, and the effect of different optical possibilities is the materialization of differently rationalized interiorities. The data-set is thus a digital archive for anatomical improvisation that, with extensive amount of labor, one could ask: what would a cut here reveal? What would I see if I pulled away the skin here?

As we watch geologists torque their bodies to manipulate their data sets in CAVES, we observe a similar embodied relation between the experimenter and their data. Their movements are provocations, questions that they pose inside their data-set: What if I try this? Or this? What can I see now? They don't only inquire into their objects; their questions are also aimed at their instruments. They continually test and assess the robustness of the visualization software and the data structure; they invent new forms of data manipulation; or demand different parameters from the programmers. As a result they generate new techniques for collecting and assessing their data, including new ways of talking about what they are finding. These are contexts in which their experimental techniques and modes of inquiry are still in the making.

Our aim is to document the "forms of life" (Fischer 2003; Helmreich 2008) alive inside experimental systems that engage responsive media. "Experimental systems" is a concept we modify from Hans-Jörg Rheinberger. In his account, experimental systems are "the working units a scientist or a group of scientists deal with." They are:

> …simultaneously local, social, institutional, technical, instrumental, and above all epistemic units. [A]n experimental system [is] a unit of research designed to give answers to questions we are not yet able to ask clearly…a device to materialize questions. It cogenerates, so to speak, the phenomena or material entities and the concepts they come to embody. (Rheinberger 1997: 287–8)

We are interested in the *in betweenness* of Rheinberger's formulation, this "cogeneration" of phenomena and concepts. And in addition to the social, institutional, technical, and epistemic dimensions, we reflect on the formation of scientists themselves in this generative encounter. A scientist's modes of embodiment and sensibilities are also inextricable from an experimental system, and this is especially true in systems that make use of interactive and time-based media. Experiments that use computationally responsive media such as CAVEs or the time-bending technologies of live-cell imaging ensure that the relations between the experimentalist, their data, and their instruments remain in flux. Questions posed with such interactive media

allow the observer to reorient herself continuously. In the process of posing exploratory questions, the relations between experimentalist and object get continuously reworked and reconfigured.

Embodiment, Experimental Agency, and the Middle Voice

> *"Meaning and matter are more like interacting excitations of non-linear fields – a dynamic, shifting dance we call science."*
>
> (Barad 1996: 188)

Anthropologists of science, technology, and medicine have made the call for a cultural phenomenology of embodied experience (Csordas 1994; Scheper-Hughes and Lock 1987). They have resisted approaches to living bodies that flatten them out into abstracted objects or objectified abstractions. Rejecting the *mise en abyme* of representations, they have opened up inquiry into the liveliness of being-in-the-world. Merleau-Ponty offers a generative approach for reinvigorating a phenomenological anthropological of science. He asserts, "bodies are … the ground of perceptual processes that *end* in objectification" (Merleau-Ponty 1962: 362; cited in Csordas, 1994: 7). We take this formulation as a positive description of the creative process of experimentation. From this vantage point, objects, concepts and representations are merely what precipitate out of the experimental scene in science. This phenomenological approach to experimental forms of life has oriented our attention to scientists whose experiments get them caught up what Barad (1996) describes above as a lively "dance" between meaning and matter. These scientists are caught in the midst of an active struggle for what can only at the end of the experiment be called "objectification."

And yet, bodies must never be taken as self-evident grounds for knowledge. With Deleuze, who moves with Spinoza (Deleuze, 1988), we must continually remind ourselves that we still *don't know what a body can do*. To keep answers to this question open, we must keep pace with these experimentalists as they get tangled up in their experiments, their stories, and their technologies. What we have learned is that embodiment vacillates for experimentalists. We know this because we can observe moments when they are *in between embodiments*; that is, we can track them *in the midst of* acquiring a habitus. Thus, with attention to the partial, incomplete, and labile nature of embodied relations in experiments, we enter into our inquiry not knowing in advance what we will find. We couple the question of "what can a body do?" with the question "what can an instrument do?" In the process we observe the ongoing making of subjects and objects inside experiment. We make the claim that an experimentalists' habitus is necessarily temporary, makeshift, and tentative.

Take an example from another site of our fieldwork: a geologist leans sideways, looking up as she twists her elbow to reposition the wand she is using to track the leading edge of a rock projection. She's half-crouching in a CAVE. She's wearing stereo goggles that flicker in tandem with projection screens, making three walls and the floor appear to be a space filled with rock structures. Her head-tracking device adjusts the projections so that she can "touch" the 3-D data-set in precise locations, rotate and enlarge structures, define and color surfaces, and make measurements. As

so many other scientists seem to do when they start interacting with their data in the CAVES, she is clearly playing with the images. She is lured into and caught up in the data as she tunnels into its depths. At the same time, she has come to this project with prior goals of rendering the complex structure quantifiable, so that the data can be made available as graphs and charts (Lynch 1988). According to Dawn: "The ease of measurement means that measurement is limited by the decision of where to measure rather than the mechanics of actually making the measurement – this can be seen by the hesitation of the user in this example (Sumner 2007).

