INVESTIGATING POSSIBILITIES AND PROBABILITIES OF BIOMEDICAL INFORMATICS (BMI): BEYOND BIOLOGY AND INFORMATION

by

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Abstract

My work focuses on how medicalized minds and bodies are refashioned through the concepts and technologies of Biomedical Informatics (BMI). I attempt to make visible objects of informatics that mark the human as a digital machine operating among and within computerized agencies, artificial intelligence, and what has been termed *Big Data* correlation. Specifically, the anthropological puzzle that I investigate focuses on the BMI imagination and its implicit and implemented effects upon doctors as operators, patients as sites, and informaticians as technicians of “new” medicine in a world of expanding computerized data that shifts and refashions the human care encounter.

I argue that the contemporary of BMI has a far wider organizing effect upon healthcare and medicalized bodies than previous aspirations based on computer technology as mere *tools* in medicine. Through a rapid development and deployment of intelligent databases and computerized networks, BMI is currently restructuring modes of clinical care. As a set of scientific practices, it is reconstituting earlier medical informatics of the 1970s, 1980’s, 1990’s and pushing these modes of care in different directions. Such restructurings come in contact with non-human operations of medico-scientific systems of knowledge and through programmable expressions that impinge upon doctors’ deliberations through everyday encounters with patients.

I approach these puzzles and clinical experiences through the figure of an *informatics body* that frames emergent arrangements of computerized algorithms, organization, disease, genomics, and therapeutic order. As an *informatics body*, the human falls under questions embedded in this deeper convergence of medical digitalization. Complex computerizations and algorithmic forms that are designed to bring clinical *improvement* are giving rise to

unanticipated effects that are refashioning the body of the patient and the mind of the physician in ways that have been under-examined. In futures of biomedicine that I investigate, an informatics-based medicine, the figure of the human in the continuum of care is constantly being reengineered and redeployed.

Throughout my investigation I ask what acts, human and non-human, possess the possibility of therapeutic improvement and can bring other things to life that do not originate in current therapeutic order? I suggest that systems of machine agency that are targeting and monitoring for disease and health are reconstituting *who* and *what* has access to care, as well as access to decision agency among intelligent and computerized care data.

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with abiding love and respect, as you have taught me to journey into worlds seen and unseen

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Introduction: Anthropological Encounters with Biomedical Informatics (BMI)

Conceptions of information and BMI

This dissertation explores ideas and practices of Biomedical Informatics (BMI). I set-out to encounter the objects of informatics in American biomedicine. The systems of informatics are networked computers and computerized biological and clinical machines. On another level, BMI practices and imaginaries are refashioning the medicalized body and its functional potential through massive data known as the Big Data. I ask throughout my research how conceptions of "information" shift the agents of machines and humans and in what ways these shifts are made visible. When we as anthropologists think about computerized information in relationship to medicine and health, how do we recognize and examine its appearances among medicalized bodies? Is information fundamental to life and disease? And if so, what kind of liveliness of information may impinge upon life? What computerized code or biological enhancement may *exceed* the life of a patient or the mind of a physician?

Through this wider encounter with BMI machines and mechanisms, I have been engaged with informaticians, physicians, and technology leaders who aspire to solve some of the largest problems in the U.S. healthcare system. As informatician Enrico Coiera has stated, over the coming decade more informatics systems will be implemented throughout the U.S. "health system than in its entire previous history" (2012:2). Healthcare information technology spending will exceed 69 billion over the next several years, increasing at an annual rate of 9.7% a year in the United States (Perna 2012). Financial trending tells only one part of the BMI story. While costs of healthcare rise and are redistributed, BMI has emerged as a technical and economic expansion of the biomedical imagination. In my research, I have searched for ways to explore and ground the conceptual spaces and bodies moving towards and being transformed by informatics.

Biomedical Informatics works as an *organizing field* which has come to impose logics on the visible and knowable in scientific medicine all the way down to the biological and molecular. The world-renowned biophysicist Werner Loewenstein has stated it this way: the physics of information applies "to any structure, any system. It quantifies the instructions that are needed to produce a certain organization. This sense of the word is not too far from the one it once had in old Latin. *Informare* meant to 'form,' to 'shape,' and to '*organize'* " (2000:20). Information as a universal and organizing way of thinking about biochemical structure and disease should be kept in mind here. What is often not accounted for in discussions of BMI, remarks informatician Charles Friedman, "is the important difference between information and data. Information rests within data much like a valued ore within rock. Information may indeed be present within a data set, but it must be extracted. Like rock without ore, data can contain errors, biases, or be pure noise" (2010:112-113). In this sense, information and the extent it can be made error-free is primary, but also *structuring*, what can be *organized* and *extracted* from data. When we look at data and its meaning in a Big Data context, *computerized data* has further value: it has the immense value of being *correlated*. Here, the values of *structuring, organizing, extracting*, and the wonders of achieving massive and previously unseen *correlative relationships* are in assembly across both, medical and non-medical databases. In an applied sense, the paradigmatic concept of information has potentialities of biomedical and political dimensions. In short, when we think of computerized medical information as large amounts of flexibly-applied Big Data, we need to consider the possible forms of use it can be put to in the future and not only how it may be applied in the present.

My analysis focuses on locating an *informatics body* among historically situated ideas of machine forms in biomedicine that I believe are transformative of the way they *frame together*, informatics across genomic, physiology, and medical decision-making. I link such biomedical-information frameworks with the everyday puzzles that physicians and informaticians consider when clinical decisions are made visible by and through informatics logics. By bringing BMI concepts into contact with the everyday use of computerized clinical software, I examine the tensions among informaticians, physicians, and so-called users when BMI is believed to improve care for patients. This clinical everyday as it meets both informatics imagination and unanticipated effects has been under-examined.

I trace an informatics body politic at a moment when the values and expectations of BMI are being further inscribed across biomedicine in the forms of massive data. I have been examining such constitutions during a period when industry leaders, informaticians, government health agencies, medical statisticians, and physicians have held-up BMI as an urgent promise of American medicine.

Biopower: why BMI exceeds biopolitics. The notion of *biopolitics* is often traced to the work of historian and philosopher Michel Foucault, who formulated that a shift was underway in the 18th century in the control of persons. From the control over people as subjects of a sovereign ruler to another form of disciplinary control based on statistics of the body, a body of health and disease, of epidemics and hygiene. The objectives of sovereign rule on taxation and the presiding over death shifted to organizing modes of production and presiding over life itself. Such biopolitical "technologies of power" were divided into "regulatory" and "disciplinary" modes that as Foucault described were "superimposed." Here, biopower flowed forth from a grouping of practices of individual hygiene and self-regulation and could extend to epidemiological norms on cholera outbreaks, longevity practices, or prenatal health practices extended across a population. The object of "man" was recalibrated to capture the subjective and functional in one sweep. Regulatory technologies focused on creating "a sort of homeostasis, not by training individuals, but by achieving an overall equilibrium that protects the security of the whole from internal dangers" (2003:249). Biopolitical conceptions framed body in terms of "general biological processes" and in terms of subject formation. In the late 20th century, biopolitics reformulated into emergent and more portable forms of power (2003).

A modern phenomenon, biopower took two centuries to emerge and is still present. These dimensions of biopower—disciplinary and regulatory within institutional borders hospitals, schools, prisons and factories—define 21st century modes of biomedical informatics. Biopower's augmenting dimensions were exceeded through the physics and promise of informatics. The biopolitics that Foucault envisioned based on biological process begins to behave very differently based on the marvels of informatics process. We find here dispersal of bodies into computerized information marked by electronic audit trails, archiving, mathematical reasoning, tissue generation and banking, digital augmentation, and reuse. Informatics intervenes not only at the level of life itself but at once at the level of self, artificial life, system, cell, and groups of human beings as *units of data correlation.* What this means is that general biological processes are converted to data and then to information and then to circulations of correlative data, Big Data, the cycle continuing from silicon-based to biological-based, from life to non-life, from non-life to life. Biological life loses its centrality in the liveliness of advanced informatics. The study of disciplinary regimes of hospital and clinic gives way to a study of BMI systemic effects, circulations, and reasoning. We have left biopolitics behind for new forms of liveliness.

In the early 1990's, Gilles Deleuze was puzzling through an informatics world when he remarked that the kind of society Foucault had identified was "what we no longer were, what we had ceased to be" and there was "no need to fear or hope, but only to look for new weapons" (1995:178). In his suggestive formulation, *Societies of Control*, Deleuze formulated that in such societies types of machines change. We move from pulleys and clocks (sovereign societies) to power plants and transportation systems (disciplinary societies) to computers and computerized systems (control societies). Operating in *Societies of Control,* computers as a central object recede into the background to make room for a transformation in ordering of life and the calculation of disease and health. Eroded frontiers of urban development and hospitals care may exist alongside hyper-development of medical data monitoring and computerized augmentation. Humans modulate between interruptions of computerized viruses and forms of rapidly changing electronic communication that deeply impinge upon one's ability to imagine certain forms of life. There is a certain tempo that differentiates disciplinary from control societies: "Control is short-term and rapidly shifting, but at the same time continuous and unbounded, whereas discipline was long-term, infinite, and discontinuous" (1995:181). Deleuze was puzzling through a transition from disciplinary enclosures that constrained the body to certain deeper psychic interruptions to human imagination and freedom of thought that digitalization suggested.

From my perspective, one mode of society does not replace another one. *Sovereign, disciplinary-regulatory*, and *control* forms of power exist side-by-side. The paradigmatic concept of *information-based* health transactions exists next to broken hospitals and state-based forms of healthcare. An informatics body operates intimately and publically; however, it moves along different lines of flight than does a disciplinary body. General biological processes are converted to data and then to information and then to circulations of correlative data, Big Data. These lively circulations of medical data seem always *on*, in motion, being newly mined and gaining in value and probable futures. They do not die but are stored and continue to order life through therapeutic intervention.

To examine such informatics objects, I have deployed the term an *informatics body.* At this level, the primacy of computerized data in medicine comes in contact with local ways of doing things reflecting wider technical-social shifts that are currently underway. Applied informatics in physician practices runs-up against challenges of automating embodied forms of informatics use. Conceptual forms of informatics run-up against the challenge of representing (and refashioning) the medical mind, a core effort in BMI and translational medicine.

Anthropology and Informatics. Specifically, my approach to the anthropology of BMI draws from a range of anthropologists and their examination of biology, computerization, medicalization, and science and technology. I cite anthropologist Paul Rabinow's theories on assembling and the anthropological work of Margaret Lock and her notions of the cultural embeddedness of biological-informatics agents and their role in shaping perceptions of health and illness. Michael Fischer's notions of "emergent forms of life" among technoscientific imaginaries has assisted me in moving between theoretical to local contexts of informatics use and computerized algorithmic potentialities in biomedicine of late modernity. The ethnographic explorations of Diane Forsythe in medical informatics and artificial intelligence labs has been formative in directing me to the problematics of informatics system design and its implementation in medicine. The insights of Veena Das regarding new medical technologies in reconfiguring relations between bodies, populations, and scarce resources have been very instructive in assisting me to untangle assessments of value-free medicoscientific technology as unproblematic opportunities for cure. We can begin to investigate such occasions when BMI has been applied with promise and success and when such promises do not always match up to biomedical expectation or clinical outcome. BMI refashions biology, physician mind and information, ontologically, and epistemologically.

My work differs from a STS (science and technology studies) approach. I anthropologically and historically examine BMI as *ongoing* emergence. I do not seek to focus on technical novelty or constructions of technoscientific phenomena. The objects of BMI are not merely scientific constructions or materiality but groupings of aspiration, imagination, and possibility that unfold in the system design and local implemented effects in and around the medicalized body. The notion of "technology" as particular types of "machines" can be construed as human and non-human, silicon-based and biological-based forms in constant formation and unpredictable application. What this means is that anthropology of BMI draws from local and historically-situated analyses but is not historically determined. BMI objects have the possibility to *become;* that is, they have the possibility to come into being along different lines of flight than histories of computers, biomedicine, or information technology have indicated.

I have found that informatics concepts are very portable, constantly being reapplied across non-medical industries and medical application. Therefore, I have situated my work among a series of ethnographic reflections on scenes where information has both promising and unanticipated effects in everyday clinical settings as such locations adjust to larger political-technical changes in Big Data correlation and machine-based medical reasoning.

Dissertation Structure

Following my introductory chapter, I have structured my dissertation in the following ways. I begin with a scientific literature review covering BMI and move into a discussion of mind and consciousness. I follow with ethnographic examples and historical ideas on machines and the medicalized body. I then follow with an empirical chapter that examines implemented effects of informatics and my conclusion that focuses on wider ideas of the machine *within*. This moving back-and-forth between scientific expressions of informatics, history, ethnography, and meditations on machine forms is meant to remind us that these registers are in operation at local levels of informatics effects and possibilities of informatics futures.

Specifically my first chapter focuses on the *Journal of American Medical Informatics Association (JAMIA)* as a founding peer-reviewed journal of United States-based informatics. Many of its debates and policy roundtables have set the tone for informatics thinking and curriculum-building in academic medical research and development centers in the United States. On another level, *JAMIA* serves as an important window through which the disciplinary making of BMI has proceeded scientifically, conceptually and organizationally.

By way of my *JAMIA* literature review, I move to the ideas expressed by Claude Lévi-Strauss and Clifford Geertz on the concept "Savage Mind." As I will demonstrate, it is here that anthropology began to break-off from the cognitive revolution and its adjacency to artificial intelligence and the potentialities of large-scale computerized systems. The imagination that the human mind is *incalculable* and located in the everyday "variousness of life," as Geertz has suggested, as opposed to *calculable* and functionally the same, as Lévi-Strauss has suggested, has placed subtle but lasting imprints on anthropology as it seeks to come to terms with the outgrowth of computerization and cybernetic theory. These are concepts that anthropology has had to puzzle-through in attempting to come to terms with the effects of modern engineering biological and non-biological forms of intelligence and agency.

The third chapter explores what I have termed the "computers in medicine" approach to investigating BMI. Such an approach has wrongly positioned analysis of informatics as a story of technology development and the adoption of technology by physicians as a form of resistance. I suggest that the larger BMI ethos is an organizing and standardizing enterprise that is in search of a language and set of unifying principles across medicine as an alternative. I next discuss the disciplinary challenges found in the ways BMI sets-up the boundaries of *a problem*. In such problem-formation, BMI has sought to reframe how biology, physiology, and diagnostic and therapeutic orders align with informatics. The founding perspective on American medicine by William Osler sets up a form of medical training and mental attitude that anticipated the increase and management of scientific data.

My fourth chapter is a reflection on the eleven months of ethnographic fieldwork I conducted in one of the largest private thoracic surgical practices in the New York area and in a busy community health center that sees 75,000 patients annually in the immigrant communities of Fair Haven, Connecticut, and interviews with industry leaders in biomedical informatics. In these reflections, I explore the working practices found among programmers, scientists, software vendors, software engineers, medical staff, physician-leaders, and regulators issues of computerized clinical software deployment, and what may have seemed simple practices of upgrading software or maintaining such systems in clinical settings were defined by ideas concerning error, use, breakdown, stability, and efficacy. In my concluding chapter, I examine the "machine" in biomedical imagination, which entails listening to ethnographic voices and picturing large-scale possibilities of Big Data in calculating human and non-human forms of medicalized improvement.

My Ethnographic Direction: Setting-out to Encounter BMI

Ethnographically, my object of anthropological study has been focused on historical-conceptual displacements, informatics artifacts, and clinical encounters of BMI. There have been no international flights awaiting me, no distant others through which I have encountered ways of being or suffering (although suffering was highly calculated and mapped along certain technical reductions and clinical norms). My ethnographic predicament has not been to find myself lost among forms of life that were different from my own, at least not initially. Instead, I set-out many times to community health centers, private medical practices, and the offices of software programmers, most often encountering the imaginaries of informaticians and dreamers who were crafting "new" medicine. Broadly, I found an American form of medicine that was in structural and technical transition. My encounter has not come to an end as I am still discovering and exploring the informatics horizons found among things I have not fully understood and among the emergent promises of the computerization defining late modern medicine. This predicament is based on rapidly emerging and transforming mathematical ideas and computational forms that continually open new possibilities for relations between computerized agents that "think" and "act" in the space between concept, design, and implementation of informatics systems.

I have often found myself attempting to articulate my encounter with structural changes in healthcare that have served as a backdrop to informatics implementation and development. Paul Rabinow suggests that such ethnographic engagement is one of “marking time,” a reflective and political act of always asking “where should I go next?” (2006:81). Journeying-forth in this way, I have been marking my way in the continued emergence of BMI imaginaries and implementation. Hesitantly, I have often had to take very small steps in my research and fieldwork among rapidly changing technologies.

My institutional position as an anthropologist among highly technical terminologies, powerful surgeons, and information technology professionals has been a humbling one. I have felt at times as though I were moving about as a kind of ragmuffin among the princes and princesses of masterful and instrumental ideas that have real demonstrable impact on patients’ lives and the science of biomedicine. However, there have been times that my presence, I hope, has injected a critical hesitancy into computerized and manufacturing-based care models—models that can leave everyone, at times, exhausted and wanting something more from biomedicine.

The term “biomedicine” has suggested invention born of certain epistemologies and technical promises of mastery of the natural world, a product of modernity. The notion of “information” has become as fundamental to this form of biomedicine as an element in the Periodic Table. Computerized information has become the carbon in the wheel of life, not only on genomic levels but also on organizational and clinical practice levels. A CEO of an innovative surgical practice whom I will here call Andrew expressed the unforeseen and continually emerging value of informatics as he wondered if he was lagging behind a certain kind of information “curve.” In considering this, he stated that such curves didn’t apply anymore and that biomedicine was taking on accelerated product timelines and risks that are administrative, financial, and clinical. "Medical data" could be thought about as a commodity "and if this is true, then our values will need to change about how to get and use [medical] information." As he put it, some "clinical outcomes don't always give the kind of information we expect or *want*" (Anderson, interview with author, December 30, 2011).

I understand Andrew as attempting to come to terms with the notion of *information* as *organizing.* If informatics does not always provide clinically what we expect or want by way of computerization and does not always fix a so-called broken healthcare system, we should bring our attention to its reflexivities that have remained largely unexamined to learn its potentiality and consequence even if such effects are highly localized and specific.

One brief example of such potential and consequence can be found among a team of research scientists led by Dr. Carolyn McGregor of the University of Ontario Institute of Technology. She has applied informatics to problems regarding premature babies (preemies). She has been developing software to capture patient data as they occur, incorporating them from "infusion pumps, EEG monitors and cerebral oxygenation monitors," to collect data from 1,260 points per second (James and McGregor 2012). Dr. McGregor and her team have been creating patient models that enable them to understand small changes in the condition of preemies that may suggest infections before the symptoms become visible. The naked eye cannot identify such changes, but a computer can constantly scan and detect the infinitesimal anatomical changes that mark the emergence of disease. In this way, the system does not pick up *causal relations but relies on correlation*—not the "why" but the "what" of preemie physiology. This early warning can lead to early interventions that might address emergent problems. The hope is that this type of monitoring can improve patient outcomes.

McGregor as a known informatician has embraced informatics approaches to long-entrenched clinical problems. Her approach not only mines for uncaptured data but also turned that data (EEGs and blood oxygenation) into information that can be used again and again; that is, it can be correlated across Big Data to pick up unseen patterns, trends, and potential outcomes for future diagnosis. In this case, such patterns can provide a glimpse into BMI logics. Computerized algorithms did not make a medical decision but instead offered a way forward towards better outcomes. For instance, she discovered using captured neonatal information, that preemie vital signs looked remarkably stable *before* an infection struck. Therefore, stable vital signs may not represent a stable patient. This was counter-intuitive since we would expect vital signs leading into an infection to appear erratic. However, McGregor's study suggested a different story. Such vital signs were a kind of eerie stability before the baby's body went into overdrive to fight the infection. One can imagine before McGregor's research physicians' checking vital signs and ending their shift relieved that all was well, then later getting that alarming call that all hell has broken-loose for one of their "stable" patients (Mayer-Schonberger 2013).

When we look more closely at McGregor's work, we find extraordinary correlative potential drawn from multiple data sources to predict neonatal outcomes. Both seemingly random and highly specific events can be rendered clinically understandable and predictable. In an informatician context, McGregor has been harnessing this potential to save the lives of preemies by data-mining ICU devices and making the data from these devices available to clinicians. When I use the term "correlative potential," what I point to is the phenomenon of Big Data that has been operating on the level of "bits" (a basic unit of information, standing for binary digits). McGregor's work builds upon the historical idea that actions in the world and bio-physical processes can be measured by information-theorist founder Claude Shannon's idea of "bits" that break down organic and inorganic forms into their potential to produce and be represented by binary code. From a wider and late-modern frame of information measure, Big Data can be seen as the culmination of years of capturing and bringing together the bits of market behavior, disease outcomes, drunk driver records, FICO scores, effects of high glycemic diet, and infant mortality into correlative order.

In the clinical context of McGregor's research in busy neonatal settings, how we apply ideas of clinical improvement as informatics ideas and deployments may be ill-proven or still under development. For example, neonatal ICU's have been typically technologically-saturated environments. Tubes, networked computerized systems, LCD display screens, pumps, environmental and infection control units, and sensors of wide variety take-up the majority of the ICU environment. Therefore, when physicians and informaticians apply additional data monitoring regimes, what devices should be selected for inclusion and which taken away? What editorial decisions must informaticians make to capture the valued ore of data and apply it across patient's bodies? And, *what* specific data do we capture? Do we open the gates and capture anything in the ICU that we can digitize and feed into a computerized network? If so, which preemie physiologies have been slated as information-producing and which ones have been slated as information-poor and therefore invisible to computerized data-mining and predictive modeling? At the point of digitizing preemie data into ones and zeros, we are making a judgment that such ore holds valuable clinical information. On a larger level, the gathering of digital information implies that a baby's EEG and blood oxygenation may hold future correlative value and side-effects beyond individual body or specific clinical outcome.

Expressed by one informatician's perspective I call here the "localist perspective," most medical errors can be contributed to "local configuration and implementation decisions rather than to the technologies themselves" (Yackel et al. 2010:107). From nearly the opposite perspective, the "universalist human change perspective" errors and reflexivities come from physician "related issues" irrespective of local setting in which shifting knowledge and behaviors among people have posed major problems (Moxey et al. 2010). From another camp, the "technology-only perspective," poorly functioning information systems have been based on poor technical design ideas (Stead 1994). Additionally in McGregor's case, medical errors will be reduced when a certain level of data standards comes into practice (MacDougall et al. 2010).