Following Karen Barad, we recognize that act of measurement conditions what the data and objects of knowledge will become inside the experiment (1996, 2007). And yet, we want to pay attention to a related phenomenon: the ambivalence of the experimenter's relation to the data. As the geologist reaches out and hesitates, not knowing yet what or where or how to measure, we observe both her subjectivity and the objectivity of the phenomena wavering. The scientist is no longer the architect or choreographer in this experiment. There is no well-mapped experimental method: experimenter, instrument, data, and phenomena are all in the making. The result is that there are no clear-cut subjects or objects, until the final proof is rendered. In this geologist's hesitation, therefore, everything is at stake: the experiment, the instruments, the data, the phenomena, her lived perceptions, and her status as a scientist.

In immersive 3D one uses a mouse-like object to engage computers through screens; there is a tendency to describe this engagement with the term "interactivity." This term has become ubiquitous in human–computer interaction research, and in the process rendered self-evident. But movement and performance artist Susan Kozel, who experiments with media like CAVES, suggests that this term is incorrect. Through her practice she is closely attuned to the unpredictability of experimental forms of life, and has learned first-hand that the experimentalist is not in control of the experiment. Indeed, one of her experimental findings is a critique of interactivity that calls into question the directionality and source of agency inside experiments:

> Purposive decision making covers a certain range of actions of the autonomous agent, but is a construction of agency generous enough to include other states and actions? The acts of listening, prevaricating, meandering, stumbling, thinking, reassessing, and hesitating; the states of confusion, uncertainty, frivolity, intimacy. Agency might be spread across a range of human modalities, distributed across bodies and across materialities. (Kozel 2007: 186–187)

Kozel's account allows us to make a distinction between intentional control in which one knows the outcome in advance, and another mode of engagement that takes more time; one that embodies a relation to time that does not seek to reduce it to a minimum. This wandering, wavering and indeterminate form of experimentation is what she calls "responsivity" (2007: 182). She experienced a constant slippage of control between her body and the technologies in a rhythmic but unequal exchange of activity and passivity that she describes as a prolonged and iterative "initiation and response and response and response" (2007: 202). What we find useful in this definition of responsivity is a phenomenological insight into the intra-activity of improvisation, and the escalation of excitations that ignite creative insight.

With this invitation to rethink agency in experimental systems, an artist and experimentalist herself, Kozel enters into the fray of ongoing debates about the distribution of agency across bodies and materialities, humans and nonhumans, material-semiotic actors and technologies entangled in experimental forms of life (see, for example, Barad 1996; Callon 1986; Haraway 1997; Latour 2005; Pickering 1993; Suchman 2007; Thompson 2005; Wei 2002). While STS scholars Karen Barad (2007), Charis Thompson (2005) and Andrew Pickering (1995) have developed important concepts like "intra-action," "ontological choreography" and the "dance of agencies", these very dynamic descriptions don't necessarily speak to the actual movements of bodies and the relation between movement, feeling, and meaning. Indeed, we are drawn into these particular fieldsites by the dancing bodies and stories of experimentalists. More than just intra-action, responsivity generates a kind of "intra-animacy" (see also Myers 2006). In other words, responsivity keeps moving bodies in motion and in the process of making meanings. Excited bodies produce animated affects, gestures, and stories. And this is the source of the liveliness that thrives in the encounters we document.

How does this responsivity manifest in our fieldsites? How do experimentalists talk about their experiences? How might we recognize responsivity when it is happening? What we've noticed is that even though they feel like their technologies have transformed everything – how they see, feel, and know – experimentalists have trouble communicating their insights to others. They speak in a voice that is challenging to decipher. Ludwig Fleck, doctor, researcher and autoethnographer of scientific practice, described discovery as a "relationship of active, living intervention, a reshaping and being reshaped, in brief a creation" (Fleck 1979: 48, cited in Rheinberger 2010: 29). This scientist's relation to experiment and discovery is not easily parsed. Listening very closely to the embodied language of improvisation and insight reveals something other than an active ("I moved it") or passive voice ("It was moved by me"). In those voices, the subject is exterior to the action, whether an active agent or the passive nonagent. By contrast, Fleck and Rheinberger reach toward what has been called a "middle voice." This is where the subject is interior to and affected by the action being signified by the verb.

The middle voice is a grammatical form lost to most present languages (Benveniste 1971). It is sometimes assumed to be "in between" the active and passive voices, like a reflexive subject acting on herself. But contemporary linguists argue that it is a form that predates the passive voice. They suggest that even the reflexive voiced "I moved myself" still preserves a separation of one's will from one's body. The middle voice was originally opposed to the active voice, and situated the subject intimately in the unfolding action. The subject of the middle voice is *affected* by the verb, interested or invested in the process, and often transformed in the doing of it (Klaiman 1991; Saeed 2003: 170–174). The scientist conducting an experiment becomes *scientist* as she is "reshaping and being reshaped" in the experiment. These are examples where "the subject performs or experiences the action expressed by the verb in such a way that emphasizes the subject's participation" (Cline 1983).

We invite ethnographic engagement with this middle voice, which inflects the tacit and embodied processes of scientific insight we find in our fieldwork. These processes are already clearly evidenced in the work of anthropological, historical, science studies, and especially feminist accounts of science and knowledge making, through concepts like "intra-activity," "co-production," "performativity," "historiality,"

"emergence" and "actor-networks." And while in these analyses the actors are recognized to have stakes in their experiments, what we want to foreground is how the actors are *themselves at stake*. We are interested in the scientists' *affective entanglements* with their objects and instruments and the ongoing transformation of their modes of embodiment inside of their experiments. This is evident in how carefully invested (body, mind, career) researchers are in the reception of their data *as data*, and the reception of their modes of reasoning as scientific. The middle voice constantly refers back to the speaker, their actions and bodies, and brings with it a self-consciousness and reflexivity. Literature on the middle voice directs us to attend to "a heightened moral consciousness on the part of the subject performing it," drawing attention to the subject's concern and care and in the action that includes a care of the self and a care for the process (White 1992: 186, cited in Sandoval 2000: 56; see also a growing conversation in STS on care: Fortun 2005; Myers 2006; Puig de la Bellacasa n.d.).

In our use of grammatical definitions of "voice" we are in no way limiting our analysis to the linguistic or representational. Scientific speech, like writing, is not only material but embodied. Voice ushers forth from a body and is also a process of transforming one's body, of learning to embody. And when we do talk of representations like the live-cell image of the macrophage, we always include the bodies that have made them and which dance alongside them. A representation, in this sense, is only ever the end-point effect of an extensively laborious rendering process, and so it is always inflected by the bodies and affects of its makers and interpreters (see Myers n.d.). Treating representations as renderings, we can claim with Deleuze and Guattari that "representations are bodies too!" (Deleuze and Guattari 1987: 86). Where "embodiment" risks a tendency to naturalize and take for granted bodies as a kind of pre-existing substrate, we insist on partial and tentative mid-embodiments in such a way as to evoke the ongoing and never ending process scientists participate in as they search for a place to stand and speak about their findings.

A responsive body is one uncommitted to one mode of embodiment over another; it is willing to move with and be moved by another. And, as researchers improvise with their data, instruments, and stories, these mid-embodiments also suggest *an experiential and experimental* moment between Merleau-Ponty's two bodies, the lived (active) body and the objective (passive) body. This is clear in the example described above, where Dan is caught mid-embodiment. As he oscillates between becoming the rock-climbing cell and narrating himself in the third person, as a scientist pointing to a pre-existing cell, he is engaged in a process aiming toward objectification, but not quite making it there.

We want to inhabit the dynamic spaces indexed by these theories by pursuing a cultural phenomenology that can keep pace with these researchers as they waver between embodiments, and between confusion and insight. To do so we model our method on the approach of the experimentalist. In response to Latour's (2005) provocation, "Is not being moved, or rather, put into motion by the informants exactly what we should mean by an enquiry?" we offer what Fleck might call a "living intervention": we aim to move with and be moved by these experimentalists. They are no longer figured as our "informants"; rather, they have become more like partners in a contact improvisational dance, where we move together in a collaborative project that aims to evidence the *affective entanglements of inquiry*, more generally.

Articulating The Excitable Habitus of An Experimentalist

> *"Observation, discovery, is always feeling one's way, that is, literally a reshaping of the object of knowledge."*
>
> (Fleck, 1979: 53)

> *"There was another thing in the embryology course that I took that was helpful, which was that they gave us a lump of clay and you know, we had to mold what we thought we were looking at and, you know, it's an important, this tactile component is a very important part because you can look at something and think, 'oh, I see the details and all that stuff' but your hand really betrays what your mind is actually processing and is actually noting."*
>
> Dan Hijiko

Dan realizes that observing, thinking and talking can seem straightforward, but what we think we see, and the concepts we use to describe an object, often turn out to be empty clichés. Seeing and discovering depend not only on finely tuned instruments, but also on a repertoire of creative possibilities supported by one's own sensory dexterities; these are one's own instruments for seeing and sense-making. In the words of movement trainer Barbara Adrian, "You will not realize your creative potential unless your functional skills can support your expressive impulses" (Adrian 2008: 23). And yet the instruments of our sensorium are not prosthetic objects we can pick up and wield like microscopes or telescopes. With Csordas and with Haraway we assert: "The body is agent, not resource" (Haraway 1991: 200). In what follows we rethink instrumental models of the sensorium through a theory of the responsive excitability of bodies. This helps us to account for how it is that experimentalists acquire new kinesthetic, affective, and conceptual dexterities as they engage in the process of learning to see, feel, and know.