When BMI as a discipline strives for better clinical outcomes, it often does so by changing habits, perceptions, clinical routines, expertise, and resources and by changing the value we place upon computerized information itself. When we consider informatics as tools, we strip the discipline of this broader transformative dimension. When we consider informatics as merely "new," we set-up certain kinds pictures of users as passive recipients of novelty with little agency to evaluate risk and the locality and appropriateness of medical knowledge. In this dissertation, I have attempted critically to bring attention to the wide-ranging and changing relationship of BMI as an emergent dimension of American biomedicine and healthcare.

Anthropological Contributions to the Investigation of BMI

There has been little attention paid to Biomedical Informatics as an expression of American medicine, yet other studies on the cultural dimension of computerization have served as productive areas of cultural and social analysis. Anthropological and social theorists Sherry Turkle (1995, 2004, 2011), Scott Lash (2002), Kathlerine Hayles (1999, 2005), David Hakken (1993, 1999, 2003), and Wolgar (2002) have examined informatics-based forms in the workplace, conceptually and through the experience of children. From an anthropological perspective, BMI represents particular kinds of conceptions and beliefs about the plasticity of the human body and its relationship to computerized data. Its underlying conceptions have been drawn from mathematical, cybernetic, and computational histories. Anthropologically, I am suggesting that the presence of these technologies and practices in their applied sense are crucial to understanding, but examining their utility should not disregard imaginaries of the medicalized body closely aligned with one of the transformative technologies of the 21st century (Strauss 2006). The medical anthropologies of Margaret Lock and Veena Das have been important to this work (Lock, 2001, 2011; Das and Das 2007; Das 2010).

Drawing on research of BMI development and use, I build-upon the work of anthropologists with ethnography focused on entrepreneurs, community health clinicians, histories of information in medicine, and informaticians who frame what they do and the patients they imagine and serve, within particular social futures that anticipate better medical outcomes. Conceptually, I have attempted to locate the body that is made visible through 18th and 19th century European and America medicine and through emergent forms that continue to evolve through contemporary informatics logics and applications.

From another perspective, the embodied dimension of information can be traced back to a history across anthropology and social theory that foregrounds symbolic constructions of the body, emotion, and the senses. The seminal works of Marcel Mauss and Thomas Csordas have marked-out important territory here (Mauss 1973; Csordas 1994, 2002, 2004). Such constructions have in the contemporary of BMI repeatedly suggested that the rise of intelligent databases and computers in everyday life leading to shifts in notions of selfhood and constructions of human reality that social theorist Scott Lash has noted (2002). In this sense, human being has been a struggle over conceptions of a body that can be expressed as mathematical programs and internal functions. Conceptually, a programmable body fits remarkably well into applications of computerized archiving, data-tissue-banking, and forms of commodification as anthropologists Leslie Sharp (2000) and Nancy Scheper-Hughes (1987, 1990) have consistently reminded us. If a certain kind of body in the contemporary of BMI has been finding its potential in computerized forms of diagnosis and healing, this body has also been very particular in its ability to be consumable, storable, and modifiable.

Thus, anthropologists and sociologists have attempted to approach different technological and embodied dimensions of informatics but have not taken-on the specific set of practices and imaginaries of BMI as an object study except in a few notable cases. Some examples on the periphery of BMI have been socio-cultural examinations of artificial intelligence (AI) in medicine by Diana Forsythe (2001) and Gary Lee Downey (1998), the emergence of neurobiological understandings of thought and agency in regards to positron emission tomography (PET) by Joseph Dumit (1998), end-of-life technologies in comparative cultures of medicine by Margaret Lock (2001), human-machine interaction by Lucy Suchman (2006). Although these scholars have focused on various aspects of the development of human-machine interaction, they have not focused on the continued development and emergence of BMI practices and assumptions as large-scale computerized data convergence. In sum, BMI's truth claims of the efficacy of massive computerized data, bodily amendability, utility, and medical reasoning are focal points in my following research.

I wish to leave you with a poem by Rae Armantrout that has framed this amendability as a kind of massive cascade within which we can sometimes find ourselves:

an automatic/cascade of responses
in his/her body

As if you could escape
by following

the path you carved
there

to its prescribed end (2009:38)

Armantrout's prescribed end can be thought about as a destination we have found ourselves carving-out in late modernity. Her cascade of automatisms and responses in and among bodies moving along paths carved and prescribed is a cautionary tale, one that I continue to negotiate in my encounter with the machines of BMI ideas and practice.

I. Emergence of The Science and Practice of Contemporary of Biomedical Informatics: A Review of Foundational Debates in *JAMIA*

Change in technology only moves the challenges; it does not eliminate them.
(Hammond 2001:232)

Contemporary of Biomedical Informatics (BMI): Ethnography of JAMIA

In this Chapter, I examine the emergence of contemporary BMI in American scientific literature and its resonances in ethnography: I locate controversies of BMI through implicit themes in the journal. These themes have been reorganized for the purpose of making visible informatics ideas with the unanticipated effects they have produced. Instead of a narrow emphasis on modern and specialized technoscientific newness, I attempt to show how objects in this field are better characterized by the possibilities suggested by rapid technical change. Like the quickened objects produced by BMI, the field's rapidly shifting boundaries do not settle into a cohesive scientific enterprise but rather operate as a set of practices. In what follows, I try to capture these objects and practices as marvels of diagnostic and therapeutic enhancement and as anxious scenes of systemic error in biomedicine.

In attempting to locate such BMI objects, I have taken the scientific and technical discourse as found in the *Journal of American Medical Informatics Association* (*JAMIA*) as my privileged site of inquiry. As the oldest peer-review journal of its kind in the U.S., *JAMIA* is the premier publication of the American Medical Informatics Association (AMIA), the largest and most respected biomedical informatics organization in the country. Thus, *JAMIA* serves as barometer for detecting disciplinary debate in the field of informatics and an early-indicator for ways of making informatics objects visible for a technical community made-up of computer scientists and medical professionals.

Prior to 1994, no single publication brought together original BMI hypotheses and case studies. William W. Stead, the editorial founder of the journal, envisioned a journal that reached beyond BMI to "educate the public about the potential of the field" (1994:76). With a 2014 impact factor of 3.571, the journal ranks in the upper tier of peer-reviewed publications in biomedical informatics (AMIA 2014). Publishing on BMI science practice, it has consistently suggested disciplinary growth and possible futures for informatics. However, from its beginning, *JAMIA* has had to navigate a difficult task—to define an evolving scientific field within an equally evolving field of a global healthcare industry. It has, on one level, sought value in clinical efficiency through the instantaneity of clinical information across organizations, biomaterials, data agents, and artificial and human cognition; at another level, however, it has sought other kinds of value in paradoxically both codifying and leaving open informatics effects. These less visible effects upon biomedicine have gone largely unexplored in anthropology.

A central BMI truth claim runs through the pages of *JAMIA*: bodies and organizations are fundamentally amendable in their forms to informatics representation, malleability, and reasoning. The claim is that patients' bodies, physicians' minds, and organizational realities are not fixed in nature or social structure: they are fundamentally digital and quantifiable as information. The anthropological challenge here is to map the computer that hides within and that represents the world by codification and as code.

In order to achieve such a mapping, I have organized this Chapter in the following ways: I explore 1) origins and questions of scientific "emergence" as conceived through BMI practices and techniques and certain kinds of problem formulation; 2) what is the notion of science in BMI discourse; 3) ideas on system failure and medical error; 4) temporalities of failure and error in forms of BMI reasoning; 5) the becoming patient; 6) what kind of BMI future is being imagined through the figure of doctors and patients.

Origins and Qualities of Emergence in Biomedical Informatics

The Concept of "Emergence." In this section, I describe characteristics of BMI as an emergent field. To provide a brief background for this discussion, I sketch ideas on emergence as they have been expressed through major scientific movements. I follow with a larger discussion on the particularities of BMI emergence in debates that contest BMI's acknowledged scientific form of biomedicine and the possibilities of its application in the field of biomedicine.

The work of Charles Darwin in the 19th century marks the point of origin for modern notions of emergence. His notion of evolution articulated adaptation as resulting from emergent dynamic between environment and species. In the collateral field of political and economic theory, Adam Smith proposed that markets revealed an order in which the whole was greater than the sum of its parts, since it was not through the consciousness of individuals but through the actions of an *invisible* hand that order was achieved in aggregating millions of dispersed actions by producers and consumers into *a* viable whole. The invisible hand might then be seen as an emergent property of all social relationships (Smith 1790). Finally, in the classical use of the term, emergence as conceived in theories of causality, physical causality proposed that when two objects intermingled, a new property was created. One property was not simply added to another property but produced a wholly new entity that could not be reduced back to its constituent parts. On the level of causality, if emergence was novel, it could not be easily traced back to original entities and interactions.

Scientific truth could not be deduced from general theory back to specifics. Emergence was a concept that attempted to describe unexplainable phenomena.

However, current science does not operate along such self-evident truths. Different accountings of emergence have followed from modern BMI. Mechanisms, not causal agents, it is argued, have given rise to emergent events. Emergence does not lead back to constituent parts or causes. In contemporary terms, it exists in non-linearity and can be ongoing and propelled by futures imagined. As *ongoing emergence,* BMI's epistemological status is always shifting; knowledge is derived from functions and effects of computerized information not anticipated at the time—these often become evident only after they have had an implemented effect. What this idea of ongoingness implies is that the emergence of phenomena can be propelled by both possibilities and present unanticipated outcomes. As we have seen with studies on consciousness and brain function, mental states have been localized and situated in detailed neural-cortical function. As with silicon chip and now biological-based computerized memory, new forms of massive data archiving, data breach, and data permanency have come into reality. Unintended effects of these technological innovations have given rise to new social relationships that are greater than mere databases or computerized networks. One cannot explain these phenomena as wholes or parts but as shifting mechanisms at work. Objects of information can have competing uses and consequence. Therefore, informatics emergence must be mapped-out in the contemporary not as distinct parts or tools but as locations of possibilities. Emergence is a location of possibility to understand mechanisms of BMI at work.

Origins of Computational Reason: An Attempt at a Cohesive Scientific Discipline

From a *JAMIA* perspective, Biomedical Informatics was grounded in post-war computing but not defined by it. These origin stories of early medical informatics were drawn from theories of mathematicians Alan M. Turing and M. H. A. Newman and their colleagues in the 1950s who explored computational logics beyond tabulating numbers (Collen 1994). As an alternative to Cartesian mind-body dualism, Turing introduced another kind of dualism, computational concept of mind, which inverted the Cartesian account of machines as mindless entities into types of machines in the mind where the limits of computability determined the boundaries of human cognition (Luciano 2004). The machine within the mind gave human mind limitless possibility. Machine intelligence was a potentiality against which human intelligence was to be judged: computational speed, neural connectivity, and parallel processing were compared to human judgment, intuition, and subjectivity. Turning mind from a human good into a machine good extended how computationality could be imagined. What Turing's origin story really started in biomedicine was not a post-war computational revolution but a revolution in the *confidence in machines* that could be applied to biomedicine as biological and therapeutic problems.

To understand this revolution in more specificity, it is helpful to describe what Turing was up-to early-on. Turing Machine is a term coined by American logician Alonzo Church in 1937. The term captures what was then a new kind of problem-solving that Turing called the *Entscheidungsproblem* (decision problem), a precisely-stated problem in mathematical form that brought notions of "limitless memory" and a scanning process that moved across symbols, 1s and 0s to construct an archive from "tape" of unbounded length. Turing's machines were of course abstractions: they demonstrated the theoretical possibility of establishing a machine that wrote, memorized inscribed symbols, and solved decision problems of seemingly endless duration and complexity. As Wittgenstein, an engineer by training, has noted, Turing's computational image existed as a dimension of the human: "Turing's 'Machines" were "*humans* who calculate" (Wittgenstein 1980:1096). From a Turing point-of-view, humans had potentiality to bring *machines* into being, they had the potential to *become.* "A man provided with paper, pencil, and rubber, and subject to strict discipline, is in effect a universal machine" (Turing 1948:9). Either way, machines were a dimension of human action and mental life.

Wittgenstein's notion of "machine" did not suggest independent mechanized intelligence or humans as lonely operators of automated systems. He was turning the idea both of "machine" and "human" on their head by gesturing towards the limits of computability—computing pain, boredom, and hope, all had *human* limits. Wittgenstein's discussion of Turing Machines circled-around shared human ideas of culture and cognition. Machines were based on our capacity to imagine the calculable as a problem of the human and to imagine the human as a problem of calculability.

From Turing forward, the machine that lay within stood for a standard for medical cognition representing the "computable" as a form of speedy and endless processing of data. Gazing upon computational potentiality in medicine, *JAMIA* sought to build a space where machines, computational theories, systems, and applied testing of real software and hardware could thrive together, a space in which "solutions" could be investigated only loosely related to the "problems" they may answer. What this meant was that early informatics systems could be built and applied and yet not judged by their results. A kind of Turing-like confidence framed computational forms as an inherent good in medicalized mind, body, system, and network. If hospital and clinical settings were not ripe for implementation, it was only a matter of time for such good to be realized as true biomedical possibility. It was only a matter of time until BMI systems would prove to hold clinical and biological value. The possibility of BMI was not curtailed by poor outcomes; scientific progress marched forward to bring computational forms and intelligent machines into present biomedicine. Founded on a radical scientific shift in the capacity of machines, BMI developed as a set of technical practices around systems and computerization that were always partly realized.

American Biomedical Informatics developed its first clinical systems in the 1970's, and the first academic training book was published in 1990. *JAMIA* has consistently described such movement in the field as interdisciplinary with a focus on applying computerized systems. In the early 1990s, Greenes and Shortliffe defined Biomedical Informatics as "the field that concerns itself with the cognitive, information processing, and communication tasks of medical practice, education, and research, including information science and the technology to support these tasks" (1990:1114). Shortliffe, a major figure in the field and frequent contributor to *JAMIA*, has consistently pushed the boundaries of the field, championing BMI's place as a scientific discipline within biomedicine. From one perspective within informatics, the proper place of clinical computing was within the discipline of medicine as an ensconced field within academic medical institutions (Shortliffe et al. 1996). From another perspective, informatics has opened borders and spanned across the applied and theoretical dimensions of BMI, hence it cannot be localized within one discipline or one kind of institutional setting (1996). Still another direction is suggested by the fact that BMI had grown through global companies like General Electric and Siemens Medical, building development centers that had the resources to conduct expensive research across disparate knowledge domains that led to the sub-discipline *Translational Informatics*.

Since the mid 1990's, the academic medical department model has given way to business start-ups and global corporate locations of innovation. By the early 2000's, definitions of BMI had circled around defining the paths of medical reasoning as applied to programmable methodologies and correlation of biological, protenomic, clinical and non-clinical data (Big Data) in the name of beneficial medical outcome. From *JAMIA*'s inception, there has been a field already happening or about to happen.

This field that is constantly coming into being has been marked by restless aspiration towards technical innovation and newness, seeking to distinguish itself from other biomedical specialties. As debates about BMI's emergence demonstrate, multiple perspectives are at work in determining the scientifically new. In 1977, a founder of the *JAMIA* annual symposium predicted that in a "few years," BMI would have emerged into the everyday private practice of medicine "whereby even a practicing physician can implement his own information system" (Lindberg et al. 2002:333). Some see an evolutionary development or a "gradual emergence" (Friedman et al. 2001:520). Here objects of knowledge move along what informatician and registered nurse Judy Ozbolt has termed a "horizon that may revolutionize again what is possible" (2001:521). In 2008, BMI was still emerging as a cluster of "emerging medical informatics solutions" that will "transform healthcare in the 21st century" although the majority of physician practices were without or saddled with inadequate computerized systems (Groen et al. 2008:2).

We begin to see clues of emergence caught-up in this applied-possible tension in one of the first issues of *JAMIA*. Edward Shortliffe wrote that the provisional "future influence of computers on society" currently imagined was mistakenly "drawn from our current world. In imagining the impact of twenty-first-century computers on the relationship between doctors and patients, we err if we simply imagine individuals from the 1990's thrust into a future world with the technologies that will be available at that time" (1994:77). Shortliffe held-up a different future for BMI. Computers were objects that should *release time,* assisting society at-large in "building precisely the kind of caring relationships that both patients and physicians have always sought" (1994:78). What these objects were to bring was greater physician autonomy with the tools to sharpen medical reasoning, detecting disease earlier, and targeting treatment to individual patient needs. Deepening physicians' relationships with patients while computers do the impersonal data crunching, however, has not been realized, and Shortliffe was aware of possible consequences. He warned of another future that may bind not release time, threatening "our goal of humane care" (1994:78). Doctors may be increasingly pulled into relationships with impersonal systems that would transform human caring relationships in powerful but unforeseen ways.

Reflecting further upon the emergence of machine intelligence, Shortliffe expressed that there is a difference embedded in computers as objects for they are not "like conventional devices" (1994:77) that other generations grew up with. Echoing the analyses of Sherry Turkle, who has consistently maintained that the "computer is a new kind of object… psychological and yet a thing" (2011:17), Shortliffe was thoughtful regarding a form of computerization that may shift medical care in unforeseen ways. This was a balancing act for the field between the powerful agencies of informatics over the relations a physician has with her patients. In his words, "It ultimately [is] the sense of control *over* the technology, rather than *by* the technology" and in the coming decades "people will change just as much as computers do" (1994:77). Shortliffe was referring not only to people in general, to their psyches or ways of adapting to computerized interaction but to a skepticism toward the absolute value of computational reasoning in improving care of the sick and management of persons' health. Here, technology "over" and "by" represented a tension in the field of BMI. Control *by* technology suggested data-overload and impersonal computerized labor; control *over* technology suggested the promise of BMI to fashion new forms of care improvement that extended physicians' efficacious reach, to impassion patients with being cared-for that extended beyond functional aspects of their diagnosis or illness. BMI occupied a wider social location in which caring relationships between doctor and patient were paradoxically being automated, streamlined, digitized, *and opened-up*. Shortliffe's image of informatics held-up the possibility to both humanize and harm relationships between caregivers and patients—a current that continues in the field.

What is a Problem in BMI: Problem-Solutions Scenarios of "Use" and Information Infrastructure

What constituted a "problem" and at which level a biomedical problem was best approached through computational thinking were often hidden behind discourse focused on success or failure of the *technology*. Viewed this way, informatics thinking typically represented a kind of applied technical inevitability. A biomedical problem could be converted into a technological problem that could be solved through designing and managing computerized information. In this way, medical knowledge was a hard-bounded thing that could be mined like mineral from clinical ground, then encoded and made part of care-delivery transactions. Taking information as transactional, "solutions" generated new kinds of bounded and transactional problems that could be endlessly replayed.

Informatics problem-solution scenarios can be seen from another perspective. With the aid of Deleuze's philosophical perspective, Paola Marrati has suggested that problems can "incarnate themselves in solutions without being exhausted by them" (2011:47). In her reading, it was not ready-made problems or solutions that Deleuze called for but a freedom of thought "as ethical and political beings" that allows us to establish "our own problems" (2011:47). Philosophical problems and solutions are not the same as BMI problems and solutions. I am pointing-out an alternative way of thinking through informatics solutions that were seen to call-forth certain kinds of problems embedded in informatics systems. Such problems *exceeded* as they at the same time *incarnated* themselves in particular informatics solutions. Unlike the freedom of thought Marrati has invoked, the relationship between informatics problems and solutions had a screening-off effect: solutions circumscribed certain kinds of problems, shaping how biomedicine was to be improved and how barriers to such improvement were perceived to arise. Other biomedical problems and solutions disappeared or were perceived as threatened with disappearance.

From within *JAMIA*, problems were framed as issues of 'system implementation,' 'administration,' organizations that lack 'management structure,' and problems of BMI scientists in so-called ill-suited service roles. These were *barriers-to-success* problems that seemed to push away a deeper problematic that stemmed from a kind of anxious gaze upon a "limited time horizon" wrote William Stead—a problem best solved when "an innovation can be handled like a light bulb: when it is ready, you plug it into the pre-existing lighting system, and it comes to life" (1998:299). Plugging new scientific-technical innovations into preexisting system-infrastructure that gave them immediate liveliness suggested limited time and value for the operation of novelty within complex systems. Finding suitable system infrastructure for innovation posed the additional problem of gaining rapid acceptance for informatics systems within information-rich and ill-developed infrastructures. The timeliness of an innovation would exceed its horizon of value if it were delayed and could not readily plug into an infrastructure of existing application networks and ways of working and at the same time could not demonstrate rapid improvement. At this level, a problem was not one of "handling" compatible data objects or systems: it was a larger problem of giving rise to a new kind of concept of *system complexity* that would bring informatics innovation *to life* requiring large-scale biopolitical reform. As a kind of system liveliness and social reform, *JAMIA* signals how BMI continues to revise the scales of consequence of massive medical system-data relationships.

Technically, a different kind of systemic thinking was naturalized into the culture of BMI: how complex systems were considered to act—dynamically, chaotically, openly, biologically—was deeply embedded in informatics thought. Thinking *systems* was indispensable in linking and codifying clinical practice variation, pharmacological interaction, biological function, genomics, and medical decision-making. Pulling-together uncaptured levels of tacit knowledge "from cell to system has been long anticipated" was a goal of computational reason and wove together "low-level biology through to clinical and organizational levels" (Tsafnat et al. 2009:768). The merging of cell to system to medical mind should not be underestimated. It was announced in 2009 that a new level of informatics integration was underway, a period of large-scale linking "of biomedical databases, from tissue banks and electronic patient records, gene and protein databases like Genbank, Kegg, and the biomedical literature stored in repositories such as PubMed" (2009:768). New types of problems were emerging that this type of systemic thinking was not prepared to fully capture.

Following such ambitious thinking, informatics determinism was understandably difficult to challenge for many theorists and practitioners of BMI who sought to participate in an informatics of revolutionary concepts. The confidence in the discipline to computationally map and solve clinical problems from cell to system seemed indisputable. Innovations would proceed, systems would be found, software validations would be constructed, and medical sites would be identified for system implementation. This confidence rendered biomedical problems identifiable and open to augmentation by computers.