Starting with these careful descriptions that draw us into research and expertise, we are intrigued by the potential for what Csordas calls a "*cultural phenomenology of embodied experience.*" We follow Csordas to move past a phenomenology of some universal subject and body in order to attend to specific scientists whose "bodies carry the social about inseparably with [them] before any objectification" (Csordas 1994: 287 and 270). We thus use Bourdieu's notion of a habitus as "a system of lasting, transposable dispositions which, integrating past experiences, functions at every moment as a matrix of perceptions, appreciations, and actions" (Bourdieu 1969: xx) to orient our attention to the cultural subjectification of a scientist. Drawing on Omar Lizardo's recovery of the Piagetian roots of Bourdieu's concept, we see habitus as an ongoing action-generative and classificatory process, capable of producing "practical metaphors" through bodily operations (Bourdieu 1984: 173 in Lizardo 2004: 7). Articulating a habitus in experimentation starts with the scientist's previous dispositions and then requires sensitizing the experimenter's tissues to respond to excitations. This is a process of opening one's body towards new phenomena not yet knowing what they might be, and of conditioning the body to see, feel, know, and be affected by phenomena. We treat the experimental habitus of scientists, individually and in collectives, as excitable tissues inextricable from the tangle of forces that we still clumsily demarcate as "biology" and "culture."

Dan's mentor is recalled via such a habitus:

> There were mannerisms. So he would look at a picture and then he would hunch his shoulders forward and his eyes would sort of narrow and, you know, he would bring it close and he would sort of look and look and look and turn it upside down, you know, turn around to see it at all angles. And, he really thought that it was important to really observe all the details that a picture could show.

As Dan talks, his hands hold an invisible picture out in front of him and he leans forward with narrowed eyes, mimicking the mannerism of his mentor. In this moment Dan assumes Ted's bodily habits, and in so doing momentarily *articulates the habitus* of an apprentice. An apprentice, as Marcel Mauss (1935) has described, is one who models his comportment after his mentor's. Dan invokes his mentor's bodily techniques in order to evoke what he learned as a student: that looking and seeing are active processes. As he rotates the invisible picture in his hands he shows how microscopists must always keep their vantage point moving. By changing their relationship with the object, they keep opening up new views. Here Dan offers insight into his training, which involved acquiring both dexterities for seeing, and a capacity for improvisational reorientation in relation his data.

In their essay "The Fixation of (Visual) Evidence" (1990), Amann and Knorr Cetina suggest that, among the scientists (molecular biologists) they study, "the problem appears not to be, as Merleau-Ponty (1962: 78) said that 'what you see depends on where you sit,' but rather 'nothing is more difficult than to know exactly just what we do see' " (1962: 86). We want to push their claim further, and suggest that in addition to the difficulty of "knowing what you see," scientists are at the same time being faced with a new kind of challenge; this being that *nothing is more difficult to know than just where it is that you do sit*. An experimentalist's situatedness is precisely what is at stake.

Dan and Dawn demonstrate a reflexivity in their modes of seeing that is akin to what Donna Haraway calls a situated knowledge practice: one that hinges on embodied knowledge, limited locations and partial positioning (Haraway 1991). Indeed, once inside their experiments these researchers experience the dizzying effects of ongoing relocalization, reorientation, and the constant transformation of their modes of embodiment. These ongoing reconfigurations unfix relations and transform the politics of positioning between observer and observed. The key here is that these experimental systems show how a situated practice is precisely not about taking a seat and settling into a view from one location. Situated knowledge in the context of responsive media requires a dexterity tentatively inhabiting *mid-embodiments*; in other words, scientists must learn to dance with their data and instruments, and find ways keep pace with the rhythmic materialization of new modes of embodiment, objects, concepts, and phenomena.

Ted's lesson, which has been embedded in Dan's tissues all these years, was about how to keep one's body in motion in relation to an image, and how to lean into new views to generate new insights. Not surprisingly, Ted's techniques for training students to acquire deep visions and deep insight resemble those of a master painter instructing her student:

> He would ask me, "Well, what do you see?" and I would describe it and then he would say, "Well, you know, there's that, and then did you notice this?" And so what I saw was obviously the top level of detail, you know, the most basic kind of thing. And then he was

> like, "it's like unpeeling an onion." He would just go one level and one level and one level, and he would go deeper and deeper and deeper. … I also took a zoology embryology course where we had to collect gametes from those animals … fertilize the eggs and watch them develop and we would have to draw them.
>
> Now, you know, you could take an egg and you could just draw it as a circle and I remember when I showed my professor that he said, "Well, Dan you didn't spend too much time looking at that egg did you?" and I said, "Well, what do you mean?" He said, "Well, you go back to that microscope and spend about a half an hour and see how that egg looks after about a half an hour and just draw, add in more detail." And he was right, you know, you just sort of look and then there's graduations and color and texture and then you see. You start noticing that the surface isn't really smooth and there seems to be some things located near the edge of the cell and some things in the middle.

Through this long process of training, Dan eventually acquired the dexterity to notice new things. In other words he could start to discriminate minute differences in color and texture that he couldn't see before. In Bruno Latour's (2004) terms, Dan was in the process of becoming *articulate*: "An inarticulate subject is someone who whatever the other says or acts always feels, acts and says the same thing… In contrast, an articulate subject is someone who learns to be affected by others – *not by itself*" (Latour 2004: 210).

An articulate subject can get excited by the details of an object and recognize phenomena that an inarticulate subject cannot register. As Dan shows us, this capacity to be affected is acquired over time. The effect is that one sees more than one saw before, not only because one is learning to see, but also because one is *inventing a new mode of seeing*. This is a creative mode of attention, "introducing difference into the very idea of sensation" (Rajchman 2002: 16 cited in Kozel 2007: 251). This mode or mood of "going the next level in" literally draws out an actual, a sensorial difference and a conceptual one, from what is now felt to have been virtually there. Articulate bodies, capable of being affected are excited into responsive encounters with their objects; they *create* intra-actively.

> And yeah, that's what I mean about going the next level in detail. And so, you know, I think I got the best training as a scientist right at that point, because it's all about observation and it's all about trusting your ability to observe… You are mentally trained to just go that next level and that next level. You know, it carries with you because then when you start reading papers and you start thinking about things…

Dan wasn't just trained "mentally." Having articulated a habitus, being mid-embodiment and searching for new embodiments, he gets entrained on phenomena that have the capacity to excite his sensorium. In the process, scientists in training start to get interested and involved, they start reading the literature and working through concepts. They are lured to follow phenomena, to "go that next level and that next level."

In the next section we examine how scientists *get interested* in phenomena they have yet to figure out how to observe or interpret. What we find is that when an experimentalist's interest is piqued, this is expressed as an excitation that propagates through their bodies and stories. These are the moments when they alight on phenomena that resonate with their habitus. We explore how their interest forms and how, in the

process, experimentalists get caught up with and inside of the phenomena they study. As they learn how to see and feel their way through their data, whether in the form of time-lapse film loops or 3D immersive environments, we watch them strain to articulate their hypotheses in the form of stories. We show that these stories are inflected by a kind of creativity that sweeps up their bodies and imaginations in the invention of and experimentation with new metaphors. We call this affectively and kinesthetically engaged practice kind of haptic creativity.

Seeing, Scaling, and Story-making: Haptic Creativity in Responsive Media

Lit up in brilliant color with fluorescent genetic marker systems, live-cell imaging tracks the movements and transformations of organelles and proteins within cells, keeping pace with the flux of cellular and intracellular activities (Keller 2002; Myers 2005). As Hannah Landecker (1999) documents, "cellular 'behavior' " became "an object of study that was unthinkable in static modes of representation" (143) and "cells and tissues became entities to be thought about as having time, or occurring over time" (145). For some, the cinematographic camera acted like "a time machine, with forward and reverse gears, capable of expanding or compressing time scales at will" (Robert Watson-Watt quoted in Landecker 1999: 144). As Landecker demonstrates, "the particular nature of this trace – the film – and its amenability to acceleration or retardation, produced phenomena that it had not been possible to see before the use of microcinematography" (143). Contemporary techniques for live cell imaging operate with the same logic but ramp up the responsivity of this medium through computer intensive visualization. In the hands of live-cell microscopists, cellular time is rendered elastic, and users can engage kinesthetically and affectively in telling new kinds of cellular stories.