Such confidence pervaded *JAMIA* and pushed back reflection upon the types of problems that emerged from the field. Framing of problems in the contemporary demanded practices that re-crafted medical knowledge and clinical care as forms of equipment. I take this idea of *equipment* from Paul Rabinow and Gaymon Bennett to have two senses (2007). The first consists of technical objects that are not new but are *recombined* out of both old and new ideas on biological systems and information forms. The second sense of *equipment* offers-up objects and their effects that hold the marvel of *improvement* of medicine and that operate to "reconstruct problems"; that is, to reconstruct the field upon which BMI science is conducted (2007:14). Such improvement drifted undetected into BMI science-building.

Where Is the Science?

In the following section, I address the place of science in BMI disciplinary-building discourse and examine how our idea of science may need to change in order to accommodate BMI as a set of practices that sometimes resemble a unified field but often fall outside disciplinary wholeness. The actual place of scientific work within the field has been in question starting from the very first issue of *JAMIA* in January 1994. What constituted scientific location appeared hidden or, more accurately, was kept behind walls of BMI's disciplinary orthodoxy. Informatics objects are different kinds of things epistemologically and ontologically when they move from being computer constructs to concrete practices involving patient-care; as objects in motion, they have different implications for the formation and practice of science among and in medicalized bodies.

Charles Friedman, head of Biomedical Engineering at the University of North Carolina at Chapel Hill, stated that there was a "dilemma for the whole field of medical informatics. Indeed where *is* the science?" (1995:65). He related a story of a dissertation student who delivered an excellent dissertation in which an algorithm for a "prototypic" clinical decision support system (a model) was developed. The committee applauded the student's theory as having the potential for contributing to the practice of medicine. But as Friedman noted, the committee took things a step further. Behind closed doors, they discussed if the student went far enough. Designing models that are highly generalizable are considered core informatics science. However, in this case, the student's model theory was not *science enough*. His model needed to engage an essential next step. As Friedman noted, models "*look* and *feel* scientific," but developing a stable system that produced practical biomedical knowledge and information "is more than a straightforward act" and required a deeper form of practice, the "majesty of the empirical" (1995:66). The "theoretical" in tension with the "applied" did not go unnoticed here. *Science* was not located at any single level or data model but rather was situated where "creative acts might be" (1995:65). Informatics models had to be *peopled.*

I believe Friedman was searching for something much more interesting than a home for BMI scientific practice. The science of BMI was manifest at various locations, but these locations were not always evident or visible. At certain levels, scientific work was easy to recognize while at other levels *creative acts* required a different level of discernment. Not all creative acts were seen to rise to the level of science, but others exceeded BMI science. For

Friedman, the conditions of possibility for a new kind of science were already present within the discipline; but since the experts who controlled the definition of what constituted BMI were forcing these creative acts into unifying principles, they were in-effect stifling their creative potential to redefine *science* itself.

In short, when Friedman used phrases where science *might be* or the *look and feel* of the *scientific* and "not a time to be doctrinaire,, he was insisting against the grain of his discipline not to define BMI's role *in* science but to define a new role *for* science with BMI serving as its exemplar (1995:67). He was attempting to assemble a scientific language that was specific to an expanding field while suggesting creative scientific practices that were resistant to doctrinaire tendencies. The *scientific* in the *might be* of scientific location needed a new language. Such a language offered possibility of integration of clinical care with "human and informatics components…with different definitions and modes of operation" not present in biomedicine at the time (1995:67).

Friedman was not alone in calling for a new form of science. The language of BMI appeared to represent only partially only partially the possibilities of informatics. In this direction, it was suggested that informatics become a "science of design" accompanied by a "creole" language including the social sciences that could capture the subjective and local dimensions of computerized medicine across "phenomena…simply too complex and diverse to be reduced to a single set of universal principles" (Kaufman 2008:490). However, due to an effort to codify BMI science, this project has been largely abandoned. Instead, the language that has slipped into its place is increasingly universalizing, describing *a* science from which problems "emerged de novo" from expanding expertise that was challenged by its own technical solutions. The problems represented by BMI's emergence had deep social and scientific implication; but in meeting such challenges through an integration of social-scientific and ethnographic methods within biomedical informatics*,* a door was being opened to a more open and flexible scientific enterprise. However a more flexible definition of science was jettisoned.

Friedman's line of thinking of the *might be* of science was a call for scientific self-reflexiveness and inclusiveness. Clearly, thinking about scientific and disciplinary emergence had all the markings of a skeptical attitude toward present ways of defining science. Instead of seeing objects as fixed in time and space, Friedman was advocating that computational artifacts be conceived not in a Platonic universe of representation of abstract entities but through local engagements with the materialities of informatics, wherever they may present themselves. The *might be* of informatics science was built upon daily contact with computerized data (simulated drug delivery systems, electronic health records, diagnostic imaging) and from the other way around daily contact with clinical and non-clinical behavior of people (autonomous decisions, intuition, and affect). In this sense, scientific practice was not only hypothesis-testing but also was left open to agentic effects after systems were promised and implemented but which had very different results. In an exchange with informatician Stuart Hunter who claimed "learning from data is the objective" (2010:112), Friedman countered by stating that BMI applied "to many domains of work" (2010:113). It was "less clear" to Friedman that current scientific method had the capacity to render flexible understandings across domains of organizational order, research protocols, data, and administrations without radically reducing these phenomena. His phrase "less clear" was suggesting that scientific method required reform and was certainly not useless in learning about these domains of work outside computer engineering, but in the absence of such reform, scientific method by itself was "almost certainly less profound" (2010:113). Again, Friedman was making an interesting move. His notion of "profound" pointed to a lack of depth and scope in scientific method to adequately link together what was most valuable to BMI knowledge. Friedman and his sympathizers valued an ethnographic informatics that took into account human contingencies that BMI practice rendered-up empirically but that escaped universalizing ways of thinking. In this way, BMI would bring its logics into being through an understanding of the everyday experience of biomedical practice, preserving the discipline's potential for self-reflection under the majesty of the empirical.

'Majesty of the Empirical': Shifts to accommodate a new mode of science. The *might be* of science speaks to possibility and to unsettled definitions of scientific practice. The rapidly produced objects of BMI and their embeddings in large scale computerized and administrative systems speaks to effects upon doctors and patients. The majesty of the empirical would need to be expanded. As Friedman admitted, at certain levels BMI science is perceivable while at other levels it becomes opaque and difficult to discern. Conducting BMI science would require systems to affect people, to move from concept to implementation rapidly. The *empirical* would span across model-building, AI, neural networks, and or software and network development but would also span behavioral and affective dimensions. The sanitized idea of clinical "outcomes" would be constantly countered by new objects created, received, negotiated, lived, and returned to science in computerized form. The *might be* of scientific praxis here would dismantle a hypothesis-based science in favor of a performance-based science focused on the circulation of things and their effects upon doctors and patients and a wider health-seeking public. Such a performative science would be a peopled science of informatics things, circulations, and effects.

When we imagine the performance of scientific objects as a way of thinking about BMI, we do not need to reach far. We can draw from daily encounters with new and daily software updates to our laptop computer shifting our responses, thoughts, and relatedness with others based on programmed criteria scheduled into computerized systems. We can think of bioinformatics "performance" in a similar way as *non-human forms of effect.* These are effects that hold clinical and biological potential that scientific method has not yet accounted-for.

As an example of such effects, let me introduce you to Alice, an "algorithm." I will call Alice a certain kind of imaginary performance of objects among massive data archives and correlations. Let's call Alice "promiscuous," which means she is intelligent code that targets both medical and non-medical databases to arrive at clinical and health correlations. She is not promiscuous in the gendered sense but in the engineering meaning from the Latin *promiscuous*, which implies 'indiscriminate' grounded in *miscere* 'to mix.' This term captures computerized data's potentiality in medicine today, to "mix together" and therefore to encourage new combinations and correlations of elements.

Alice enjoys encounters with clinical data. However, the phrase does not describe the widening range of what "clinical" stands for: she is after any number of relations between biology, health, and human behavior. She scans her way through massive tables of terms, formulae, and numeric values in search of potential clinical outcomes. She tags locations to return-to: employer-funded health insurance plans, Google flu data, voting rights acts, historical voting records, immunization rates among suburban patterns of auto insurance coverage and inner city automobile accident rates by uninsured motorists, tanning salons participation rates among men and women of 40-plus years of age. Her encounters with "clinical data" grow in complexity. She is tagging and aggregating data without an end in sight. She's assembling a certain kind of body, a body of data routes and correlations-to-come. Her journey leads her to the Intermountain Health System and Mayo Clinic databases. She finds here that the pharmaceuticals Revlimid for the treatment of melanoma and Abraxane used in the treatment of metastatic carcinoma of the breast have had increased application by 35% over the last three years. Further on, she stumbles upon changes on the Board of Directors of Mayo Clinic that indicate new Board appointments from the Celgene Corporation, makers of Revlimid and Abraxane.

She settles on an interesting grouping. Hospital discharge summaries are mixed with malpractice settlements and lengthy depositions of insurance claimants. The nano-particle albumin bound technology platform used in the development of Abraxane has been repurposed by a small group of scientists treating non-small-cell lung cancer. Alice bumps up against chemical and biological agents that have blocked her progress. She is stopped by a rogue grouping of scripts that have mutated and split-off from their original function. In her attempt to journey-forth into the widening meanings of "clinical data," she has found her access permissions denied but not finished.

My brief demonstration of non-human effects among large-scale data conjures objects potentially rolled-out upon human subjects or users. We can imagine that the performance of such things happens only when objects have had demonstrable effect upon people. This is a different kind of science, one in which the origin of scientific production around data objects could be written-over and correlated far removed from original hypotheses, intentions, or models. Users, errors, online hive-activity, and unintended modifications thrive here. In the highly-regulated world of biomedicine, the idea of a type of open science as a field of *object-*

effects may seem farfetched. However, the point here is that in the contemporary, data objects may not stay put, meta data seemingly non-descript ones and zeros extend beyond individual lives and biologies and can be reused under new rules and industrial ownership when the time becomes appropriate. Such ideas were not Friedman's alone, and they shaped a field that has been seeking new ground rules to set its scientific boundaries and epistemologies.

Artificial intelligence. In this brief section, I focus on concepts in the multidisciplinary field of artificial intelligence (AI). The concept of AI remains one of the guiding pursuits in the field. AI has been defined as the science and engineering of intelligent machines and, in particular, intelligent computerized algorithms. It has been associated with cognitive science and studies on consciousness applying computerization to reverse engineer human intelligence. AI does not confine itself to approaches that are biologically observable.

In current definition, AI is not limited to human mind or body as sources for intelligent action. Machine-intelligence has implied learning from other activities and agents. A machine as intelligent performance and feedback went beyond naturalistic and psychological epistemologies and has been termed "android epistemology" (Luciano 2004). This form of knowledge has been considered possible because of the belief in computational machines and their capacity for knowledge and in their capacity to understand human beliefs and actions in association with their own synthetic mental states. Special attention was not paid to whether an act was biological or non-biological human or machine, *all action* fell under this broader definition. A pioneer in AI research, Marvin Minksy advocated for a form of reasoning based on new approaches to puzzling through ideas of "thinking" and "feeling" (2007). Minsky's notion of "thinking" and "feeling" was distributed in a range of materiality, of what political scientist Jane Bennett has termed a form of vibrant "distributive agency" that does not locate a "human subject as the root cause of an effect" (Bennett 2010:31). From a *JAMIA* perspective and in line with such views, Shortliffe stated in 1986 that AI consists of "intelligent action," an "act or decision that is goal-oriented" and that came to be arrived-at by moving through symbolic and reasoning processes and that are drawn from "knowledge of the world to inform and guide the reasoning" (1987:61). AI did not have to mimic human intelligence; it involved a broader analysis of human and non-human action and cognition. These encompassed problems that moved beyond the borders of human cognition. AI here indicated a move toward computational intelligence that sought to compensate for and enhance medical decision-making. The presence of machine decision-making suggested that clinical decision-making had already been exceeded or required enhancement to keep pace. Synthetic intelligence emerged just in time to cure widespread cognitive lack in doctors. This notion of lack was not based on an idealized and unobtainable image of self as theorized for example by Jacques Lacan but rather referred to the state of medical judgments' being overwhelmed by rapidly generated scientific data. From a *JAMIA* perspective, diagnostic and therapeutic choice carried with it a problem of information-overwhelmed cognitive agency that informatics sought to relieve and solve while expanding the boundaries of intelligent action. However, the assembled nature of intelligent actors appeared to throw clinical decision-making into a kind of spatial-temporal configuration "like a pebble thrown into a pond, or an electrical current sent through a wire or neural network" to use a description from Bennett (2011:32). Human cognitive intentionality and medical efficacy should not be regarded as necessarily lessened: they required enhancement, prosthesis. Physician decision-making was one cognitive node among other nodes of intelligent action. In this picture, such action did not cancel-out clinical intentionality but rather redefined an image of doctors' holding a strong and autonomous form of judgment among intelligent machines. As human-machine interaction shares similar ground in healing and health outcomes, such interaction can also share in a person's morbidity and poor health outcomes. Put simply, if machines can cure, they can harm; if they can enhance decisions, they can contribute to error. What kind of harm and error may we be seeing as human intentionality and medical efficacy are enhanced?

Notions of Failure and Error in Biomedical Informatics

Sometimes truth comes riding into history on the back of error.
Reinhold Nieburh

In this section, I address a BMI paradox: computers are viewed as inherently efficient and capable of addressing 'real world' problems, yet they can create inefficient care delivery and disrupt clinical environments. A concern for this tension runs throughout the field of biomedical informatics and includes emergent error and categories of distributed harm within large systems.

As some of the reports have indicated, in 2009 at least 40% of IT systems achieved their original goal. "Some sources report[ed] 70% failure rates" (Kaplan et al. 2009:291). These systems range from electronic health records, computerized order entry systems to practice management systems. Of 176,409 medication error records for 2006, 1.25% resulted in harm; 43,372 (approx. 25%) involved some aspect of computer technology as at least one cause of…[medical] error. The computer technology implied in these numbers covers a spectrum from hospital-made and proprietary software and hardware. Technical causes of medical error in using computerized systems circled-around a much larger idea of "complex systems" that included people, so-called users, social and medical context, biomaterials, and the belief in and working-through of informatics forms.

Between 2006 and 2009, *JAMIA* brought unprecedented attention to understanding errors that arise as a consequence of computerized systems. For example, medical errors were detected resulting from the use of medication distribution robots in nursing homes (van den Bemt et al. 2009). The presence of robots effected medication compliance among patients, resulting in substandard treatment. When the question of compliance was extended to human-robotic interaction, it became crucial to design new types of controlled long-term empirical studies on non-human care in nursing homes. The use of computerized robotics demanded that ideas concerning medical harm should be expanded to include the consequences of humans interacting with new and unfamiliar technological devices. There is a marked expansion from the idea that a technological agent that fails to perform its promised task might be the cause of harm to the idea that the actant here is a human using technology.

One can see that automating care invites or calls into being forms of kinship between humans and non-humans. The picture of an understaffed nursing home where patients required ongoing monitoring and care leads to images of computerized robotics and the development of informatics-based relatedness as a solution to the problem of understaffing or boredom from performing repetitive tasks. But one needs to insert into this scenario the uncertain medical outcomes that could arise from a distancing and separating-off of human care from patients.

It was increasingly recognized within the field of biomedical informatics that the success of IT systems "required a mix of organizational, behavioral, cognitive, and social factors (2009:292). On the organizational level, the failure of Biomedical Informatics was framed as "managerial"—meaning that it could be solved by the supervision of proper management techniques. By improving ill-applied "system training" or "process," corrections could be applied to failures of BMI's implementation (Ninja et al 2009). Reminiscent of a kind of later-day Taylorism for healthcare, emphasis was centered on streamlining teams and clinical workflows. Emphasis on user training became system-adoption strategy. One was trained and then internalized such system standards as a user. Randomized control studies (RCTs), the major standard of success in the field, were consistently suggested to the study of failure but were poorly applied due to "barriers." These barriers were on one level organizational in nature, organizational failure anxiety. Here, the barrier was that failure studies brought unwanted attention to organizational competence in informatics, which opened hospitals to unwanted scrutiny. Under scrutiny, it became clear that IT departments, medical staff, and hospital executives behaved in bounded and separate networks of expertise and often did not collaborate. From another direction, the study methods of errors were often inconsistent and not rigorously applied. "Very few studies reported data on the severity of errors" (Reckmann et al. 2009:621).

In one of the most comprehensive efforts to collect data about patient safety, a landmark report by the Institute of Medicine found that as many as 98,000 deaths and more than one million injuries per year in the United States were attributable to medical error (Kohn, Corrigan, Donaldson 2000). That report, conducted by an independent consultancy group, led to a national movement to reduce medical errors and to make hospital stays less harmful to patients. What the report seemed to miss were biomedical informatics errors. When such errors were addressed, the problems were attributed to system complexity. System complexity implied machines that eroded decision-making over time by information overload. In the case of interacting with IT systems, physicians were seen as "operators" who carried the "risk of having too much information to interpret or of not getting the right information" (2000:61).

Medical error in BMI enacted a different type of harm. Its origins and operations eluded conventional forms of automation. Computerized systems, linked across massive databases, had the potential to produce what *JAMIA* contributor Jonathan Weiner described as "the ultimate of unintended consequences…"e-iatrogenesis" (2007). An e-iatrogenic event was broadly defined as "just about any aspect of comprehensive HIT [healthcare information technology] system …. that involve errors of commission or omission" (2007:387). An "e-iatrogentic" event had three potential causal domains: technological, human-machine in origin, and organizational. If we follow what e-iatrogenesis as a descriptive term was referring-to, we find a fascinating problem for the anthropology of BMI, namely that *agency* as a term and concept did not serve to capture the characteristics of e-iatrogenesis. Error here was multi-causal and emergent, which puzzles established ideas of attribution and responsibility. No individual human agent and no single electronic actant (code, data server, errant data, electrical power source or computerized network) is a single cause of error. "Causative agents [in HIT] almost never occur in isolation" (Campbell et al. 2006:554). E-iatrogensis implied error in which there was "*no exact analog in the non-electronic context"* (Wiener 2007:387). To claim that "e-iatrogensis" was ultimately caused by physicians does not hold-up. To claim that such errors were multi-casual did not capture the specificity of its distributive form. To state that they are easily preventable does not account for the way computerized information is maintained unevenly across different organizational orders. E-iatrogenic errors are of a different order: they emerge not only as a result of poorly designed systems but also from well-designed and tested systems designed to breach the boundaries of physical location, body, or operator. We can picture a proven traditional medical intervention that may result in patient harm, and a proven HIT system "used appropriately may also contribute to an undesirable outcome" (2007:388). The puzzle of e-iatrogenic error lies in its computerized distributiveness and ill-design of systems but also in *appropriate design and use* of such systems. Errors of this sort represented "a new 21st century vector for medical care-system induced harm," a kind of side effect of informatics expansion (2007:387).

Medical errors were framed within the phrase *unintended adverse consequences* (UACs) associated with BMI systems. UACs are numerous, and I will mention only a few. The number one UAC was added work for clinicians. As noted by one clinician, such additional work was factory-like trickling down from upper "to the…fingertip…and the cumulative effect of all those [informatics mandates] is not fully appreciated" (Campbell et al. 2006:489). 'Cognitive fatigue' was cited as contributing to errors of both commission and omission. Software updates, bugs, fixes, and system implementations brought about the effect of workplace stress and uncertainty. Another type of UAC was e-related 'juxtaposition errors' resulting from clicking on the wrong item on a computer screen without being aware of the mistake. A patient name could be wrongly selected due to crowded adjacent information, which could lead to data being wrongly associated or hidden from the next physician responsible for caring for that patient. Patient data were then not necessarily lost: they were stranded in unreportable sections.

Professor Abraham Verghese of Stanford University School of Medicine embraces a less strandedß disposition towards error, describing error-prone occasions as a form of dependency. Humans were "glued" to computers. Human-computer dependency, Verghese argued, contributed to an "atrophy" of a doctor's fundamental talents at diagnosis and treatment of patients. Computerized automation amplified, even invited, a loss of sentience between physician and patient.

> Medical students [are still taught] how to properly examine the body. In dedicated physical diagnosis courses in their first and second years, students learn on trained actors, who give them appropriate stories and responses, how to do a complete exam of the body's systems (circulatory, respiratory musculoskeletal…) but all that training can be undone the moment the students hit their clinical years. Then, they discover that the currency on the ward seems to be "throughput" – getting tests ordered and getting results, having procedures like colonoscopies done expeditiously, calling in specialists, arranging discharge. And the engine for all of that, indeed the place where the dialogue between doctors and nurses takes place, is the computer. (Verghese 2011)

Verghese outlined an occasion for a more insidious form of error than operating on the "wrong part of the body," the consequences of which could be dire. This was the type of error that was e-iatrogenic and emergent but not directly a result of a computer error or physician intervention; it existed as part of a shift in relationships between "throughput" (efficiency) and medicalized ritual that allowed physicians to cross the threshold that bonded doctor and patient together in a face-to-face encounter over time. The potentiality for error here transformed the affective relationship between doctor and patient. It did not suggest an erosion of caring relationships of the doctor *to* the patient but rather a kind of cutting-up of this relationship *into* information transactions. Digital dialogue between doctor and patient was extenuating the doctor-patient relationship and moving it away from the face-to-the screen—or a simulation of face-to-face. The affective relationship with the patient has not disappeared, but the computer as an "engine" of intervention in this dialogue rendered the physician's promise of supporting the patient through the illness process open to new forms of interruption and enhancement.

An unintended consequence of BMI reported in *JAMIA* was the inducing of "changes in the power structure and culture of an organization" (2006:552). Hospital departments became centers of data-gathering and clinical oversight that physicians viewed as a threat. In a vivid example, such unexpected shifts were seen as an inevitable "diffusion" problem. Technology not only changed "work processes," it replaced them with new tasks. Discourse here included terms "diffusion," "adoption," "productivity," "workflow," and "compliance"—all appeared to hide rather than make visible the tensions and emotional charge that emerge with system failures and errors (Davidson et al. 2007). As one physician aptly stated, "I don't even know what I don't know" (2007:362). Failure and error thrived in a space of analogue-to-digital transition; however, their ongoing side-effects as an *embedded part of BMI theory and practice* was rarely commented-on. BMI discourse persistently framed this space in terms of achieving computerization to improve patient outcomes. Silence surrounded questions of moral responsibility. If questions concerning responsibility were opened, they quickly turned to problems of measuring performance outcomes, technology effectiveness, or calculating organizational and management styles. From an anthropological perspective, if e-iatrogenic error were an emergent form of harm, then we might be seeing an under-examined area in biomedicine that exceeded quantification, medicalized rituals between physician and patient, and biomedical ethics.