But, seeing in time generates significant interpretive challenges. The "molecular practices of cells" are anything but self-evident (see Myers n.d.). What are the challenges that come with interpreting the rhythms, flows, and processes of cellular life? How does a generation of scientists trained to interpret static images orient themselves inside of moving cells and incorporate the flow of time in their analysis? In an interview with Dan, Natasha asks: "If you're not trained to do it, seeing in time might present some difficulties in terms of being able to interpret what's going on in a cell. Have you experienced any moments where in introducing time you lose your bearings in the image?" Dan responds:

> I think in the current sciences some of the hardest processes to follow in time are these movements of little vesicles where there are just a lot of things moving at the same time. And as a result your eye doesn't know what to focus on. Well, in actual fact, the important point is not the movement of any one particular vesicle, or object, it's what the collective movement of the objects are.

No matter how much researchers slow down or speed up the rate of video playback, no matter how many times they loop a video clip, the blur of movement within a cell is hard to parse. Learning how to see in time is no small feat. It takes, as we described

earlier, a newly articulate body, an excitable habitus (in process), one sensitized to time-based phenomena.

There is an intriguing play here between the virtual and the actual in Dan's live cell images. In one sense, it is challenging for novices to distinguish what is happening in time-lapse footage of cellular activity. And yet, once the phenomena are articulated and storied through time, these images can seem to impart too much life. In other words, an excited habitus sees not just motion but also intention and personification in cellular processes. Early biologists using film recognized the double-edged sword of moving images. Moving images shocked them into new ways of seeing after decades of rendering living tissues into one-dimensional data sets, flattened, frozen, and arrayed it into graphs. While moving images are a corrective to static habits of mind and body, they also risk setting the experimentalist in motion. Live-cell imagers are always on the verge of falling for a moving story (Kelty and Landecker, 2004). And here we use the phrase "moving story" quite literally. Words put our perceptions and emotions into motion. Working in responsive, temporally elastic media, researchers don't just intra-act with the cells, they *intra-animate*, and so produce affectively charged stories of cellular life.

Similarly for CAVES researchers, the shock of swimming in a 3D environment is the *liveness* – the tangibility and multidimensionality – of the structures that had been so reduced in previous publications. They too are working with data whose scales and spaces and temporal dimensions are not easy to parse. They are faced with a slew of shifting questions: Where to look? How to look? What to look at? What counts as an interesting phenomenon? What might be an artifact?

One peculiar phrase gets repeated over and over by those working in the CAVES and watching time-lapse footage. It goes like this: "I'm looking for something interesting." This "looking" is an example of the middle voice. Normally, the things we are interested in finding are already known ahead of time, before we go out looking. But here the subject of the sentence works to "locate" or "discover" something they don't already know about, something worth further exploration. This thing will be one that piques the scientist's interest, and in fact, changes what is interesting for them. As one researcher put it: "I'm still at the stage where I'm deciding where I'm looking at what thing." There's a marvelous disorientation in the syntax of this statement. For us, this dizziness demonstrates the openness of inquiry in the CAVES.

In the CAVES, slicing through the data-space is exciting, a form of *extasis*, that is, the experience of being carried away or fully caught up in the experience. As the data they have been manipulating for years on flat screens comes alive for the first time in their hands, these scientists cannot suppress their excitement. The oft-repeated phrase, "I've been staring at this data for years on my computer screen but [now I] finally see it," points to the power of this environment to generate new insight. This excitability erupts through their bodies in expressions of like "Cool!" and "Wow!"

Marilyn Strathern (1991) has shown how scaling is culturally patterned activity. As we watch these scaling experiments, we recognize that the ways users manipulate their data and the possibilities that these technologies afford are part of a learned repertoire, and do not escape cultural limitations. But we do hypothesize that the degrees of freedom that the CAVES afford for scaling and rescaling are what makes this experimental system such a creative space for improvisation. This system gives researchers the ability to select, slice, color, enlarge and shrink, and rotate objects in "real time,"

that is, at the pace of lived perception. This gives them a context in which they can creatively conjure time-based and embodied analogies and metaphors.

This embodied dexterity manipulating scale and story is what we call haptic creativity. For example, Dan's shadow puppet dance with the rock-climbing bacteria illustrates how scaling becomes a potent mechanism for conjuring new analogies and experimenting with metaphoric connections to tell new stories. Like other experimenters, Dan does not know ahead of time what he is looking for, but he's on the lookout for something interesting. Dan has already shown us that the acts of looking and staring are not passive activities but active forms of embodied learning. In Merleau-Ponty's terms, Dan's insight is consistent with a "changed structure of consciousness" that comes in the wake of the "truly creative act [of reflecting] upon an unreflective experience" (Merleau-Ponty cited in Kozel 2007: 210). As he learned early on from his mentor, cultivating the dexterity to see and know takes time and creativity.