Temporalities of error and failure in clinical computational reasoning. I wish to return to an idea in Paola Marrati's examination of Deleuze: problems could "incarnate themselves in solutions without being exhausted by them." Following Marrati, a problem could be construed as puzzling through unintended consequence embedded in computerized solutions. A new informatics solution could bring new efficiency and different tempo to clinical workflow, but at the same time it might invite new problems that may be hidden in conceptions of such solutions. Thinking about this problem-solution framework was from my perspective a way of examining problems that would roll-out over time. Informatics solutions were missing a social way of thinking about error *in* time, or better put, thinking through error that ruptured the *limited time horizons* of BMI innovation. Problems that were incarnated in the very solutions they were designed to answer were often made visible when new informatics objects affected people. Such encounters were often situated and local and could not be easily universalized or quantified. On another level, errors were *possible*; that is, they held both "actual" and "potential" harm—a near miss, an e-iatrogenic event "may" result in harming patients over time. The possibility of error is based not only on what *has* triggered a harmful error but also on what *may cause* harm in the future. Distributive electronic error is imagined as "only the tip of the iceberg" of adverse events, and the potentials for harm are still unknown (Weiner et al. 2007:387). Imagined in this way, error, its frequency, and potential effects, is based on causal and temporal unknowns.

From a *JAMIA* perspective, error proved crucial to reshaping the temporal experience of the clinic. In this sense, physicians were exposed not only to new automated steps in cognition and action but also the adoption of such systems was expressed as "revenge effects" (Tenner 1996) of technology and "repairing a jet engine in flight" (2006:550). The logic of computerized information flows has long suggested speed. This sense of speed is often experienced as being in flight, according to many who work in medicine. An example from a 2010 *JAMIA* paper offered a picture of accelerated temporalities and their effects upon clinical consultancy. "One of the difficulties in the consultation is the severe time constraints that we have" … "We" experience time as an "indiscriminant, excessive generation of clinical [software] alerts" that are on-screen notifications that act as checks against ad hoc decision-making (Moxey et al. 2010:549-550). However, between physicians and engineers, the experience of time has been remarkably different. As one engineer noted in the early 1980's,

> I feel very comfortable talking in nanoseconds …. nanoseconds are *wide*. I mean you can see them go by. 'Jesus,' I say, 'that signal takes twelve nanoseconds to get from there to there.' Those are real big things to me when I'm building a computer. Yet, when you think about it, how much longer it takes to snap your fingers, I've lost track of what a nanosecond really means. (Bolter 1984)

Experiencing nanoseconds of information *as wide* as opposed to clinical problems *in flight* are indeed different temporal scenes—one based on controlling time in a machine and another based on possibilities of error in or around the patient's body. Error in medicine has become conflated with, and caught up between, computational time and diagnostic time—the immediacy of information and the unfolding of the causes of illness. Time here is caught in a tension: it is "wide" and "in flight" and subjective. As physician Lisa Sanders tells us, "illness" has been traditionally defined by patients' subjective understanding of sensation (2009). Physicians were not examiners but interviewers of symptoms that patients expressed to them. "Disease" was put together from a grouping of subjective symptoms and "distinguished based on the type of symptoms, the sequence of their presentation, their severity and rhythm" (2009:137). This subjective experience of the unfolding of disease between physician and patient, once computationally adjusted by "diagnostic decision support systems," may not, by Sander's admission, "take the form we anticipate" (2009:238). These different senses of time—of impersonality of machine time, the urgency of clinical time, and the unfolding of symptoms between patient and physician—was a tension in BMI efforts at improvement. Error represented temporality in which past medical histories, present technical urgencies, information time, and future improvement of clinical outcomes were unsettled. Error could be as much related to failures in past information system conception as to present implementation shortcomings, as well as to possible errors. Error could be imagined as an opportunity to proactively redesign the performance of systems or a warning that potential hazards were unavoidable. The flow of time, its temporality in BMI and in clinical care, was experienced differently; and from my perspective, this instability invited new levels of information anxiety for physicians and patients.

If the location of error was highly distributed and caused by both human and system-based factors according to informaticians, what or who was to be monitored for error? Was the problem of error "incarnate" in a BMI solution? The fields efforts to anticipate electronic errors and their technical kin, error monitoring, is set against wider perceptions of the computer's persistence in all areas of clinical work. I refer to an account from a primary care physician taking on the persona of an overwhelmed Superhero who plunges "into the next pit of human suffering…only to check schedules, to ensure productivity remains on target" (Groopman 2007:81). In this image of exhaustion and impossible demands, networked devices and clinical documentation proliferate in all directions from smart phones and EHRs on tablet computers to "notes from specialists, lab results, patient phone calls, referrals, radiology requests, beepers, handheld formularies, patient-satisfaction surveys, color-coded preferred-drug charts from insurers, and quality report cards from HMOs, we forge on, as our patients wait, shivering expectantly … The superhuman demands of our specialty have either morphed us into steely-eyed combatants or reduced us to blithering, overwhelmed, white-coated globs of jelly. We now practice triage medicine—surrendering time-honored bedside roles to hospitalists; slicing face time with patients…" (2007:81-82). This is not solely an informatics setting where triage medicine is a default form of medicine but also information systems set within systems of administrative and clinical pressures.

It takes superhuman effort to overcome the experience of “slicing” and “surrendering” time. As an image, I am not indicating that bedside time has been actually reduced. I am pointing-out that the experience of time as *sliced* or *being overwhelmed* along lines of ensuring “productivity” and “quality report cards” has appeared to usher-in fears of a dehumanizing managerial scientism. In this managerial science, the physiological unfolding of the patient’s disease and distress has been unlinked from the organization of clinical work and linked to information efficiency. Sanitizing these ongoing problems, a 2010 *JAMIA* study proposed that “worthwhile progress” would arrive when focus is brought to “both, computer system enhancements and the human factors influencing responsiveness to new systems and change” (Moxey et al. 2010:32).

Thus, in conceptualizing error, informatics may be usefully positioned within the genealogy of thinking around what French physiologist Claude Bernard in the 19th century stated was the “very frequent application of mathematics to biology … the use of averages which, in medicine and physiology, leads, so to speak, necessarily, to error” (1957:134-135). Bernard had not yet arrived at binary orders, computer hardware, clinical ontologies or bio-computational theories of twentieth century medical computerization, but what he was imploring future medical scientists and practitioners to pay attention to was what lurked in the mathematical “average” when applied to computational medicine. He was skeptical of probabilities and averages in which “true relations of phenomena disappear,” insisting that mathematical averages that standardize and universalize physiology “must therefore be rejected, because they confuse, while aiming to unify, and distort, while aiming to simplify” (1957:135). Informatics thrives and in many ways makes possible standardizing and universalizing forms on a scale never before experienced in biomedicine. This unprecedented growth of biomedical and administrative practices of BMI are not literally machines, but they have produced managerial objects as well as information orders within biomedicine that have machine-like characteristics that are prone to produce errors resulting from this human-machine conjugation (see Lock et al. 2010).

It has been acknowledged within BMI that the idea of "use" is a very imprecise way of referring to what happens when people are faced with implementation of an idea or a program. Theories of informatics design and adoption simply do not fit within this rubric of description. From a BMI standpoint, when ideas which seemed to be robust in theory run into problems of implementation, adverse effects tend to be couched in vague terms: "sociotechnical incidents" (Redwood 2011) compromises "decision making power" (Peng et al. 2010) or can be paradoxically linked to an increase in "decision support affectiveness," "optimization of functions," and improved "patient safety" measures (Peng et al. 2010). The terminology here may appear technical, but it points to a search for a science of informatics that can understand effects of computerized automation at the level of actual clinical settings. For instance, take the following statement from a founder of a radiology software company: "we test and release [software] to our sites and they sometimes pick up the pieces. That's how radiology systems (I think most clinical [software] systems) are made. Not just with programmers, but in the hands of physicians where the action and feedback is" (Blogh, interview with the author, December 3, 2011).

Informatics innovation does not, or perhaps cannot, occur without certain levels of risk that are passed-on to patients and physicians at work in the healthcare system as a whole. From this perspective, "we are caught in a bind" as Enrico Coiera and his colleagues have stated, for reforming the health system is now a national priority and "so compelling that there appears no choice but to implement complex ICT [information and communication technology] on a large, often national scale. Yet these ICT systems appear less mature than we would like and our understanding about how to implement and use them safely remains in its infancy. As such, we are faced with a pressing policy challenge on both the national and international stages" (Coiera 2012:2). The kinds of harms produced by informatics system error embedded within wider healthcare settings should not be limited only to implementation and use but should be focused on the space between concept and application. Complex computerized systems seem to beg the question of side-effects and embedded risk while at the same time promising improvement. While informatics innovation relies on rapid adoption and feedback on systems while in clinical use, an understanding of their safety is still in its infancy. Anthropologically exploring the science of BMI as a science in formation can bring definition to locations of clinical benefit and system error among agencies circling the experiences of physicians and informaticians. Encountering such a biomedicine as an anthropological object allows for understanding how the patient's body, as an informatics body, began to speak, exceed its borders, and represent a certain type of computational order to be explored.

The Becoming Patient

To find the figure of the patient's body in BMI, we have to look for concepts and signs—where this figure as a problem may be located. What I am terming the *becoming patient* is computational problem of unsettled materiality: bio-medico, informational, computerized, ethical and temporal—a contested site of targets and transactions. On another level, enhancing human and compassionate caring of patients was not lost upon BMI discourse. Yet, this figure of the patient—data flows, pathways, decision trees, probabilistic models, and software alerts—haunted BMI literature in *JAMIA*. It was a struggle on my part respectfully not to sweep away assumptions about clinical "quality" and informatics "improvement" but instead listen for certain vulnerabilities in the imagination of BMI that opened-up the present of medical computerization. To explore this further, I will briefly mark this figure along ideas that are shifting our understanding of the human.

The *becoming patient* can be viewed along several points from 1994 to 2014, along fears of computerized dehumanization, vulnerability to emergent medical error, optimizing doctor's cognitive and diagnostic performance, and as a patient-consumer of health-monitoring tools in a world of mobile devices and Big Data. The figure of the patient from a *JAMIA* perspective was located in "patient-specific models," "simulated patient problems," and patient "self-management tools." During the early 2000s, emergent error cast the patient as vulnerable to medical care-system-induced harm. As a corrective, the patient was a beneficiary of computerized enhanced clinical decision support systems. Several years later, the patient was a site of "personalized care" brought together through "consumer-centric" forms of "management plans" based on "culture, environment…family health histories, and the individual's unique genetic/genomic makeup (Glaser et al. 2008:392). The *becoming patient* was not so many different patients or technical developments as an assemblage of data models, potential harm, physician decision-enhancement, vulnerability, data correlations, and customized health management tools. Such a becoming was also, and importantly, an aspiration for a humane relationship between physician and patient. Shortliffe offers a description: "We [saw] kind and caring individuals who talk[ed] to patients, [held] their hands in times of need, and [provided] precisely the kind of comfort and support that we envision[ed], [such individuals] were widely available when country doctors made house calls a half century ago. Are we seeing twentieth-century values unrealistically projected into the future" (1994:78)?

Such comfort and support were being fashioned upon a figure of the patient projected across computer networks and computational futures as a container for a kind of nostalgia for human care that was being repositioned among agencies that included human beings and machines and that challenged common notions of time, agency, and human touch.

The becoming patient nested in unsettled notions of clinical and machine order: efficacy, signs and symptoms flowed along with the persistence of error, the capacities of machine intelligence and efficiency. Anthropologically, thinking about temporality of machines in clinical computing and the transformation of care could be examined in ways that anthropologists Joao Biehl and Peter Locke suggest as "new intersections of technology…desire, and imagination" that may give rise to "unexpected futures" (2010). These unexpected futures circle around the becoming patient as forms of informatics potentiality.

A "Machine" in this sense could symbolically stand for any complex human or non-human programs and systems. Notions of "care," "life," "information," and "patient" were terms that gave no special epistemological status to human systems over other complex systems, biological or non-biological. This style of thinking or ontological form has cast systemic and programmatic time as applying to a wide range of distributed and networked agencies, errors, bodies, and artifacts. Framed in this way, the becoming patient was a particular instance of both *system* and *program* open to computational reason. This form of reason has claimed a particular future of care, but it has also generated a new level of error that may overrun the solutions it has proposed for biomedicine. "There is little difference" writes George Canguilhem, "between the error of life and the error of thought" (Canguilhem 1991:278). In a world in which informatics implies cell to system relations, error suddenly grips us differently. An error is more likely to occur at any juncture or flow between computerized, genetic, transcriptional, metabolic, mental, and physiological models and systems. Therefore, are we seeing the concept of error expanding to include certain potential "micromonstrosities" that link-up to deeply embedded informatics "solutions"? Are errors of nature merging with errors of intelligent machines in a new kind of symmetry? What kind of becoming of patients, monsters, and biological forms may we discover here?

If we are to see the becoming patient in this way, *JAMIA* may offer clues to a much larger shift that BMI potentiality represents. William Osler, often cited as the father of American medicine, has perhaps said it best when in 1904 he stated that medicine and its innovations are derived from a "proper spirit of eclecticism, a willingness to take the good wherever found, that augurs well for the future" (1902:689).

As I have pointed out, BMI is not only a scientific field of ongoing and contested emergence but also a world in which the possibilities of computerized data, error, and conceptions of the patient are aligning as certain kinds of problems to be solved through and by the marvels of computerization. Materialities of care—medical judgment, enzymes, hormones, genomics, speed, efficiency, anxieties, limited time horizons, and medical harm—should not be taken as separate phenomena but as new potential alignments. In this sense, BMI would be wrongly seen as a collection of epistemologies set on top of biomedicine in America. Instead, I argue that such computational thinking and automation are in line with and yet reformulating the relationship between biomedical and informatics. American biomedicine is not being *intervened upon* but is the ground upon which a specific kind of informatics is made possible. Expressed through the voices of informaticians, BMI "systems" tend to inform each other, giving rise to rapid new problem-formulation across computerization and human. Following Wittgenstein's notion of humans as Turing's "Machines," we should be reminded that we are witnessing deeply human encounters with very particular limits and problems, but the terms of what limits human and machine as something to be computed remains an open question. This does not suggest that BMI will take the "spirit of eclecticism" in medicine to more a humane or inhumane height. Rather, it suggests a need for further exploration into the imagination of BMI and the futures to which it aspires.

Conclusion: What Kind of BMI Future is Being Imagined through the Figure of Doctor and Patient?

The futures that emerge from the pages of *JAMIA* focus on two figures: doctors and patients. The possibility of what doctors will become as decision-makers and the potentiality of patients as sites of diagnostic and therapeutic order are foundations upon which BMI imaginaries of value are situated in biomedicine.

Earlier, I pointed-out that computerized decision support tools—information systems that associate clinical findings and research to points of care—emerged *just in time* to cure an apparent cognitive lack among doctors. This relationship between cognitive stress and mental inadequacy in the presence of powerful correlative and intelligent informatics casts the role of physician as requiring *decision tools* to remedy gaps in medical reasoning. In framing this figure of cognitive lack, doctors are out of step with the time demands of contemporary medical judgment. Patients require acute care immediately. However, if we take a small step back, a medical decision has always had a degree of lack, lack of information, lack of certainty, lack of time to deliver an important therapy or life-saving surgical intervention. Among physicians' lack in the form of assembling a proper course of diagnosis and treatment, spaces in which the art of medicine could unfold have always been present. However, in an era of BMI, such lack has required a different image of the physician space-time. Here non-human forms of assistance, "always on" databases and quality assurance benchmarks instantly delivered to networked devices amplify this image of human cognitive lack. The physician is an operator of information prostheses.

This figure of physician-operator embedded in informatics prosthetics always supplementing her lagging cognitive performance functions in a shifting domain of uncertainty. What this means is that the reduction of uncertainty and risk in medical decisions is shifted from physician (human) to distributed intelligence (non-human algorithms and data analytics). The causal turns to the correlative and powerfully computational.

As part of this BMI future, the patient has become a *site of delivery* that impinges upon the notion of the patient as a site of care. For the moment, let us leave the idea of "delivery" open to both medical and non-medical uses. As a *site*, the functional aspects of the patient come to the fore: demographics, primary and secondary insurance coverage, tissue data banking, medical history, lab tests, physician examinations, behavioral health records, payment histories, next of kin, genetic profile and predispositions, and health targets. As a site, the patient is codified. The "site" here has been programmed among transactions financial and therapeutic in origin. Further, the *delivery* of care continues flowing to the so-called site with a kind of momentum and goal-directedness that is efficient. Crudely put, the patient as a site of delivery is the epicenter of the most efficient, intelligent, correlative, and information-rich human and non-human agencies that biomedicine has to offer. In this scenario, we can imagine that the delivery "site" and the "patient" may part ways: they may be unlinked, but the "site" lives-on and continues receiving deliveries of insurance charges, expert opinion, and research. The patient as a site of delivery has been an occupant or, more accurately, a tenant in a particular location of biomedical informatics. When the patient is cured or deceased, the site's functional aspects live-on to serve other functions and futures. And as a tenant, the patient has all the rights of one who rents but does not own the care nor the information compiled and aggregated that has amounted to care. The patient is part of a wider circulation and ontology that place computerized data as an asset worthy of preserving and transacting while the human body and patient are distributed via archivable biomaterials or potentially rendered beyond use, *decommissioned*, as is said in IT. This future figure of the patient can and may often receive excellent care from a physician or many physicians and specialists and may have added control over chronic pains and conditions; however, as a site of delivery in an informatics world, the patient's agency has indeed become secondary to BMI uses, maintenance, updates, and biological augmentation. "Life" has been given-over to the longevities of computerized medical data.

I wish to return to two ideas that Shortliffe and Friedman set forth in *JAMIA*: we should not project the future of biomedicine from our current knowledge and technologies, and we cannot properly envision a science of BMI without a continual search for its value in the everyday lives of patients and doctors. This view suggests that futures are being shaped but not determined along the paradigmatic idea of information as a form of biomedical and social order. To mistakenly project from current informatics, we as anthropologists may forget the ethical ground upon which doctors and patients encounter each other and exchange insights, identify disease, and share emotions—all for the purpose of healing the patient. What this future-everyday ground points-to is a new level of complexity in examining non-human biomedicine in which data models and their attendant massive data correlations move across larger and larger infrastructures of digitalized medical knowledge. BMI as *a* science should instead be called *practices of science* within an expanding field that increasingly resembles changing disciplinary linkages rather than disciplinary enclosures. BMI pursues genomic and biomedical sites of patients and diseases and cognitive representations of doctors as decision-based operators. And herein lies an anthropological puzzle that I wish to explore in my following research: to examine BMI imagination and its explicit and implicit implemented effects upon doctors as operators, patients as sites, and informaticians as technicians of "new" medicine in a world of expanding computerized data.

II. Savage Mind In The Modern: Culture, Cybernetics, And Information Theory

> Society is, by itself and as a whole, a very large machine for establishing communication on many different levels.
> (Claude Lévi-Strauss, *An Appraisal of Anthropology Today*)

> Lévi-Strauss has made for himself…an infernal culture machine. It annuls history, reduces sentiment to a shadow of the intellect, and replaces the particular minds of particular savages in particular jungles with the Savage Mind immanent in us all. (Clifford Geertz, *The Interpretation of Culture*)

Introduction: Lévi-Strauss and Geertz Debate **Mind**

In this Chapter, I reflect upon images of human mind that have not always nested within individual brains or within stable ideas of society. *What* can 'mind' be said to be and *where* has it been imagined to exist? Can it be found in systems, brains, machines, cultures or emergent between persons? These questions are central to my exploration of informatics. I am interested in concepts of mind on-the-run so to speak, mind as it moves through such liminal spaces as the inside of networked computerized systems, between bodies, scientific practices, or as it is found in artificial intelligence. Specifically, my goal is to open-up the intellectual passion and anxiety brought-on by the rise of informatics and attendant imaginaries that circle around the idea of *savage mind.* As an anthropological concept and object, this figuration provides a route to reflect upon modern ideas of system complexity, computerization, indigenous, and human forms of thinking that taken together can render-up a particular moment when anthropology and the foundational concepts of the information and cybernetic sciences were taking form. I take Lévi-Strauss' idea of mental capacity and corporeality into contemporary forms of computerization.

Lévi-Strauss and Clifford Geertz argued about such unsettled concepts of body and mind decades ago; and building on the exchange of their ideas, I re-explore how anthropology has come to terms with and resisted specific sets of ideas circulating in an era in which informatics has been promising to transform the linkages of human mind and body, cognition and computerized systems. *Savage mind* is an idea pointing to indigenous and synthetic forms of thinking in contemporary tension with how mind was framed as a uniquely human object. Theorizing a certain kind of mind allowed for a certain kind of anthropology to be acted upon and flourish as a field.

When we begin to open-up *savage mind*, we find a site for human mental qualities against an assumed threat from theories applied to thinking with non-human machines and mechanisms. *Savage mind* was not an actual human mind, but I argue a conceptual rallying-point for a tension between human and non-human-centered anthropology as new forms of information and communication technologies were coming to the fore. Geertz's attack on Lévi-Strauss focused on what he sometimes called the *Cerebral Savage* and Lévi-Strauss' larger project of anthropological structuralism so as to turn-back information theory and cybernetics, exposing them as stultifying influences upon anthropological thinking and practice. An "infernal culture machine" represented scientific shifts in cognition and a potentially hellish (infernal) view of a world populated by thinking machines. By turning away these threats, the discipline of anthropology would be preserved and the anthropologist would be free to interpret her findings creatively and scientifically. However, I believe a deeper perceived threat to the discipline of anthropology was at work: the routinization of the anthropological imagination by mathematical and computational forms. Instead of looking for the potential contributions of cybernetics and information theory to anthropological forms of knowledge, Geertz and his followers placed computational forms of thinking at odds with public expressions of mind. Ironically, the threat that Geertz feared by thinking machines has caused his own project of interpretative semiotics to fall into stale territory. The machine that seemed to encroach upon the anthropological imagination has flourished or has become many different interpretations of machine-life, requiring anthropologists to engage in some reverse engineering to discover its value.

On the Lévi-Straussian side of the debate, mind was seen to be universal, a fundamental aspect of human forms of mental life and by extension functionally universal—a claim that biomedicine and neuroscience has repeatedly made. On the Geertzian side of the debate, mind was seen to be irreducible and located in shifting signs and symbols of everyday life—a clam that literary representatives have repeatedly made. This tension of universal mental mechanism and irreducibility of human forms of mind still runs through theories that impinge upon the boundaries of artificial and human thought. Ideas of functional mental machines and human irreducibilities are woven throughout the entirety of their debate.

In the ferment of 1950-1970's information sciences, Lévi-Strauss asked questions about the underlying logics of native behavior and thought that drew from wider scientific ideas: are "all forms of social life…substantially of the same nature…do they consist of systems of behavior that represent the projection, on the level of conscious and socialized thought, of universal laws which regulate the unconscious activities of the mind (1963:59)?" Here, structural anthropology with its emphasis on systems of behavior and expression seemed to diminish the freedom of individuals in favor of unconscious laws that were representative of the universal human attribute of acquiring and creating specific linguistic forms. This picture of mind appeared at the same time both localized and outside of conscious thought. Mind could be construed as a mere functional mechanism, a kind of universal language machine immanent in us all, as Geertz persistently complained. But what species of "machine" was Geertz defending anthropology against?

Lévi-Strauss and Geertz had very different ideas of what was meant by "machine." Specifically for Lévi-Strauss, such machines were *coded* at the deepest levels of mental function. What this implied was that Lévi-Strauss was drawing from information and cybernetic theories to suggest highly flexible and complex codification mechanisms behind neurological brain function and cultural forms. Politically, he was also suggesting a cybernetic analogue in organizational and political systems. This form of mind found in Lévi-Straussian cultural structuralism was a search for a type of intelligence that was an *indirect outcome* of humans moving among, and through, the behavior of large-scale systems, systems that human was bound-up in creating and that held potentiality for exceeding human. For Lévi-Strauss, "machine' meant more than the mechanization behind mental and emotional life: it was a search for complexity in human and non-human relations. For Geertz, "machine" meant the reduction of interpretative (human) engagement with anthropological objects. Machine was a kind of non-life that could reduce anthropologists' deep reading of the world's everyday signs and symbols.

Lévi-Strauss was fashioning an anthropology that was informed by, but not determined by, computational, system, and information theories of the day. The machines he focused upon were derived from the challenges of *control engineering* and *communications engineering* brought together under the ideas of the *message* and *feedback* (Mindell 2002). These were ideas regarding early systems of sending messages and calculating human interaction as "feedback" that could be learned and reused, first developed for military and corporate uses. Here, mind from a structuralist perspective could be construed as being composed of physical laws sharing a kinship with mathematical forms of analysis that cybernetics founder Norbert Wiener had championed as "control systems." Cyberneticists, however, did not view "control" as coercive and were against the militaristic and corporate origins this term implied. Cybernetic mechanisms of control *were open systems that were deeply informational and human* but under-appreciated in their scope and agentic potentiality. Structuralism took clues from *The Mathematical Theory of Communication* by Claude Shannon and Warren Weaver (1949). Communications theory proposed new quantifications of "information" into *bits*. Lévi-Strauss was echoing such theories on an anthropological register and cleverly refashioning them by bringing them in contact with explorations of Native American myth, kinship, and linguistic forms as a central call for anthropology to exceed traditional disciplinary boundaries and discover underlying orders of local culture.

Geertz took issue with the idea of discovering local cultures based on physics of information and underlying order. He bristled at any view of indigenous life or any form of life as mathematically imaginable and law-governed. Cybernetic imagination that gave creative impetus to modern systems and communication theory stripped away the excitement of fieldwork conducted in the richness of local public settings. For Geertz, the anthropological journey was a passage through unpredictability. The ethnographic encounter was irreducible and could not be boiled-down to physical laws or bits. Anthropologists sought different "messages" scrawled across the celebrations and speech acts of everyday life. Geertzian ethnography was at odds with a world of automated messages and thinking machines. From my perspective, the problem imagined here was not individual human agency swept-up in vast systemic and computerized logics but the mind of the ethnographer negotiating intelligent agents that had potentiality to act and displace the free play of interpretative inventiveness of the anthropologist. The ethnographer had to descend into an everyday that was always being found, took-up again, and contested by local inhabitants. Before entering into the field, anthropologists were to leave laws at the door and step into meaning-making.

American anthropology's relationship to and denial of the cybernetic and cognitive sciences has informed the field's ways of speaking and writing about consciousness, brain, culture, complex systems, and artificial intelligence in late modernity. The denial goes back a century to Durkheim's suspicion of psychology's being able to properly account for social order. From Durkheim's perspective, particular minds were a vehicle of society at large: "It is society who speaks through the mouths of those who affirm… [mental representations] in our presence." An individual voice "has an accent which that of one alone could never have" (1915:208). The voice of all could be heard *distinctly* in the individual. We are inescapably social creatures echoing collectivity.

Geertz put this puzzling through, and denial of such cybernetic-cognitive terms, as a struggle with forms of haunting and darkness. He characterized this problem as "ill-framed or elided doubled questions," the mental foundations of culture and the cultural foundations of mind preoccupying anthropology "since its inception" (2000:204). In reaching for anthropological clues where such questions could be properly represented, he turned to the poetry of Richard Wilbur:

> The mind is like a bat. Precisely. Save.
> That in the very happiest intellection
> A graceful error may correct the cave. (2000:215)

Through his encounter with communication theory and cybernetics, Geertz recoiled at Lévi-Straussian modes of explanation that suggested mind possesses an underlying logic that was the same everywhere (1983). Such a mind-machine was a bat bouncing around in the darkness of the human skull without the grace of textual liveliness to lift mind into public knowing and without human culture to lift it to its happiest intellection.

Geertz: An onslaught of incommersurabilities. To have a worked-out concept of mind in post-war American anthropology was a right of passage. The Homo sapiens mind was a central anthropological object. In this context, Geertz called such puzzling through, during the encroachment of informatics, an "onslaught" of "grand incommersurabilities" (2000:206).

Let's take this *onslaught* as a certain kind of space of conceptualization. From the Lévi-Straussian perspective, human consciousness circulated through myth and brain function in ways that had the potential to reflect broad operations of the mind ([1949]1969). From the Geertzian perspective, mind was ethnographically a black box in which meanings could be teased-out only by observing "mere recognizable ways of doing recognizable things" (1983:14). Writing during a period that was late in Lévi-Strauss' career but early in Geertz's, cyberneticist Norbert Wiener had a different vision of mind that went beyond individual cortical regions to broader operations embedded within institutional systems. It is of little consequence whether the "raw material" of mind "is flesh and blood" or that "we entrust our decisions to machines of metal, or to those machines of flesh and blood which are bureaus and vast laboratories and armies and corporations" (1954:185). Wiener's cybernetic theory was cited by both Lévi-Strauss and Geertz, but for very different purposes. Expanding on ideas of system as vast and potentially explainable, Lévi-Strauss viewed Wiener as an ally in how mind was constituted socially and within certain logical operations. Expanding on ideas of systems that may diminish individual freedom, Geertz viewed cybernetics as a product of modern systems of automation and therefore diminishing human mind. At the dawning of artificial intelligence, Wiener, a brilliant public intellectual and mathematician, concerned both Lévi-Strauss and Geertz with the idea that intelligence and therefore mind may not always be human-given but could be built out of synthetic forms. As a conception and material form, mind could be exploited. Concepts of mind were expanding beyond rather than being limited to individual brains. The way people thought and what human equipment exclusively constituted thinking were heading into contentious territory.

In order to understand the nature of these tensions, we should clear-up a few theoretical matters. At the time of Geertz's writing, the concept of human mind developed within a single body no long held-up after Wittgenstein's attack on private language. In a close reading of the later Wittgenstein, mind was not "in here." The skull and individual self were not containers for thinking. Mind was publicly inflected and constituted. Mind and its origins were a deeply cultural concept. Wittgenstein's fundamental insight on the nature of thinking derived from cultural criteria and language games that marked the human subject's pains and entry into the human world. Put another way, such private language was built upon puzzling through what we find as "people's language" versus private "expression of sensation" (2007). Such a notion of mind directed by the Wittgenstein of *The Investigations* allowed Geertz to pull mind out of "stoppered fly-bottles" and move it into the "public square where one could look at it" (2000:xii).

Using Wittgenstein, Geertz based his idea on mind on *the publicness of thought*. He was interested in people's making sense of a peopled world out in the open, in the street, in groups, and celebrations. Mind was out *there* and situated locally. On another level, such *local mind* was ultimately unknowable, opaque to ethnography and yet could be touched here and there interpretatively. To this point, Geertz appointed himself the leader of an interpretative program that regarded mind as residing in the complex play of recognizable and meaningful signs in the alleys and ceremonies of what people do, how they act, what they speak, and how they behave. Mind was to be rescued from a physics that tied human consciousness to information theory and functional darkness of brains everywhere the same. Local mind was to be freed and discoverable in the semiotics of culture, or through ways he sometimes comically stated in "public, like a burlesqued wink or a mock sheep raid." Mind did "not exist in someone's head; though unphysical, it [was] not an occult entity" although difficult to pin down (1973:10). Although unknowable *local mind*, figuring out the relationship of brains and local worlds, was a high-stakes conceptual project that he admitted had been set in full motion.

From Geertz's point of view, thought existed *between* others, in the world "culturally coded and historically constructed" (1973:14). This in-betweeness of mind could be best captured through reading signs read-off the everyday actions of others. Geertz would claim his idea of mind was found in an ethnographic attentiveness to a "recurring cycle of terms—symbol, meaning, conception, form, text… culture"—that the anthropologist reconstructed accounts "of the imaginative make-up of a society (1983:5)." The ethnographer sought-out "wanderings" while putting into perspective that what people think and imagine looked a lot like "how things stand in the world." These imaginings were not grand or large scale but found through pursuing "smaller sideroads" (1983:8).

However, Geertz was not establishing a diminutive form of anthropology. Pursuing smaller sideroads meant to produce big interpretative returns. Moving beyond "Cerebral Savage" as a "quaint…academic curiosity," ethnographers had to set-out to engage minds as they were "directly encountered" not in mathematical logics or structural linguistics but in the local and ultimately unknowable "clattering variousness of…life" (1983:5). Geertz's effort to dismantle Lévi-Strauss' idea of the *savage mind* opened the door for a semiotic free-play of analysis across literature, economics, psychoanalysis, human and biological sciences as social activities (1983). Mind here modulated back and forth between cataloguers, journalists and ethnographers, those serving as both subjects and objects of textual understandings. What this meant for ethnographers was that interpretations of such variety kept open the idea of human thought that was socially ordered and embedded—object-transformative (1973). Ethnographers received local ways of thinking and at the same time interpreting cross-perceptions between people in the affective tone that they express collectively (1973). Upon this, mind was *distributed* and *outside* and made visible through the games people played in the symbolic wild, living-out everyday encounters in and with the local. The ethnographic lens applied here—"thick description"—brought clarity to the "lifeline of the world" (1973).

Geertz was attempting to break with limits of causal explanation and mathematical formulation; but in doing so, he left the concept of the mind of others in semiotics of free play. Scientific reductionism had no place in his interpretative enterprise. Human mind was irreducible, a creative object for ethnography. The everyday world was steeped in being and phenomenological; that is, the mind could not be decoded, as it were. The experience of being could not fit into "stoppered fly-bottles." In this way, each human was a producer of signs "*en plein air*, out in the world where the action is; and it is in that trafficking that meaning is made" (2010:225). The argument here, as Geertz and his followers saw it, was to pull anthropology out of the Lévi-Straussian explanatory grip "of experimental mind reading" and reposition it towards the social nature of thought in "its natural habitat…the houseyard, the marketplace, and the town square" (1973:357,45). Meaning required the bustling of crowds and the expressiveness of people. It required anthropologists to turn-away from individual brains and impersonal systems and turn towards the celebratory and action-oriented nature of the local.

Why should we care about Geertz's take on structuralism and the savage mind? Lévi-Strauss attempted to lay-out a scientific project of mind at a moment when cybernetic, information, and communication theories were just beginning to be applied. Geertz attempted to lay-out a project of mind that could not be codified and formulated into a form of anthropological physics. But in order to locate and properly investigate the pivotal influence of informatics upon the field of anthropology, we turn here to Lévi-Strauss' original figuration of the *savage mind*.

Turning to Lévi-Strauss' La Pensee Sauvage, Scientific Objectivity and Colonialism. *La Pensee Sauvage* ('The Savage Mind') presented a problem: Western scientific inquiry "overestimate[d] the objective orientation of its thought and this tendency [was] never absent (1966:3). Western scientific claims of objectivity were biased at best and the *savage mind* presented a conceptual challenge to reflect upon western objectivity not as a given but as it may be reimagined applied to indigenous mental life. Scientific rationality here was making persistent inroads into the nature of human consciousness. Minds of distant others were bundled in terms "natural," "mythical," "primitive," "savage," but also "exact," “meticulous,” and “sustained” (1966). By encouraging a skeptical outlook upon western scientific objectivity when exported to locales in which different logics of thinking held cosmological prominence, the *savage mind* served as conceptual territory to investigate the problem that “every [scientific] advance” created new anthropological stakes and risks that were “unending” (1991).

Savage mind did not emerge from panoramic Brazilian forest mists or distant parrot calls but was made visible “only through very recent inventions: telecommunications, computers and electron microscopes” (1966:268). What this means was that scientific modernity was deployed to discover the savage mind, and perhaps ironically this same science was also responsible for the objectification of this very object (1966). Here, structuralism was not only the scientific search for the code of culture that underlined native ways of thought but also was an exploration into a “dense intelligibility” that drew from “the same nature *as* the world” (1992). Dense intelligibility was *of* the world of technologies and binary oppositions. Such intelligibilities were being cast into ways of seeing such objects as indigenous minds, Brazilian rainforests, urban decay, computerization, artistic invention. These objects of modernity were being transformed as they were being made anthropologically visible. To take this further, we can say that anthropology, although built upon earlier western scientific traditions, came into its own as an object of modernity. It is a driver of the decay, computerization, and indigenous modernity that *savage mind* attempted to crystallize and predict.

In our case and as an anthropological object, *savage mind* was both being made visible by science and being made historical by colonialism, a kind of museum piece in formation as it was being praised for its *bricolage ingeniousness* and *logics of science of the* *concrete.* The *savage mind* was also a by-product of colonialism and paradoxically a counter-point to the Western scientific imagination. Its totemic and symbolic objects were disappearing as mental mechanism was made visible by modern scientific perspectives. By pouring over its dissembled parts and trying to piece them into a systemic whole after colonial encounters, Lévi-Strauss saw the primitive mind in a state of modernity comprised of fragments (1995). Savage mind was not of a whole but discovered in pieces and drawn from what science allowed us to see and frame. In other words, the savage mind as a conception was being constructed as its traces were detected, reassembled, and scattered among local habitats and customs.

In piecing-together such a mind and making it understandable to modern sensibilities, Lévi-Strauss mobilized earlier versions of games, automated procedures, and binaries. Such minds, according to Lévi-Strauss, unconsciously operated according to scripts and mathematical rules. He saw no contradiction here. The *bricoleur's* working with things at hand—wood, metal, and rock—also represented underlying *logics* at work that could be revealed through modern procedural informatics: *scripts, mathematical demonstrations,* and *oppositional schematics.* Envisioning savage mind, one pictured living tableaus, automations, and unfolding games. Picturing information theory of the time, one pictured mathematical procedures, electronic circuits, little machines, and unfolding networks.

If savage mind was invented in modernism's ruins of environmental and cultural destruction and science's very recent inventions, I am suggesting that this particular kind of object was not "natural" or "savage" at all. The *mind* that Lévi-Strauss found in the archives on Native American customs, the Brazilian forest, or the Burmese frontier was not "wild" or "indigenous" but a site of broken modernity and scientific speculation. Lévi-Strauss was fully aware of this object of thinking that savage mind represented. The trampled-upon and already-modified scientific conception of mind was precisely what he sought. The mind here was no mind inside the skulls of so-called primitive or *people without history* but a route of investigation.

The kinds of minds being readied for colonial extinction were being remade through information and linguistic communication theories. In other words, our judgments of other minds are a product of our values and can never serve as absolute judgments. As a conception, savage mind was always suggesting a modern state of transition, uncertainty, entropy, and projection. To this point, Lévi-Strauss was, I believe, quite aware that savage mind served as a reflexive object from which to view the ravages and transformations of indigenous forms of life by modernity. On another level, this site of mind served as a reflexive object for examining the risks of modern scientific rationality, a point that Geertz seemed to miss.

Idea of Mind as Reflexive Site of the Modern: Cultural Modernism, "Entropology," and Colonialism

The idea of *savage mind in the modern* was informed by other domains, namely art. Associations of *bricolage* and native logics were associated with "cheap junk" (1992). Such junk was not an image of filth or unusable but suited for artistic and anthropological invention. Lévi-Strauss' image of junk was the discards, the traces of our world that could be reexamined and reapplied. He cited the filmic works of Georges Melies, known as the father of special effects, as one example of using 'stuff' at-hand to meticulously build spectacular miniature stage-sets that quivered and fired cannons into blinking moons and the debris of stars with disappearing faces. Drawing upon the surrealism of Breton and the modernity of mid-century America, the *savage mind* was described here in terms of objects reassembled and found close-by. Such a mind was never natural or originating but rather made visible by modern forms of visual automation, scripts, and collage/editing techniques. In the 1920s, the magic of Melie's special effects and the new modes of photographic representation spoke to fragments projected and continuous—images of a filmic apparatus. Collage and early special effects shared a kinship with Lévi-Strauss' savage mind in other ways as well. Early cinematic expressions were an outgrowth of spectacular entertainment based on earlier forms of making still objects perform and animate. These illusionists, as they were called, attempted to startle the public with feats of disappearance and automatic responses that took on seemingly human characteristics.

The writings of surrealist Raymond Roussel represented an idea of mind confronting psychic fragments of "unexpected display." In Roussel's mock anthropological encounter *Impressions of Africa*, he wrote that the living and animated existed side-by-side "blocks quiver[ing]" and giving form to "tentacle like an elephant's trunk[s]" and "suction-cupped branches began spinning like the spokes of the wheel"—all of this emerging from a "curious specimen" that was phosphorescent with a beating human heart within a living sponge that displayed a circulatory system. The mind of the writer-pseudo-anthropologist was to open-up an "Africa" that was no place but an *exotic within* filled with automata, scripted emergence, mechanistic responses, and fusions of human and non-human forms of life (2011). Andre Breton captured this obsessive display between machines and human affect very well. In his first draft of *The Surrealist Manifesto*, he claimed that the surrealist was "pure psychic automatism by means of which one intends to express …. "the actual functioning of thought" (1924). The surrealists had to give themselves up to an idea that mind was a "silent receptacle… filled with echoes, modest recording instruments" (1924). Roussel was unafraid of territory that Lévi-Strauss was familiar with: that machine-like behavior could be explored at the deepest levels of visual representation and subjectivity.

At the time, Lévi-Strauss' savage mind was a meditation on modernization thrown into doubt, a form of *dense intelligibility*, as he stated, that began to reveal its tattered effects and creative automations. From my perspective and in the shadow of colonialism, mathematical and computational forms were pressing-in on anthropology; notions of the psyche and surrealist production were good indicators (1963). It was art that could embrace such contradiction. Cultural modernism attempted to synthesize together such automation and decay. For example, through the work of Beethoven, Lévi-Strauss suggested that we consider both "algorithms" in creating a work of art and in establishing "feedback" among brain, sensory mechanisms, and "nerve centers" (1997:87). The work of art could be considered the result of feedback from the cerebral schema projected onto the work, thereby fusing thought object and sense impression (1997). Highly suggestible, the mind of the artist and savage were constructs of an overexcited civilization, sites for the puzzling-through of algorithms, neurological process, repetitions, and programmatic forms that lay behind the surface of thinking. Lévi-Strauss was clear that the islands of native others were shrinking by modernity's encroachment and the "universe of instruments" were beginning to produce different kinds of creative returns and anthropological objects (1966:17).

Seen from this perspective, the image of Lévi-Strauss as anthropologist who appreciated startling juxtapositions was very much of a scientific-cultural moment. Early-century modernism of the Italian futurists or bold expressions of the poet Guillaume Apollinaire, who first coined the term "surrealism," was cooling into another kind of post-war modernism that was less striking in its juxtapositions and use of the unconscious as a source of artistic inspiration and imagery. Artistic representation was settling into formal, unified, and systemic characterizations. The settling of modernism was fitting for the white-cubed cities of le Corbusier and the "space age" of aeronautic systems that propelled us upward through the wonders of engineering. This was the time of anonymous corporate executive, modular furniture and human imagination linked to disembodied systems. Lévi-Strauss' footprint was being mirrored across the arts and sciences. His mix of rational order, mystical journey, and binary logic was part of a particular cultural and social landscape exploring a world of changing objects and impersonal systems (Wilcken 2010).

He applied structural logics (binary algorithms) to the Oedipus myth, suggesting we avoid interpreting mythic structures literally or offer specialized explanation (1963). He suggested instead that we explore myth through a certain kind of *technical* "demonstration" or *model.* His example of such a demonstration was the Oedipus myth. When proposing the use of mathematical relations to understand the trials of Oedipus, Lévi-Strauss was not deploying barren mathematical form but exploring a *different form of making explanation visible.* His form of explanation was based on rendering objects as concise and visible as possible by referring to what was at hand, in the street, the everyday. As an example he describes a toy in the hand of "the street peddler, whose aim [was] not to achieve a concrete result, but to explain, as succinctly as possible, the functioning of the mechanical toy which he [was] trying to sell to the onlookers" (1966:213). Taking from this both function and simplicity, here, Lévi-Strauss imagined not only a mechanical toy but also how to bring scripts down to the everyday, visible, and replicable. If the peddler's toy could serve as a type of scientific-technical explanation derived from an everyday procedure, it could be applied endlessly and simply, like a well-written computerized algorithm. The movement of the mechanical toy could be expressed as a simple but powerful formula that could be widely applied. Such an object of wind-up drum beats and head-bobs held in the hand of a child and in this holding and child-like display could serve to highlight kinship structures or Oedipus' relationship to blood relations.