Dan spoke to this issue of learning how to see in time during a lecture he gave in Joe's undergraduate STS course on scientific visualization. He used the same looping video of the macrophage in the class as he did in his presentation at the NSF workshop we described earlier. In that first version he used the looping video to tell the story about the cell as a rock climber; but in this version, the cell acquires a new dexterity, in the form of little "sticky feet":

> When a cell moves parts of the cell move forward. In order to move the cell has to adhere to something. We can infer some of the forces… The only way we can see it is by imaging.
>
> Our lab is interested in the beginning steps when the membranes are pushed forward. And so you can think of these membranes as little sticky feet. If we just look at one area, we can see the membrane moving forward. But notice these dots. The more you look at these pictures, the more detail you see. The longer you stare at it the more you see. There are a lot of dots. As you stare at it longer and longer lots of details appear. These dots are phase-dense, which means that they contain lots of proteins. These are the little sticky feet that pull the cell forward. So, here we see part of the structure important for when cells move.

The rock-climbing cell performed by Dan in the NSF workshop is rearticulated in this presentation at a new level of molecular resolution. The cell acquires little sticky feet in the form of aggregations of proteins. Rescaling his seeing, he is able to tell a new kind of story.

He extends his participation with his data and instruments and so changes the experimental system. These extended processes of scaling and rescaling, orienting and reorienting allow him to be open to perceiving new phenomena. Dan stays with the cells long enough to learn how to see: "As you stare at it longer and longer lots of details appear." But for the scientist, it is not only their memory but also their imagination that is touched, and excited. Hovering in a space of not knowing, mid-embodiment, his interest gets piqued. This is the space in which improvisation and creativity flourish. This is what Kozel would call a space that encourages responsivity, where the time of engagement is not minimized. It is in his dance with the data that Dan contributes to the materialization of the phenomenon through a metaphor, which in this example manifests as dots and little sticky feet.

Metaphors, as George Lakoff (1993) describes them, consist of ontological correspondences or mappings between one domain and another (e.g., Love-AS-Journey, Time-AS-Money). These mappings are usually seen as cultural or language-level templates. Dan agrees with this formulation and recognizes both his own limited starting point and the limits of visualization software to make better connections:

> But what the image tells us about function relies on our ability to relate to other images and other information. The informatics package that allows us to go from image to function is very poorly developed. We don't have very good ways of representing them; that is, visualizing structures and extracting information from structures so that we can query other databases.

Dan speeds up the motion of the cell using time-lapse imaging and computer power, and magnifies it to the size of his body. While his ability to extract information is limited, we recognize in his practice a flexibility with regard to mapping-potential. By manipulating the spatial and temporal scales of the phenomena, Dan creates new possibilities for associating these images with biological functions in a way that bridges distinct domains of data. In particular, when he scales the video to his own size and speed, he makes available a learned repertoire of movements, gestures, and meanings (his habitus corpus) that help him make new connections and "practical metaphors".

The KeckCAVES allows its users to play with scaling itself. As noted in one of their grant proposals, the design principle from the beginning has been to "bring complex phenomena within human spatial and temporal perceptual and cognitive ranges." As users reach into the data, they reshape it: enlarging and shrinking, selecting and rotating. The scientists Joe watched were conforming their bodies to the data and vice-versa.

From field notes:

> A new dataset collected by a professor and grad student. From Baja Cal Mexico where there was a recent 7.2 earthquake, they immediately got down there with laser tools (LIDAR) to measure the large earth displacements. Today we looked at the first of four datasets. The immediate reaction was COOOL!!! "Seeing" the dramatic earth displacement and length and sub cracks thrilled everyone. 10 people watching while one "drove" the visualization, taking turns doing the driving, trading glasses around.
>
> After the initial excitement, three researchers and the programmer stayed for a couple of hours, working with the data, thinking through the process. One spent a lot of time playing with the data and tools, exploring the geography in different ways, drawing things on it, rotating and looking, pondering, redrawing, tilting; trying both to make sense of the displacement and to discover new aspects of it.

For the scientists playing in the experimental system, this is an intriguing form of engagement. A story emerges out of possible stories, with named actors and actions. One of the stories solidifies through a positive feed-forward cycle in which the narrative recursively affects how the scientists see. Seeing and story intra-act; each builds on and deepens the other through an escalating process of testing and validation. In the process, the scientist's attention becomes relatively fixed. In the process they make a remarkable shift out of the open space of improvisation, into a space in which they

now know what to look at and what to look for, and therefore they have acquired the grounds to argue for particular ways of seeing.

Field notes:

> Much of the time was first spent determining what was interesting (they didn't know what, but they knew *that* something was worth discovering): the shape of the displacement; a long plane, then jagged then plane again (almost parallel). For each possibility that occurred, they had to figure out how to define and measure it, and here they discovered that the tools were limited – because the data tools were designed for other purposes. The use limitations were a function of the original intent design for the tools that now didn't make sense.