I believe Lévi-Strauss' point was not that *this* or *that* model was correct for understanding of the world of myth. It mattered that simplicity and broad applicability were sought-after. The goal was to ethnographically and scientifically locate points when simplicity (scripts, drum beats, mechanics) gave rise to complexity (human-neural, cultural, mythic forms). He was against the idea that simplicity breeds simplicity, a Cartesian dead-end. Lévi-Strauss conjured an image in the peddler's toy of a simple model that does not produce simplistic results but rather, as computer scientist Steven Wolfram has noted, "despite the simplicity of [software] rules" such simplicity can produce behavior that was deeply complex" (2002:2). Automata or basic programmed rules can give rise to and provide a way to understand complexity not predictable in advance. In attempting to examine and locate models that opened up complexity, Lévi-Strauss had to navigate inner logics behind savage mind, bringing one to a modernist juncture between art, science, and colonialism.

Entropology: problems of mind and colonialism. It could be argued that 'the Savage Mind' did not represent an epistemic appearance like a scientific proof but rather a lifting of anthropology to what surrealist founder Breton aspired to—to see the world fresh in "the fleeting, the extreme facility of everything" (1924). The anthropological imagination was not far from the surrealistic poet who "knows no bounds" and goes about her work in the field "in strict accordance with the laws of an arbitrary utility" (1924). According to Lévi-Strauss, this anthropological effort to ground the fleeting and binary left the anthropologist in a position of being colonized “on behalf of a silent world of which we have become agents” (1992:380). From a Lévi-Straussian perspective, the anthropologist was the witness, colonizer, colonized, and messenger of new agentic capacities that circulated through the modern world. Ideas of the “savage,” “natural,” or “primitive” were but pictures of ourselves, our minds, projected-out among others in modern systems of disintegration and upheaval. Lévi-Strauss consistently expressed this idea in various ways. Anthropology had to admit to the “strange phenomenon” that it has advanced as a field while “societies tend to disappear” and lose their “distinctive features” (1963:347). Anthropology was part of systemic breakdown in the urban centers and society that it observed and conducted research.

When Lévi-Strauss arrived in Sao Paulo in the 1930’s and New York and Chicago in the 1940s, he discovered such an “extreme facility” not in poetic reflection but in the way people lived. In the brief span of several decades, these urban centers already showed “signs of decrepitude” as if they shared a life span with humans. They lacked “ten centuries of history” but that was not what bothered Lévi-Strauss. They were together prematurely aged, in constant transition, fleeting, and lonely places. Back alleys and industrial districts were left falling apart. He described “brick-built warehouses in deserted streets, where there was only the wind to sweep away the rubbish” (1992:97). The search for indigenous mental life in wake of colonialism and rapid modernization was complicated by mismatched images of rapid growth, breakdown, and debris.

Locating the savage mind became more problematic when considered from another perspective: western scientific consciousness missed its own footprints upon a world already in the entropy of modernization. In order to capture the savage mind upon the trash-heap of colonialism, Lévi-Strauss suggested a strategy of “progressive dilating” cultural meanings to the very moment of explosion (1992). The anthropologist was at the modern threshold to understand "the transient efflorescence of a creation" and destruction. The study of man was at once creative and tangentially objective. The pursuit of the human was a type of journey through "ever greater inertia" out of which "creations of…human mind" were to merge in overall chaos of a modern "complex mechanism." *Human* as a category and particularly *mind* teetered between discovery and extinction. According to Lévi-Strauss, as a race, humans were only temporary visitors in a play of a cybernetic processes of information and entropic origin, "every verbal exchange, every line printed, establishes communication between people, thus creating an evenness of level, where before there was an information gaps and consequently a greater degree of organization" (1992). I believe Lévi-Strauss was suggesting that the anthropologist occupied a specific vantage point as "entropology." He characterized modern anthropology as "entropology," a study of systems "of the highest manifestations of…process of disintegration" (1992).

This transient and shipwrecked image of an anthropologist interested in social breakdown and communication forms was very suggestive. This image of the "entropologist" could be a critique of picking through ruins of a world its own Western rationality has destroyed or arrived too late to properly understand. It could be a call to a new level of analysis that suggested our categories of human and mind were outmoded and sorely in need of revision. It could be an image of a collective mental projection upon "people without history." It could be an image that the term *entropy* implies, of energetic decline into chaos and then movement towards a state of equilibrium as in the Second Law of Thermodynamics. He positioned himself as a kind of Mark Twain, arriving upon disappearing mental landscapes and forms of life that would become museum pieces or relics. He was warning and provoking. As a figure, the "entropologist" is a person journeying-forth to make visible objects among traces left by others seeking others—journalists, media figures, chroniclers, natives, scientists, and professional tourists (1992).

Lévi-Strauss has brought together sciences of his day as precursor to today's clusters of such multidisciplinary scientific fields as decision theory, cognitive neuroscience, anthropology of science and technology, cognitive anthropology, artificial intelligence, biomedical informatics, psychoanalysis, and organizational psychology. The mathematical theory of patterns (Blauberg 1976) and self-organizing systems starting with the systems theory of von Bertalanffy (1969) were redeployed in his work, suggesting ways of conceptualizing societies in relationship to complex systems of meaning, system disintegration, rapid change, and mental life.

In Lévi-Strauss' renderings, human mind was universally structured, not determined. Mind was situated in history, place, and person as well as the unending problems (and objects) scientific knowledge generated. The structures of human mind were the same everywhere. Similar limits were embedded in mind as emergent properties of brain function. However, the systems, circumstances, and problems presented to the mind were arranged in "extraordinarily diverse forms." For each societal member, the "machinery [was] the same…not the input and output" (1991:124). Here in theorizing on mind and society, Lévi-Strauss was aware of the dangers of structuralist overreaching. The category "explanatory" that lurked behind the intellectual brand *structuralism* let loose all kinds of scientific proclamations made in its name. Nonetheless, structuralism was to become, in the Geertzian frame, the enemy of interpreting mind from local forms of life that were not reducible to systems or functions held by structuralist anthropologists shuffling through technological wreckages of globalism.

Modeling mental life alongside and through communication and information systems has invited others to take "savage thought" to task. On this point, Lévi-Strauss has acted as a conceptual space for generations of scholars to redefine and forge their own theoretical stances on mind, technology, and symbolic form. Anthropology still appears somewhat closed to this multi-disciplinary world of scientific, cybernetic, and information theory of mind—a field of inquiry that Lévi-Strauss fought hard to hold-open in his own time and if he were here today, probably would be deeply engaged in.

Notes on the Early Influence of Artificial Intelligence and Cybernetics

Why do certain experimental objects become the stuff of scientific curiosity and later settled scientific proof? How do barely-formed objects in dispute become unproblematic and formative scientific fact? In the case of the cognitive sciences and information theory of the 1960s and 1970s, a period of growth in the direction of models of mind that could be considered artificially engineerable, conceptions of human mind were becoming unsettled. Minds that contained analogous messaging properties embedded in larger biological systems were becoming possible scientific reality. Of the period, notions of "input-output" of Behaviorism was giving way to a more nuanced understanding of neural circuits and higher-order cognition based on large-scale and complex systems.

The first artificial intelligence department was being built at MIT under the guidance of Marvin Minksy. In this department, a reordering of human and non-human intelligence brought together information theory, stochastic modeling, cybernetics, and computer visualization. Academic research centers and post-war contributors to the military effort were the first on the theoretical scene. Such cross-linked engineering imaginaries pointed, at this time, to cybernetics as a major influence. Any thing and any human could be considered part of a system. Teeming insects, automated factories, the systemic and biologically-informed image of economic behavior were all considered, from a cybernetic perspective, engineerable.

Cybernetics at the time was a multidisciplinary area that included information and communication theory, psychology, urban planning, and organizational management sciences, to name a few. It took 'mind' into a general theory outside individual brains into wider institutional and systemic application. The conceptual frameworks of *information*, *message*, *noise*, *feedback*, and information *latency* have all emerged from cybernetics and influenced Lévi-Strauss' notions of the nature and functions of mind and cognition. The idea of cognition in the savage mind has continued to "suggest later developments in the human sciences, namely the cognitive revolution" (Sperber 2008). This disciplinary field has asked psychology to refocus on the examination of mental mechanisms, a development Lévi-Strauss might have applauded. As Dan Sperber, a former student of Lévi-Strauss, has stated, his mentor's anthropological analysis of mind embedded in culture has repositioned his work as an early indicator of cognitive investigation (2008). Examinations of mental mechanisms grounded in new technologies, scientific representations, and social relations may provide inroads into structures and potentialities of mind, both human and synthetic.

Cognition could be considered a process of *becoming of mind.* In other words, cognition as an operation also suggested a world of interconnecting processes. According to Alfred North Whitehead, the mind holds it potential precisely because it is not static. As I read it, cognition requires a world of biological, ecological, and human systems of interaction. In this way, cognition is never wholly independent nor inside a body but instead is productive of actions with consequence that give rise to becoming in others.

I tend to agree with anthropologists Maurice Bloch and Rita Astuti that cognitive science has underestimated the role of culture just as anthropology has over-valued it. Anthropology adds to and helps to further explore the boundaries of *Homo sapiens.* This means that anthropology as a study of particular people and location is also committed to theorizing human species behavior. Anthropology has vested interest in understanding cognitive properties and human intentionality. However, there are theoretical differences between cognitive science and anthropology. Mind from a cognitive science perspective is often approached through accumulated knowledge and hypothesis, whereas the anthropologist starts from the other direction—everyday phenomena "in all their complexity and uniqueness" (2012:6). Instead of such differences building-up disciplinary walls, anthropology and cognitive science may benefit by following lines of thinking suggested decades before—the interdisciplinary study of mental mechanism.

Cybernetics: Lively systems and technical potentialities. In attempting to address emerging post-war computerization and cybernetics, philosopher Martin Heidegger was asked, "What takes the place of philosophy now?" He flatly responded, "Cybernetics" (1966:7). Heidegger was not implying that philosophy (or the social sciences for that matter) were dead endeavors or being replaced by cybernetics but rather that the speed of technological change was threatening critical and philosophical reflection. Cybernetics, a nascent science in post-war America, claimed that intelligent communication and information systems would spread worldwide and become a major means for our thinking, expression, and social relations. Heidegger's flat response foresaw technical potentialities challenging the status of human deliberative and critical judgment.

Heidegger's response to cybernetics' replacing philosophy was notable for what it didn't say. In Heidegger's day, cybernetics, a science that had claimed to subsume all the other sciences into communication and information-based systems, was considered totalizing (enframing) technology. I argue that cybernetics was never this kind of totalizing threat. It in fact warned against totalizing and enframing consequences of computerization and large-scale systems. One of the themes of interest for cyberneticians was asking the question *What kind of thing and human can perform mental functions, and how does asking this question open-up possibilities for displacing and revising human agency?* Our notion of mind's being inside the skull and shrouded in representational knowledge was roundly questioned by cybernticists of the era. Cyberneticists such as Norbert Wiener and Stafford Beer imagined that mind was *performative* and not inherently *in me or you.* Mind could be ontologically explored without epistemology, *without knowing what was inside the black box of consciousness*. Mind *as performance* or a kind of performance was a conception that robbed it of metaphysics. This seems to me to be what Geertz was thinking about when he stated that *mind* was *standing in the world.* For cyberneticists, *performance* meant the invention of (mechanical tortoises and homeostatic and biological computers) and attempts to forge objects that could prove, part by part and act by act, the workings of mental life not only on paper (representationally) but through machines (*performatively*). Beers frequently stated that a system is defined by POSIWID (the purpose of a system is what it does). Performance was a creative form of proof in which engineered objects moved, bumped, signaled, broke-down, blinked, and circulated and that cyberneticists where there to take note. Extremely complex action could be broken-down, bit by bit, and acted-out and acted-upon. This ontological theater robbed the exploration of mind of a dualistic division between people and things. Every thing and body could be part of the ontological theater. Philosopher Andrew Pickering puts it very well:

> We are indeed enveloped by lively systems that act and react to our doings, ranging from our fellow humans through plants and animals to machines and inanimate matter, and on can readily reverse the order of this list and say that inanimate matter is itself also enveloped by lively systems, some human but most nonhuman. The world just is that way. (Pickering 2010:20)

Mind was not *inside* or *outside* but discovered through performance, interaction, and kinship with *humans and things.* We were not moving down a scientific road of increasing displacement of human mental life upon highly complex and intelligent software and organization. Cyberneticists did not *march science forward*. Instead, they moved skeptically. By questioning that human may be otherwise, may be part of non-human systems, cybernetics opened the door to human impermanency, as Lévi-Strauss understood—the door to a form of what I will call *modesty*, that "human" is an enduring or robust category of thinking and action. New levels of skepticism were required as science moved towards synthetic intelligence and agency. Engineering brains and minds was not a question among early cyberneticists: it was not an *if* but a *when* proposition. And this "when" caused cyberneticists to pause and reflect on the location of *individual responsibility* when mind was *out there, and in machines*. Norbert Wiener was thoughtful about what synthetic intelligence might be in a world of "machines having brains."

> I have spoken of machines, but not only of machines having brains of brass and thews of iron. When human atoms are knit into an organization in which they are used, not in their full right as responsible human beings, but as cogs and levers and rods, it matters little that their raw material is flesh and blood. *What is used as an element in a machine, is in fact an element in a machine.* Whether we entrust our decisions to machines of metal, or to those of machines of flesh and blood which are bureaus and vast laboratories and

> armies and corporations, we shall never receive the right answers to our questions unless we ask the right questions. The *Monkey's Paw* of skin and bone is quite as deadly as anything cast out of steel and iron. The djinnee which is a unifying figure of speech for a whole corporation is just as fearsome as if it were a glorified conjuring stick. (1954:18)

We have the potential, as flesh and blood machines, to become routinized, a cog and lever of larger organizational mechanisms. Wiener was putting the notion of a *machine* outside the idea of mechanization: any thing and any human can become mechanistic. It was reflexively clear to Wiener that the concept of "machine" was portable across biological, human, and non-biological organization and that he was calling for a new system of value, a new way of assessing the role and potentialities of information. Today through biomedical informatics and the decision sciences and computer engineering that underpin it, you may hear the terms "system," "information," "decision," "organization," and "complexity," and they still carry with them the trace and meaning that cyberneticists gave them at mid century along with computational theories of Alan Turing or von Neumann. Cybernetics has not vanished and runs behind conceptual anxieties that follow.

Wiener was no fan of what he saw as the rise of technocratic and military presence populated by "gadget worshipers," representatives that turned cybernetics against the mind and against society for the sake of free market enterprise (1964)—strangely similar to pronouncements in *Tristes Tropiques*, in which Lévi-Strauss famously wrote that Western modernization may take the "rainbow of human cultures" into the "void created by our frenzy" (1992:414). Wiener writes that we in the grip of the modern world of technological possibility "are shipwrecked passengers" on a condemned planet (1964:40). Such a shipwrecked state of affairs did not mean the end of the world but the end of a certain kind of world. It was also the beginning of an ethical and skeptical perspective across sciences—neuroscience and psychiatry, systems and communications theory and psychology—that were being brought together by the "magic of modern automatization" that could be used to "further personal profit or let loose apocalyptic terrors" (1964:52). In this sense, Wiener, a booster of cybernetics and at the same time a cautious, even dark figure of great brilliance, saw a collision course in the newly popular cybernetics. He foresaw the possibility of the systemic distribution of risk across automated devices heralding new forms of technocratic decision-making and wide-spread effect.

Along with the acceleration of system and communication industries, new demands placed on individual moral responsibility was of great concern to both Wiener and Lévi-Strauss. The juxtapositions of failed technical expertise with industrial risks, psychologies and systemic epidemics that had previously been divided by time and space were being refashioned in late modernity. It was here that Geertz did not fully understand to what extent Lévi-Strauss' ideas represented technical shifts in an era of informatics' applicability to mental representation and function. Michael Fischer has attempted to encapsulate this wider predicament for anthropology: "there is a widespread feeling that social relations, culture, and psychology are being structured in significantly new ways." Terms "post-" or "late-" modern do not adequately refer to this restructuring "but rather refers to the cycles of renewal and decay of modernisms or modernities" (2003).

Conclusion: Homo sapiens and Cybernetic Brain

Against a backdrop of late modernity's renewal and decay, for Geertz the role of culture in neurological development was fundamental. Not only was culture fundamental to mind and its development, but without it the human would be a "wholly mindless and consequently unworkable monstrosity" (1973:68). He characteristically framed important matters with sardonic humor, "Like a cabbage it so much resembles, the *Homo sapiens* brain" would not come into operation outside of culture (1973:68). The human brain was dependent on culture for its function and mental process. Culture was always the ground *for mind to emerge.* Without culture, mind fell back to cabbage-like inertia. No formal investigation of mental mechanisms was valid without culture's being the primary agent in shaping human brains, subjective-objective relations: the shape, complexity, and beauty of human consciousness required human cultural and symbolic form. According to Geertz, the making of mind was fundamentally symbolic and public. Thinking happens outside in the world, and the best evidence of the development and adaptability of mind would be witnessed in shared events among people. Here, mind was made possible outside in speech acts and communal interaction. Political events, intimacies among family and friends, exchanges on busy freeway, or the passage of a loved one—symbolic order was embedded in sentient and human exchange. Our lives ebbed and flowed. Mind was a type of ongoing origin story made possible only between, and with, the music, speech, and sign-producing potentiality of human others.

If Geertz's Homo sapiens brain developed its capacities only because of culture, then cybernetic ideas of the 1960s and '70s were suggesting something different: that brains were performative, mind could emerge from brains being physically set in motion. If the Homo sapiens brain required culture, the cybernetic brain required *action*. Cybernetic mind was made possible by forms of life *expressed through action* systemically ordered through many possible agencies, living and inanimate. As cyberneticist and psychiatrist Ross Ashby described it, "To some, the critical test of whether a machine is or is not a 'brain' would be whether it can or cannot 'think.' But to the biologist the brain is not a thinking machine, it is an *acting* machine; it gets information and then it does something about it" (Pickering 2010).

What cyberneticists Ashby, Beer, Walter, and Wiener all pointed to was a critique and then an ontological opening to the idea of systems (brain, organization, physiology, culture, body) as having adaptive behavior. "A system can be both mechanistic in nature and yet produce behavior that is adaptive," stated Ashby (1954). Any system can *learn and adapt*. Therefore, any system can resemble, by definition, the functions of a brain. "The biologist must view the brain, not as being the seat of the 'mind', nor as something that 'thinks', but, like every other organ in the body, as a specialized means to survival" (1954). Conceptually, mind here was not regarded as a seat of representational human knowledge but as a site of systemic engagement, action, and a type of action that exceeded boundaries of human. Cybernetics resonated with the counterculture of the 1960s. In this way and in keeping with the cyberneticists, Lévi-Straussian structualisms, the cultural modernisms of the surrealists, and contemporary anthropological discourse here on mind-body relations have rendered human consciousness, functional brains, culture, and cognition as trajectories important to examine. We know something about ourselves and our time by the types of brains and minds we choose to pay attention to.

Investigating the pairings and tensions of the Geertz-Lévi-Strauss debate has provided me with a sketch to understand, and attempt to ground, very different technical aspirations applied to the workings and systems attributed to our *mental creatureliness*. Sometimes such problems of mind-brain can be stripped of their embodied dimension (cognitivism), rendered metaphysical (divinely given), and sometimes systemically determined (stripping human action of autonomy), but all have been equally speculative and passionate, giving us the milieu in which they gained currency. In seeking-out concepts on mind, I believe their debate has reflected not only their particular milieu but also can help to bring these concepts forward into the contemporary. I have not attempted to force a definition of what a mind or brain finally, epistemologically and ontologically, is. Instead, I have attempted to focus on the lines of flight of these anthropologists' notions of mind informed by early informatics, anthropological concepts, and cybernetic visions.

No attempt to understand cybernetics and anthropology of mind would be complete without briefly embracing Gregory Bateson. He spanned many disciplines, as most cyberneticists did, covering anthropology, linguistics, psychology and system theory. Mind was an integral part of larger adaptive (biological, environmental, organizational and non-biological) systems and did not reside, or wholly reside, within individual psychologies or brains. Such a concept of mind was not internal to human brain but was part of a larger bodily communication system that was part machine and habitual and unconscious process but also reached "outwards" into a kind of *ecology.* Bateson along with Lévi-Strauss and Geertz explored the boundaries of mind, but I believe they were sketching-out a new kind of anthropology. By considering this ecology populated by human mental life and thinking machines (both within and without), they were aware that capturing such changing objects would always be tempered by a sense of wonder for the unexpected behavior of such larger systems (1972).

As we move into the contemporary of Biomedical Informatics, I think it would be best to keep in mind that such earlier theories have not vanished. They still have the sheen of broad aspiration and applicability. They hold pictures of a better world. They also hold clues to perils of overreaching automation. The underlying skepticism challenging a human-centered world has matured, and new problems in the everyday of biomedical intervention have overtaken them.

III. Medical Reasoning and The Machines of Data: Contemporary and Historical Antecedents Deepening Anthropological Encounters

Introduction: Opening Anthropology to Informatics Objects and Origins

In this Chapter, I explore the computerization of bodies in medicine by tracing BMI's origins. Through my reflections on BMI, I ask, Have computerized and algorithmic forms, which have been increasingly applauded for producing information at bedsides, altered medical aspiration through their implementation? With the adoption of the "information revolution," has late-modern medicine been revolutionized? If so, what are the signposts of this transformation?

My approach to these questions is laid-out as follows. First, my analyses will focus on what I call the *computers "in" medicine* approach and will examine biomedicine as intervened-upon by computational forms. From here, I examine early 20th century notions of the medical mind as put forth by physician William Osler. As described in my earlier discussion, Osler developed a pedagogical structure that rendered a specific form of mental discipline for and among physicians. This discipline has remained in-place even as increasing amounts of information flow from biomedical devices and other forms of technological assistance to doctors sitting at bedsides. Does this form of medical discipline prove important to the different ways statistical- and informatics-based medicine is incorporated into the everyday practice of medicine? Certain forms of medical reasoning take shape and are prefigured in Osler's modern notion of the medical mind. This thought experiment travels through Cartesian and mathematical ideas about how biomedicine might gaze upon the expressions of its own mind, body, and forms of reasoning and how the reflections arising from this gaze have contributed to, and given a foundation for, a certain kind of *informatics body.*

Computers "in" Medicine: Promises and Boundaries of Biomedical Problems

In this section, I investigate a "computers "in" medicine" approach to BMI system conceptualization and implementation. From this perspective, typical in BMI, clinical settings are characterized as participating in an exponential increase in "health information technology (HIT) adoption" (Bloomrosen 2011:82). From the computers-in-medicine perspective, computerized information systems will transform "the world's largest, most inefficient information enterprises" (Hillestad et al. 2005:1103). Although computerization in medicine is decades old, one hears repeated calls from experts in the field that computerized technologies are "essential," "revolutionizing," "inevitable," "life-saving," "critical," and "historic" for biomedicine. In the journal *Health Affairs*, leading informatics founder Edward H. Shortliffe sums-up this widely held belief "that after 35 years of evolution of health care IT," a growing optimism is building that a revolutionary step is about to take place in "the way medicine is practiced" (2005:1222-1223). It has not been that computerized and computational agencies have not been around for decades and applied to biomedical problems but rather that in contemporary BMI, a key structural and conceptual reorganization has been underway so that biomedicine can integrate with informatics forms (Shekelle 2006). What is suggested here is that computerization was previously a time in which the switch from *analogical* forms (language, sound, and movement) has now been translated into *digital* forms (programs, code, and mathematical forms). The medicalized body has now, since earlier medical informatics, been *digitized* genomically and physiologically and being calculated as massive data. In this picture, computerization is not about only automating and managing computational problems but also serves as an answer to a larger health system over-loaded by information. Computers are tools to manage the agencies of medical data. Computerization today calls for a deeper understanding of how digital data have entered and begun to structure the biomedical imagination.

The computers-in-medicine narrative is an older story of 19th and 20th century modernization. It can be seen as growing from the desire for increased efficiency through the implementation of new technical monitoring enabled by the deployment of new devices and technological objects in the workplace. Those who have attempted to study the effects of BMI have by and large neglected this modernization story by narrowly focusing on the implementation of large-scale information systems (Blum and Duncan 1990). When viewed as a cluster of applied sciences rapidly developing toward "the applicability of informatics tools…to improve the evidence base" for research and delivery of biomedical care, computers become value-free utilities (Bloomrosen 2010). Although approaching computers and computerization as *applied to* or *applied within* biomedicine has not been altogether wrong from my perspective, my point is that computers-in-medicine has hidden larger aspirations and struggles in the era of BMI novelty and implementation.

Informatician Ira Kalet has his own origin story of the promise of the BMI in his widely instructional book *Principles of Biomedical Informatics*. He believes that this BMI era has come about when "we are awash in a massive flood of data," bringing "deep computational power…to bear on biomedical problems" (2009:1). In this scenario, computerization has arrived to relieve an overwhelmed healthcare system of massive data burdens. This kind of self-filling picture of anxiety about computerized data can be solved only through both incremental programming and large-scale computerization. Kalet frames working with computerized biomedical data as an epic fight against information overload. BMI must go beyond "arcane syntax" and find a common language (and body). In this way, the notion of *information* becomes fundamental and unifying.

Developing a unifying technical language dates back to civilizational beginnings. From this register, Kalet cites from the Book of Genesis, Chapter 11, which I quote at greater length here: "Behold, the people is one, and they have all one language." A common linguistic order has liberated people and "now nothing will be restrained from them, which they have imagined to do." Building a unifying but liberating language would help to build a new kind of liberating technical world. One standard of arithmetic code, for example, would free-up creative energies. Here, in a common technical language, imagination was unrestrained. It allowed different people to share in and express through a symbolic communication. And in a Biblical twist, the Lord then, as if to test the population, put a limit to this unrestrained doing "confound[ing] their language," and the people were scattered across the earth so that "they may not understand one another's speech." As the *one* was broken into the differences of the *many* "they [were] left…to build the city (*King James*).

This picture of building, or rebuilding, a city of possibility in order to construct a universal language expresses the larger aspiration of BMI: to engineer a common computerized and massive data structure in medicine for clinical decision-making and therapeutic care of patients. Within BMI, this area has been called *translational medicine* and *Big Data,* both of which are descriptive terms for the various attempts to form a common language and ontology from molecules to populations. The goal of such a "city" has been the development of a "rich cadre of biomedical informatics approaches" (Sarkar 2010:2). How is one to pull together approaches that make up this picture, if only temporarily, and demonstrate how they have played-out in the clinical everyday?

Effects of implementation*: *Ethnographic examples. A registered nurse who was the Chief Operations Officer of a Community Health Clinic and whom I will call Irene was aware that computerized health records were a new "geography" for her (2011). She was coming to terms with changes at her clinic. Irene and I met in 2011 during her clinic's selection of and potential transition to electronic health records (EHR). Shortly after this encounter, a local and major health system was rolling-out a more comprehensive EHR and asking practitioners at her clinic to connect into the EHR for a nominal fee—a fee dramatically less than if the clinic purchased its own system. In what appeared as a "data conversion" and an "implementation" project, over 75,000 community health medical chart records were now going to be newly and differently valued as data by the health system. Irene was coming to terms with the fact that her clinic's health records were becoming, as if transforming before her, new "gold." Through several interviews, I understood that this "gold" was perceived by her clinic as the health system's reevaluation of the clinic's patient data for their long-term statistical potential. Such computerized data had enormous clinical correlative and epidemiological value, like a stream that does not run equally both ways but in one direction. Irene was coming to terms with the fact that data have firewalls, barriers, hospital, and contractual limits – data are powerfully asymmetrical by way of who or what gains access to their "gold." In one interview, she put it this way "they [the health system] are going to use our data and we can supposedly use theirs – or can we?" However, her clinic needed to survive, and survival meant participation in a "system that was going to morph into something larger" (Cardoso, interview with the author, September 30, 2012). The idea of “use” was to Irene a euphemism, and yet in the new geography of Big Data and interconnecting computerized networks of patient data, she found herself at times puzzled about what and how she could respond to the local health system’s and governmental incentives pushing for “improvement” by implementing and interlinking medical data.

Reflecting upon such a move, Irene considered that this large health system of several inpatient and outpatient centers would siphon-off the “good patients” and leave her clinic with a future of caring for the chronically ill with reduced reimbursements for medical services. “We would have to close our doors because we would become a dumping ground for patients the health system considered not to be profitable” (Cardoso, interview with the author, July 3, 2012). This would all be engineered on the informatics level of “using” electronic health record data-capture and Big Data correlation. A financial/contractual relationship with the neighboring health system would be struck based on software “tools.” From Irene’s perspective, medical disparities—inequities that her clinic was dedicated to fighting against—would potentially grow deeper and more intractable based on such “data sharing” serving “improved outcomes” but being mined with sophisticated software that the health system could afford but the financially-strapped community center could not. As computers “in” medicine approach, inserting large-scale computerization into a community health setting was presented as inevitable and beneficial. From the enclosure of community health to the “always on” of Big Data that the health system was introducing, Irene had to awkwardly take steps forward with the health system that she expressed had the terminology of “benefit” very well rehearsed while unknown consequences for her clinic were left open.

If we keep in mind Irene’s anxious reflection upon the shifting value of computerized patient data along with Kalet’s previous call for a “coherent system” across protein sequences and clinical findings, we can begin to detect how informatics has various and unanticipated effects across very different people and their imagination of future modes of practicing medicine.

When looking at clinical software as *tool use*, I often hear questions on efficiency. In interviews in a large thoracic surgical practice, I encountered lead surgeon Samuel, whose concerns often focused on the puzzles of clinical efficiency as software systems were being deployed at his practice. "I can appreciate making medicine more efficient," stated Samuel, "but rarely does efficiency and efficacy work-out in favor of good medicine. In my office, there's a lack on the part of the developers [Electronic Health Record programmers] to make something that works for *here* [gestures to his temple] and *here* [gestures to a desk with piles of patient charts and computers screens surrounding him]" (2012). Informatics efficiency can be at odds with specialist medical reasoning and workload. On another level, machine reasoning appeared to mis-link modes of action and thinking for Samuel. He was interested in an *embodied* improvement to his workload. "Embodied" suggests here that improvement meant software that would adapt and learn as Samuel moved through his thinking and clinical documentation. Software would learn to *anticipate* his moves and style of thought.

Samuel's comment was typical: a frustrated physician user in his 50's who has perhaps not mastered the skill sets of his younger peers to adopt EHR software. Perhaps he was encountering software designed to speed-up his daily clinical work but developed by non-physicians and so fell short. But Samuel's frustration was not only a complaint: he was pointing to this space known in informatics as "representation," a term drawn from the field of informatics that refers to rendering machine learning that makes explicit how experts move through a series of decision steps or heuristics. Samuel struggled with how such software represented his thinking in charting patients with multiple lung-related conditions, patients who were at-risk for cancer with the highest mortality rate. His was not a problem of acceptance/resistance of new technology; rather, he was troubled by the ways informatics identifies and refashions medical problems through particular kinds of computerized systems. Samuel's example has suggested the challenge of *problem-formation* in machines and by machines that have been built to represent cognitive and intuitive processes of clinicians.

However, Samuel was very sophisticated in other types of systems, mainly the sterile fields, thorascopic devices and probes, pleura effusions, and biological and volume-doubling behavior of non-small-cell lung cancer. He was viewed among his colleagues as an "orchestrator," a kind of conductor of the other surgeons he worked with. What he called a "major" case (a lobectomy) would require a team composed of Samuel and two colleagues, and he would set-up the operating room well before their arrival. He was an expert at anticipating the risk a procedure posed to a patient, arranging proper expertise across a particular case.. Before the patient was ever brought into the OR, Samuel had the entire procedure and its contingencies mapped-out not only for himself but also for his colleagues. The notion of system or *systems*, was processes that allowed doctors to organize and anticipate: it allowed clinical concept and application to fall into alignment. In Samuel's case, the notion of systems had therapeutic and life-saving value. Such systems could be very different; for example, thorascopic imaging that pictured a surgeon's location in the lung or lung cancer staging protocols that established how large and extensive a cancer has spread were considered both efficacious systems and essential for his work as a surgeon.

Samuel's clinical partner, a fellow thoracic surgeon I will call David, framed this conceptual-applied tension via systems very differently and from two directions: first, his experience of robotic-assisted surgery was changing his relationship to his hands and surgical navigation. When asked what his thoughts were on his use of the robotic control console, he responded, "I'm not operating; I'm the operator of the operation. My role is [becoming] an air-traffic controller. Now, I don't think this is a bad thing, but I wonder who's doing this thinking behind the machine because in the end of the day we are still surgeons and we think like surgeons no matter what comes along." In considering computerized networked robotics, "our capacity to do surgery and the kinds of surgeries we do will change" (2012). As an "operator," David's use of his hands as haptic technology was being extended and fed back through intelligent devices. He was not resisting robotics but instead reflecting upon his experience of growing system complexity. Secondly, he stated that while he was in medical school, "we were taught to think systemically, but now I'm *in* a system, many systems that I have little access to. I'm not upset about this, or upset by the fact that [software] functionalities are pre-built into the things we use as physicians; but when I think about the hospital administrative system that wraps around all this, robotics that wraps around this, the [health insurer] reimbursement climate that we struggle with [and] the government regulating who we will or will not get paid to perform surgery on, [then] my judgment [and] my hands will probably… [give way to] programmers' ideas. Individual surgeons will be unnecessary—*systems* seem to want different things than I do for my patients" (2012). His reflecting on medicalized bodies was not pointing to bodies of patients per se but to his own embodied medical judgment *as an object* potentially being operationalized across not one but a range of electronic, computerized, and financial-hospital systems. His own decision-making was, as he saw it, being transformed by programmers' "ideas of precision." David was not resisting these so-called robotic advances in surgery but rather was in search of a way to think through and re-embody his role as one who operates to one who is an operator set within, and perhaps against, larger changes in health systems. Here, in these very brief and different examples, I have found BMI to be a space of puzzlement, which usually falls somewhere between moded and outmoded biomedical expertise and what constitutes each. David's brief example guides us to wonder how medicalization of bodies may be linked to larger imaginaries and to the politics of computerization and how physicians have been moving through the refashioning of the embodied relations of clinical medicine.

Organizing Potentialities of BMI: Informatics in Relation to Big Data

In this section, I explore how BMI organizes biomedical knowledge but also has been *organizing* medicalized bodies and medical cognition. I examine in BMI what I call an *informatics body.*

An *informatics body* found in BMI has genealogies that run through mathematical and computational sciences and, it could be argued, date back to Descartes. This genealogy follows tracks that run through the "vitalist," "iatromathematical," and "rationalist" debates in Western medicine (Porter 1997; Suchman 2006). Within this form of thinking, the calculable and incalculable are not considered to be opposites; rather, they are seen as polarities in constant tension. BMI extends these polarities and in doing so pictures a particular kind of bodily presence that is found among medical information exchange.

Consider the following example of a 44-year old patient who suffers from chronic conditions that include diabetes, hypercholesterolemia, and hypertension. This picture of a patient comes to us from Congressional testimony delivered by cardiologist and former U.S. Senate Minority Leader Bill Frist. It is his version of a patient plugged into (and constituted by) functional and computerized systems. He owns and controls his own Electronic Medical

Record (EMR)[1] and has a radio-frequency computer chip (RFID) implanted in his abdomen that monitors blood levels. His family history includes a father who died in his early 50's from massive myocardial infarction. Frist sketches this image of the patient:

> [He] does an excellent job with his self-care. He takes a single pill each day that is a combination of a low dose of aspirin, an angiotensin-converting–enzyme (ACE) inhibitor, a cholesterol-lowering medication, and a medication to manage his blood sugar. That's one pill daily, not eight. He gets his routine care at his local clinic. He can usually make a same-day appointment by e-mail.
>
> The physician diagnoses an evolving myocardial infarction by commanding [the patient's] implanted computer to perform a series of rapid diagnostic tests. The cardiologist in the "nanocath" lab injects nanorobots intravenously, and remotely delivers the robots to [his] coronary arteries. The tiny machines locate a 90 percent lesion in the left anterior descending coronary artery and repair it. (2005:267-272)

The patient is a manager and location of his own care: his medical intake is commanded and managed via email, and his clinical care takes place through electronic appointment scheduling alerts. Symptoms and technologies that swirl around and through the patient's body perform functional tests and measure dosage levels and remote deliveries. Cardiologist and former U.S. Senate Minority Leader Bill Frist's conception of the patient is as a site of nanorobots and transmission of computerized treatment regimes; yet on another level, it is a staging ground for the economic "transformation" of the U.S. healthcare system into an efficient global leader, a picture of society based on the body's alliance with information embeddedness and communication. "As a society…the current healthcare sectors cannot meet the needs of 21st century America without a true transformation" (Frist 2005:270). One could easily dismiss Frist's figure of the patient as political rhetoric. However, informatics bodies are situated among the functional promises of enhanced expert decision-making, human performance, functional diagnosis, and health projections that have been imagined to

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reach beyond "life" to functional metrics. Such a body has emerged through the powerful grouping of informatics objects—datatified post-genomics and nanotechnological agents and accompanying imagination. These are tiny machines operating among synthetic medical reasoning that has been encoded into medical devices and distributed over ACE inhibitors (angiotensin-converting enzyme inhibitor) and statins (HMG-CoA reductase inhibitors) and embedded in computerized networks. These objects of programmable intelligence block, target, act upon, transmit, and ultimately feed information back to physician and patient for the purpose of diagnostics as well as self-monitoring.

Such late-modern alignments and syntheses have not gone unnoticed by anthropologists and philosophers. Anthropologist Margaret Lock has termed these alignments as the contemporary "techno/biologicals," comprised of biological materials that have begun to "trouble 'natural' categories about self and other and producing new forms of life" (2010:1512). With similar passion, Gilles Deleuze has contemplated that we should pay attention to such little machine linkages: desiring machines that exert force upon subjects, information machines that capture us in modes of communication, and machines that produce psychic formation across territories, bodies, thresholds, multiplicities, and flows. In the Deleuzian frame, "a machine may be defined as a system of interruptions or breaks" (1999:36). Similar to Frist's machine-like universe of devices and agents of cure coursing through body and computerized networks, Deleuzian machines could be taken apart, plugged into many other systems, and therefore be very resilient. Deleuzian machines were *digital*. Deleuzian conceptions of machines fit remarkably well into the types of agentic effects that swirl around an informatics body. These are very different kinds of machines and ways of thinking about "machine" conceptually. Here, machines are part of the subject, a deeper intervention into the kinds of bodies we inhabit or build around us as patients and doctors and imaginations. As digital machines, patients' bodies can be sites of therapeutic improvement as a kind of arrival point of great flexibility and enhanceability. Frist locates such therapeutic machines of improvement through a "systems-engineering approach" for the exchange of massive data, an arrival point for computerized data, a "final human body" in digital form

> [that] actually reflects a complex system of environmental and genetic influences, expressed through more than a million different proteins. Advanced computing and a systems-engineering approach to massive databases will open even more sophisticated and useful personalized medicine fields, and a new healthcare revolution will begin. (Frist 2012).

Frist's revolution across genetic and data correlation suggests more than a straightforward dream of personalized medicine from a former Congressional leader and physician. In the contemporary of BMI, ways of ordering mind and body are deeply revisable among advanced forms of informatics.

Perhaps a few informatics "objects" should supply clues to this organizing dream. First is your health "information," which may include annual physicals, blood lipid levels, medication lists, demographics, CT scans, past medical histories, social, family and behavioral histories that have been extracted from raw data and stored in electronic archives. Information of this type is *represented* as well as *aggregated*. It has been made graphically legible (represented) on your computer screen (LCD), identified and cross-referenced (aggregated) by computerized databases for you as a consumer of medical information. *Your* medical information is not value-free but constructed, correlated, data-mined, and represented many times before it reaches you.

Second is your data, consisting of programmable and structured code—ones and zeros—that may reside in relational databases in a hospital, health system, outpatient center, research center, pharmaceutical company, genomic databank, online health aggregator, or biotech marketing department. "Your data" may travel anonymously without passport or state borders, what has been termed "anonymized" and, on another level, "meta data." It carries codified identifiers, 1's and 0's. It resides in electronic archives of supposed permanency, which means that computerized data are dependent on changing institutional and governmental policy. Computerized medical data, like all such data, are vulnerable to technical obsolescence and manipulation. Data do not vanish. Anonymized data leave traces that baffle our notions of privacy and human memory and have been associated with a cultural phenomenon—the obliteration of forgetting (Mayer-Schonberger 2013). Meta data may appear lifeless and abstract, but they can be analyzed to tell everything from who we love and when, to what medications we have taken and who prescribed them, to the fact that we have taken a vacation to a remote location. They can render a picture of how, when, and where we move and think, get sick and get well. This picture is gaining in clinical specificity and scope.

Third is that human biology is thought to align with informatics logics; the biological can be switched on and off, inhibited, mathematically codified, and aligned with pharmacological processes. In short, human biology can be mapped, sequenced, and pharmacologically targeted.

Fourth is that as computational-biological logics, one's health and sickness can be lifted from place and context, data-mined, cross-referenced, and modeled probabilistically to provide larger pictures of genetic and population-based forecasting. In short, your data can be correlated as, and among, Big Data, providing the occasion to "datafy" and "mark" the medicalized body as message and probabilistic future but also amplify the potentiality of personalized medical information to work within larger electronic and networked correlations.

Big Data Correlation

Executive Editor of *JAMIA* Lucila Ohno-Machado has written that BMI's possibilities for technical expansion have "never been so prominent" as with their relationship to Big Data in improving patient outcomes (2012:1). In the Big Data world, correlation produces surprising correlative relationships. But there is also "small data." In the small data world, human-centered judgment has been primary in sorting-out what kind of intuitive decisions should be made among non-existent or limited information. In the small data world, there is rarely enough time to gather all the relevant data before making a diagnostic decision. I have in mind here a busy level-1 trauma setting. Among incoming gurneys and rapid triage, human decisions need to be made fast, and yet human decisions may take time. This can be seen as the "art" of medicine: working with limited information. Clinical reflection has an aversion to haste, yet clinical decisions have to be made with whatever data may be available.

While Big Data is associated with what is known as "evidence-based medicine," small data require hypothesis-testing, and controlled studies and can be very expensive. Big Data requires little hypothesis-testing to produce workable results. It uses computational power to peer into data and can be organized around predictive modeling and a dizzying array of interesting correlations. Big Data does something very different from Cartesian thought: it is comprised of an "objective" decision, *free of the human senses*, as Descartes once remarked, linked across other intelligent electronic relations and sensory mechanisms. What this means is that human sensation and the truth of reason are shifted across billions of data points. A decision can be correlated and arrived-at without direct intervention from human reason and then *distributed.* In a Cartesian world, the human is central to gaining and arriving at scientific truth. In a Big Data world, such truth and objectivity depend on massive amounts of statistical data to locate the smallest correlation or statistical outlier. For example, Big Data correlations apply in non-linear fashion, crunching mortality rates of thoracic surgery, hemoglobin A1C-compliance for diabetics, and the rise and fall of insurance coverage to find the cost and morbidity among a certain population of drinkers and non-drinkers of soft drinks and tobacco users. It is not the *why* but the *what* of clinical outcomes that gains value. Localized conditions can be extrapolated across demographic and large-scale behavioral trends to be applied at bedside much earlier than long-term controlled research may allow (Mayer-Schonberger 2013). Cartesian mind is outpaced by computational and correlative speed.

From the perspective of BMI, Big Data has expanded the notion of a *patient* beyond the individual body to computerized distributions across a wide net of relations and signs; for example, lung cancer mortality rates for non-smoking women, late-onset diabetes, healthy lifestyles, and household incomes can be brought together for longevity treatments. For example, consider the place of Huntington's disease within informatics. Here, the informatics goal would be to identify implicit knowledge for Huntington's disease and convert it into explicit knowledge across data ontologies linking neurological, psychiatric, and genetic testing processes. To reach this goal, informatics would use such explicit knowledge within structured descriptions from erratic behavior to loss of muscle control. To make this implicit-to-explicit make sense in a Big Data world, such clinical codes would be cross-linked to national databases on demographic and HD mortality rates. Although the neurodegenerative disease of HD has been one of the first diseases to be genetically identified and mapped to a single chromosome (Chial 2009), the informatics problem is to take implicit knowledge—doctors' experience and patients' intake and patient's self-knowledge of HD—and map it to explicit knowledge—diagnostic check lists, specific symptom domains, behavioral DSM codes—for the purpose of making such knowledge more clinically predictable and efficacious. Big Data appears to make disease and its co-morbidity visible as well as to make known different kinds of correlative risks and benefits associated with wide variables of HD; however, there is a catch: Big Data seems to poke holes in the borders of scientific expertise. In proposing a Big Data analytic model for slowing disease progression and finding treatment for HD, scientists would need to make wider associations with treatment, behavior of patients, and genetic and environmental factors than they are currently trained for. A model would require not only wide medical and engineering expertise but also such expertise to validate what billions of data points may reveal. What kind of medical mind can embrace such scientific outcomes as distributive potentiality of *information* when the *effects of information* may rival those of disease? Long before informatics, this attempt to puzzle through medical problems as data was considered in the early twentieth century by William Osler.