The visualization programs depend on database structures that enable some forms of responsive manipulation and constrain others. A conversation between the geologists and the programmer reveals that the data and the program are limited because they embody other theories (they are "theory-laden"), based on previous histories of uses and projects. Nonetheless, the scaling freedom of the system inspires thoughts about what *should* be possible. Theories and data structures intra-act with haptic desires for new access to objects and knowledge. The programmer in this situation suggests that the data could be restructured, but all agree that this would break the real-time interaction with the visualization, and would be an unacceptable compromise. The group reaches an agreement to develop a new interface to enable the desired manipulation. In this way new forms of freedom are retrofit into the system.

The seemingly redundant phrases: "This is a story," "I am looking for something interesting," call attention first to the obvious ongoing construction of knowledge. They enact the speaker as a "storytelling scientist" in search of an object, and the visualization – the time-lapse video or the CAVES projection – is enacted as the "apparatus" or "instrument" for producing an object. There is as yet no object, only the potential for one. To put this process another way, during the fascinated time of play while an experimentalist is looking for something interesting, the status of the data itself is unknown. There is no clear cut that would clean up "raw data" and distribute "noise." In the CAVES and live-cell imaging, there is no "raw data" to be cooked, that is, until a metaphoric story contracts the free play and resolves the encounter in the form of a sensible and satisfying story. Indeed, it is a constant challenge for these researchers to pause their excited play long enough to craft a convincing story for their peers. Our future research concerns the problems they encounter "rendering proof" within their communities of scientific practice and peer review.

CONCLUSIONS

> *"Movement, not pondering, brings new knowledge."*
>
> (Irmgard Bartenieff, 1980)

A number of collaborative insights emerge from our fieldwork. One is that responsive media increase the degrees of freedom for researchers to scale and rescale data in real time. This is not just a practice of placing objects in direct relation to human durations

and dimensions; it is one that allows researchers to transform their bodily capacities and refigure what they can see, say, feel, and know. For the researcher this process is experienced kinesthetically and affectively, as well as visually; and they are drawn into movements and into forms of expression they may not have known in advance. Tracking the excitations that move through their bodies we discovered a form of "haptic creativity" immanent to experimental forms of life. We also observed the transduction of new metaphors and analogies across changing media and changing bodies: a macrophage moving on a slide is digitally rendered into time-lapse video that loops on a giant screen; mid-embodiment, Dan's hand performs a shadow dance on the screen as he conducts body-experiments to feel through cellular movement. This is a practice that could be called participatory remediation. We suggest that responsive media can excite this kind of radical experimentation with metaphors and kinesthetic stories.

These practitioners experience a tension between the haptic creativity they experience working with responsive media and conventional data forms. It is in the space generated by this tension that our collaborators' reflexivity becomes palpable; they bring a deepened attention to their own cultural practices. These include the practices that Fleck (1979) outlined in the 1930s – thought collectives, thought styles, publication limitations, journal forms, promotion requirements – as well as trans-career concerns.

In studying the twinned processes of experience and experiment we hope to lay a partial bridge between different traditions in the anthropology of science; that is, between research programs that follow the transformations of objects from "nature" to lab to text, and cultural phenomenologies that focus on lived experience as a process prior to objectification. Drawing on phenomenologists, dancers, performance artists, and feminist theorists, we address the problem of the lived experience of objectification itself, of a scientist mid-experiment. The free play of haptic and metaphoric creativity that we have described here is always in tension with the scientists' own thought styles, and the proper forms of scientific expression in a given community. Their dancing metaphors and stories were experienced both as generating new agential cuts into the data – redefining bodies, objects and instruments – and as recalcitrant forms that limited the effective propagation of objective results. Researchers mid-experiment, could not suppress the creativity and excitement coursing through their tissues, and were simultaneously compelled to embody their insights in quantifiable signs. What we've shown here is that this capacity for oscillation between embodiments seems to be their mode of embodiment. Elsewhere we will document how this gives them a habitus simultaneously for objectification, for the lived experience of insight and reduction, and for the agential cuttings that allow them to render proofs.

We too, as anthropologists, have been drawn into these experimental systems, and we too wish we could have our readers experience the haptic immersion in the CAVES and the lively dancing with macrophages on the big screen. Until that time of a regime change in embodied media, we remain part of these experiments, working with and within research groups, resolutely mid-embodiment, at that place where our research problems and those of the scientists meet.[2]

NOTES

1 Our current project not only engages scientists, engineers, and technologists, but also the artists, dancers, Laban movement analysts, filmmakers, doctors, hackers and teachers who

are actively experimenting reflexively with responsive media. Joe brings to these conversations his own expertise as a programmer and body-worker, and Natasha brings her expertise as a dancer and biologist.

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