William Osler's Aequanimitas Mind: Possibilities and Actualities of Medical Reasoning of the Physician in 20th Century Scientific Medicine

William Osler was one of the original medical leaders of The Johns Hopkins University School of Medicine, and he is widely credited as the father of modern scientific medicine in America. One of his key concerns was how physicians were to reason with scientific data while accompanying patients at the bedside. Scientific medicine was advancing, and he was invested in addressing how best to bring science into clinical practice and medical education. This was not to be achieved through computerized software systems, which did not exist at the time, but by deploying a new kind of *aequanimitas* mind—the cultivation of mind by physicians that projected “coolness and presence” among multiple inputs of data and the sense of crisis (1904:4). The early 20th century American medical imagination that Osler defined and then set-out to deploy through pedagogical techniques took shape as a new data-dependent scientific medicine was emerging. As a new object of physician mental life, *aequanimitas* mind required a certain kind of unshakeable *mental operator*.

In order to achieve this calm information-brokerage by physicians, anthropology was called upon. Before this new mind of the physician could emerge, the mind of the indigenous had to be disassembled in order for *aequanimitas* mind of scientific medicine to be assembled. What this means is that the non-Western mind of native life had to be interrogated from a scientific perspective and undone before *aequanimitas* mind could find its plac in scientific frontiers of American medicine. Osler’s notion of *aequanimitas*—a guiding ethic for the Johns Hopkins School of Medicine—had its beginnings at the disappearance of Native American ways of making sense of the agencies of disease. Osler turned to anthropology for his rationale for building a new object of medical reasoning (1904:2). The mind of the physician would rise above what “modern anthropologists claim[ed]” was an earlier stage in which “magic was the setting in motion of a spiritual power to help or hurt the individual” (1913:2). Osler was creating a picture of physician mental resolve that could cope with agentic forces characteristic of an information age, medical rationality *forming around agencies of all kinds*: human, non-human, biological, non-biological, bacterial and microbial.

The image of *aequanimitas* was that of a modern physician mind unmoved by agencies that were thought to beset primitive man's misfortunes. Although primitive man "recognized many of these superhuman agencies relating to disease,' it was the modern physician who could rise above and find the *causes* of disease (1913:3). It was the modern physician who was unmoved by human and non-human agencies, viewing them as scientific phenomena. He was rendering not only a mind of "calm judgment" based on "an intimate knowledge of the varied aspects of disease" but also a quality of medical reasoning that sought out "absolute truth…aim[ing] at the unattainable" (1904:5). The physician of *aequanimitas* temperament perceived the absolute scientific truth behind such agentic relations, managing them and identifying their causalities in the hustle-bustle of crowded hospital wards. Strategically using anthropology, Osler was announcing to the American medical establishment that a new form of medical judgment with new capacities and new calmness was emerging on American soil.

Following the rationalism of Descartes and born of Anglican roots, *aequanimitas* represented cognitive and emotional weights and measures, a kind of gyroscope that when tilted towards impulsivity, tilted back onto physician restraint. It was a brilliant model of mental stamina that deployed "mental equilibrium." In this state, "possibilities are always manifest" and "the course of action clear" (1904:5). In order to technically and scientifically innovate American internal medicine, Osler had to create a compelling picture of mental resolve and acuity that could manage increasing scientific data across a wide range of clinical experience. *Aequanimitas* called upon a different cognitive order in the building of scientific medicine. It carried with it "clearness of judgment in moments of grave peril" a form of medical judgment readied for the challenging management of scientific evidence in the accelerated development in the germ theory of disease, bacteriology, embryology, and surgical procedures (1904:4).

On another level, Osler was paradoxically building-up a mind of inner stillness out of the noise of late 19th century urban life. In creating a conceptual enclosure away from industrialization and assembly-line clatter, Osler was establishing physician mind that would allow practitioners "to meet the exigencies of practice with firmness and courage, without, at the same time, hardening the human heart" (1904:5). Osler's caution to not fall into heartlessness was derived from William Wordsworth's *Ode: Intimations of Immortality from Recollections of Early Childhood.* By drawing upon one of Wordsworth's most famous poems that suggested deeper instinctual and metaphysical purposes behind human mind rather than a mere decision-making machine, Osler turned to a guiding ethical form of thought that embodied patients' suffering. The final lines of the poem were of great interest to Osler because they suggested a certain kind of emotional depth that has no outward expression or validation. It was a compassionate image in abiding by nature's "more habitual sway." The physician was to "watch o'er man's mortality" and not allow "mad endeavor" to shake practitioner's resolve:

> Thanks to the human heart by which we live,
> Thanks to its tenderness, its joys, and fears,
> To me the meanest flower that blows can give
> Thoughts that do often lie too deep for tear [1919].

On this level too deep for tear, medical reasoning found inspiration. However, if Osler had dug deeper into the poem, he would have found a different form of heart and mind that was disembodied and wandering, like a creature in search of an object in which to settle its longing. He would have found not the integration of heart and mind, but something more fragmented, lost. Quoting from the same poem:

> Of sense and outward things,
> Fallings from us, vanishings;
> Blank misgivings of a Creature
> Moving about in worlds not realized,
> High instincts before which our mortal Nature
> Did tremble like a guilty thing surprised [1919]

Such an entity moving about in search of lost objects with high instincts evoked scientific worlds not yet realized. Osler was looking for “a season of calm weather” within the demands of early twentieth century medical science, an image of mind that could fit the vocation of medicine that medical residents could internalize. Calmness and resolve were to provide more than reflection upon the science and therapeutics of biomedicine. Here *aequanimitas* was a mode of action, a form of mental labor that was actually neither calm nor completely of human heart but refashioning medical imagination in search of technoscientific worlds not realized.

The mind of the physician, specifically empirically-based medical reasoning, was to take on new ways of integrating and retaining clinical-scientific data. The growing presence of medico-scientific data required “elasticity” of mind, which was a reasoning capacity that ould puzzle through “bodily anomalies and diseases—the machine in order, the machine in disorder” (1904). What kind of mind would be required to apprehend these orders and bring the bodily machine into “the final conquest of nature by which man has redeemed thousands of his fellow men from sickness and from death” (1913)? In this regard, *aequanimitas* would be engineered from the empirical experiences of medical trial-and-error and the flows and management of scientific information. Osler was in no way the architect of such emergent medical decision-making. Rather, he was a kaleidoscopic thinker at the nexus of European and American medicine who offered clues to possible technical and clinical futures. He was a precursor to a scientific medicine that sought to engineer uncertainty out of the clinical encounter and remedy habituated medical thought so that physician mind could shine through absolute truth and achieve the empirically unattainable. Following the rationalism of Descartes, Osler sought knowledge of disease "causes, and all the remedies with which nature has provided us" (1913). The physician was to "discover" nature, and nature would render-up its signs and symptoms under the resoluteness of *aequanimitas*.

Osler's vision for American medicine was swept-up in making sense of "circling systems form[ing] a wilderness of harmony" (1913:1). The systems he spoke of were part poetic vision of frontier American medicine, part institution-building, and part a call for the reorganization of medical knowledge based on empirical observation. This wilderness of harmony would be greatly redefined in the 20th century through the "gospel of [the] body, which brings man into relation with nature …. a true evangelion, the glad tidings of the final conquest of nature by which man has redeemed thousands of his fellow men from sickness and from death" (1913). But here also another kind of gospel was later to emerge in 20th century biomedicine, that of speed and efficiency—computerized biomedical data. He summarized such a conquest of nature by what he implored his students to commit to at Johns Hopkins Medical School, asking them to "observe, record, tabulate, communicate." The possibilities and actualities of medical reasoning would decades later flow into and be transformed by technologies that objectified clinical observation through artificial intelligence and networked communication technologies. Through Osler, modern medicine would begin to frame medical reasoning as a problem *of information*.

Conclusion: Cartesianism and Mathematical Conceptions of an Informatics Body

In this section, I examine computational and Cartesian forms of reasoning. I follow with how in a Cartesian frame we may address important aspects of the machine within. This figure of an *informatics body* can be found in the traditions of European and American medicine.

In a farewell address to the medical profession, William Osler stated that "nothing in life [was] more glaring than the contrast between *possibilities* and *actualities*" (1905:275). Osler was pointing-out a conceptual and practical distance between biomedical science and its use in daily clinical practice, signaling changes underway in the early 20th century American medical imagination. How could possibilities and actualities be bridged to reduce the sufferings of patients and at the same time be an occasion to imagine medical science as a new form of scientific progress and reasoning?

In our exploration of computerized forms and physician mind, it is important to mark Descartes' ideas on mind-body relations that have prefigured modern scientific method. He was one of the major architects of the movement from a description of nature as "properties" perceived by human senses towards explanatory forms represented by mathematically-defined "quantities" through the language and symbolic forms of mathematics. By exalting mathematics as the most accurate method and means of explaining the natural world, he reserved explanations of thinking and mind to be outside mathematical expressions. However, this did not mean he failed to speculate on how perception and understanding of the natural world was to be conducted. On the contrary, his bold, if not skeptical, attempt to order the world through mathematical demonstrations appears very modern when viewed from an informatics perspective.

Descartes sought expressions of human-mathematical pictures of bodily order. And here I do not mean the Descartes of mind-body dualism or crude mechanistic bodies that so many social scientists love to debate but rather a different Descartes, who considered an inner world populated by parts, sentience, children, animals, and mathematics. The Descartes we find here speculated about the applicability of mathematical models, but on the *child* and *animal* in us as part of an inner drama vying for scientific and computational order.

Mathematics held the possibility that what we know of the physical world was based upon "laws of nature"; and if these laws could not be received through direct experience, they could be inferred through mathematical models which provided pictures of the world which were "certain and evident" (1998). But first, before the reasoning mind could apprehend the logical order of phenomena and before mathematics could be deployed as a Cartesian model of subjectivity, the child and animal spirit that roamed in our sensorium needed to find their place (Cottingham 2008).

I am directing our attention to ideas found in Descartes concerning the mind, the "child" and the "animal" which have slipped into contemporary computerized decision-making. I take both concepts in different directions from those typically taken by scholarship on Descartes. I see "child" and "animal" as essential dimensions of Cartesian reason. In such a Cartesian frame, a "child" stood for a kind of mediator between human and non-human mental capacities. The child was a kind of conceptual warning of the dangers in misjudging sensation for concept. Next to this notion was the "animal" that provided symbolic impetus for imagining inner physical life force that animated human physiology—automatic nervous system, reflexes, and vitality, brain without a mind. When the child in us fled, there were deep consequences to thinking and reasoning. If the child roamed free in the mind, we could be duped by sensation, always potentially deceived by our percepts. If the animal roamed free in the mind, life could appear like non-sentient automata. However, to completely exile the *animal* of vitality, we were products of God's perfection, logical but expelled from the garden**.** To completely exile the *child* in us meant living a disembodied life devoid of feeling. The animal and child *within* held very particular associations when confronted with the machine.

As an example, Descartes provides a picture of a particular child, lying peacefully asleep. This child is not only at rest but also in another state of mind. The child is dreaming and thus away from the everyday of human sensation. Then a feather is flitted "lightly over the lips of a sleeping child and they [*sic*] have a sensation of being tickled; do you think that the idea of tickling which they [*sic*] conceive resembles something in the feather?"(2004:5). In this metaphor, the mind as a certain kind of child struggled against the unreliability of knowing it was touched by the feather. The sleeping child represented a form of consciousness in which touch "the least deceptive and most reliable" of the senses, did not lead ideas to properly "resemble the objects which produce them" (2004:5). The feather's physical properties were closed to the child. Mathematical explanation was not possible. This sensory machine, or in contemporary terms a "feedback loop," rattled within the frame of sensation itself.

The *child within* represented not only the mind's unreliability in regard to bodily sensation but also how the *sleeping human* represented *potentiality*, an eventual wakefulness that would free us "from many errors that can cloud our natural light and make us less capable of hearing reasoning" (1998:11). The figure of the child was an image that humans were to develop out of as they came to embody mature forms of reasoning. The image of the child in the mind was not just sleeping but was falling to sleep, was *between* wakefulness and sleep. I believe what Descartes offers is that when we confuse what touches us from the mechanical order that set such sensation in motion, we miss the truth of phenomena. If we were to continue sleeping, the truth of mathematics would be lost. And I think Descartes was making a larger point: that when we confuse what touches us with machine forms, we can miss the splendor and power of our own minds. Machines may "cloud our natural light" and dim our chances of "hearing reasoning." Without Cartesian reason, we remain unrealized sleeping children in a kind of twilight of consciousness, and our connection to the physical world is trapped in a closed loop of mechanistic sensation.

But what does it mean to be philosophically awake to reason and to recognize the child within? Here, Descartes does not offer direct guidance, but it is instructive to note where the child stands in relation to another figure of and barrier to reason. The "most perfect representatives" of monkey and parrot may come very close to the "most stupid children" if it was not for the fact that the souls of animals were "completely different from ours" (1998:41). Human soul separated children from parrots, but children and animals by their expressions could be considered representatively close. But what if the souls of animals and children were not so separated, and animal spirits and visitations from the dead populated an otherwise rational mind? That is, what if the bodies, behavior, and intelligence of machines, children, animals, and humans resembled each other in ways that confounded our rational Cartesian soul?

Descartes rendered a picture of a head cut-off the body that continued quivering and biting the ground in response to automatic signals. He attributed such reflex movements with animal spirits that have "the power to move its members [physiology], as one sees when heads, soon after they have been cut off, still move and bite the ground even though they are no longer alive" (1998:39). The spirit of animal was an animating "power" that drove the mechanics of human body without "the will directing them" (1998:40).

The image of a head biting the ground evokes automatism and crudeness. However, a Cartesian head was not *any* organ or limb but the brain, eyes, ears, and mouth. The animal within animated not only the movement of bodily "members"—blood, organs, cellular, chemical processes—but also the "non-rational animal" within human, a separation from the "genuinely human." Here, animal non-rationality took on a mechanistic feel. "It is," Descartes noted, a "nature which acts…in accordance with the disposition of their organs, just as we see that a clock, which is made only of wheels and springs, can count the hours and measure time more accurately than we can with all our [human] efforts" (1998:42). As humans, we are composed of mechanistic parts, but animals are *all mechanism*, performing specific tasks in accordance with certain dispositions. Together, the figures of the sleeping child and the animal represent versions of embodied life, one that sleeps through the passing of structures, the other dumbly animated, like a bodiless head that automatically gnaws at the earth.

Like a clock that ticked that Descartes metaphorically ascribed to human physiology or like a mind that penetrated through the deceiving senses to a state of having "absolute control over…thoughts"(1998:21), human reason appeared as a civilizing force surrounded by the perceived savagery of our senses and automatisms.

Looking at Cartesian reason in this way, such a mind could be godless and mechanical but also and paradoxically sought a seat in God's order as perfect mathematical form. Here through the potential illusion of our senses, Descartes constructed a perceiving and knowing subject that attempted to bring to awareness the *child and animal within* in order to open a certain kind of mind to the light of reason.

If we turn our attention to contemporary biomedicine and informatics, we see continuity with Descartes, if only distantly, of a kind of disembodied intelligence that has been aligning with functionalities of reason in synthetic form. We may be reminded that representationally, when we send away the child and animal spirits that haunt humans, we sometimes and surprisingly find ourselves in alignment with other kinds of computerized agencies and automations.

Human physiology can be disassembled; the child who remains sleeping can be regarded as potentiality of mind; the body that bites the ground in automatic fury can be regarded as a certain movement of disembodied reason. Descartes was attempting to create meta-linkages of things, automata, physiology, and knowledge. He stated that all things that fall within human knowledge "are interconnected," suggesting a master formula for scientific explanation of systems of matter and non-matter centuries before network or information theory (1998:53,66).

My point is that the rise of 21st century medicalization has taken place through a *conflation of domains*—financial risk conjoined to technologies of health, statistical- and informatics-based forms of medical knowledge. New medical technologies have brought promises of medical efficacy, longevity, bodily and mental enhancement. But such technologies have also brought a kind of "discomfort with dialectical modes of thought" as stated by anthropologist and psychiatrist Arthur Kleinman (1998:29). Dialectical modes question materialist nature and structure and open them to alternative forms of medical thinking. Such questioning has resisted wider meanings of Western healing practices through technological mediation and calculation.

For example, Chinese medical traditions have been, for centuries, more open to dialectical modes of healing and vitalisms of many varieties. Vital agencies exerting influence over the functions of organ and human biology do not rest easily within the material *thingness* of machines and their outputs. Culturally, Chinese medicine has not followed this Western materialist perspective on the body and instead has focused on vital "*qi* (energy that is associated with movement and breath) at the core of health and disease. The source of disease is not traced to a particular organ [in the sense of physiological pathology] but to the disharmony of *qi* circulating in the body. With the rise of what has been termed *allopathy* and principally scientific medicine of the 19th and 20th centuries, various forms of mechanism have been aimed at discrediting vitalism as non-scientific and therefore having little efficacy in the detection and treatment of physiological and mental disorders. The notion of materialism as ground for biomedical rationality has replaced vitalism but has not done away with *vitalisms*. Here, biomedicine has been unique in its power to regulate and manage such social and technical reality. Biomedicine's rationally-ordered materialism has rejected existential moments of healing and suffering while opening the materiality of suffering, registered in impersonal terms; for example, pain scales, measures of psychological distress, bodies from battlefields that can be extended prosthetically, pharmaceutical dosage levels calculated to manage depression among people caught up in cycles of violence. To understand what may be signaled here, I turn to earlier mathematical calculations that underpin machine-based forms and materialist biomedicine.

The Divine Machine*: *The Calculable and Vital Medicalized Body

Notions of machines were a hallmark of the Enlightenment (Porter 2006). Social progress and the conquest of disease were to be twin achievements made possible through a new kind of medicalized body that was a holy calculable entity delivered to the early physician by divine order and that could be represented mathematically. The divine order could emerge from mathematical order. The wonder of mathematics was pattern, formula, and principle wrapped in unshakable relationship with numeric logic. Iatromathematicians—physicians who applied laws of mathematics and mechanics to the human body—believed the body and its physiological process or "humours" held a mathematical logic. In *De praxis medica* (*On Medical Practice*), Giorgio Baglivi claimed that God had sketched a divine logic "by the pen of mathematics alone." Calculations of the human body drew from physics and the philosophy of Isaac Newton who created in his *Principia* a new scientific model that expressed the possibility of applying universal principles to the study of human phenomena. The mechanical renderings of Leonardo da Vinci provided insights into the mechanics of human and machine motion. The divine could be modeled and expressed through mechanisms, not always a cold and bloodless kind of mechanism but a sense of wonder that calculation could render-up divine order.

Emerging from the calculability of the human body has been a historical division between the body conceived of as a machine (*mechanism*) and the body conceived of as super-added soul or vital force (*vitalism*) (Suchman 2007). The notion that the body could be cured through arithmetic code or revealed to be wholly mechanistic by nature has been a theme that has run throughout 17th and 18th century literature on physician practice. Julien Offray de La Mettrie (1709-51) took mechanism to an extreme in his 1748 *L'homme machine*

(*Man a Machine*): matter itself generated thought, which implied no need for a soul, and the body was a "machine that [wound] its own springs" (Porter 2006:148). Mechanistically, human and biological agency could be explained as a series of causal relationships reducible to 18th century cogs, belts, pulleys, and processes of reflex. Yet with the advance of comparative anatomy in the 19th century that proved that tissue regeneration could occur and living forces existed at a non-conscious level, the notion of causality and pure mechanical function drew criticism. The medicalized body was sentient and irreducibly perceptive of both environment and its own physiology: at the time, it comprised both physiological function and vital force (Coulter 1982). Mechanism and vitalism as opposing theories were not so clearly divided: the medicalized body was a kind of divine machine animated with both human and divine intelligence and yet was modeled after levers, pumps, and vapors.

Vitalism and mechanism were tendencies of thought that often overlapped in the emergence of the medicalized body; in British, European, and American medicine such conceptions did not always easily divide living and inanimate. Their forms and tensions depended on either as polarities and have flowed over to modern scientific medicine. Modalities of physiological orders were made intelligible through theories of automata that reached beyond individual bodies to devices of all kinds (Suchman 2006). Historically, the idea of automata—the construction of self-regulatory devices that are commonly associated with living and animate beings—took many forms in British and European medicine. During the 18th century, Jacques de Vaucanson proposed mechanical statues, the most notable of which resembled the inner workings of a duck that produced a range of outward behaviors. Earlier, the Italian astronomer and physiologist Giovanni Alfonso (1608-1679) endeavored to explain the muscular movement of animals and humans through mechanical principles. The blurring and comparing of human, animal, and mechanical forms were common in 18th and into 19th century medicine (Warren 2003).

The idea that mechanical and vital orders were separate and distinct was constantly shifting even if the orders appeared as polar opposites. Electricity as a model of human vitality was applied to the monitoring and probing of the human body as reflex and living current. It also suggested a form of 19th century healing, Mesmerism—what historian Anne Harrington called “invisible energy” or electrical aches and pleasures moving the bodies of people (2008). Electrical vitalism was expressed in the science fiction writing of Mary Shelley’s *Frankenstein* that provided a picture of cadaver parts patched together and electrified into a living being.

As a check against mechanistic reductionism, vitalism began to change direction. The body would prove to be an object of electrical monitoring, radiology diagnosis, and electronically transmittable and archivable data. A new type of vital body would emerge that is at once “flexible,” “enhanceable,” and an object of electronically controllable networks (Martin 1994; Hogle 2005; Mindell 2002). This body, which I will call here an *informatics body*, would be made available to diagnostic and therapeutic techniques that allowed direct access to the interior of the living body. Well into the 20th century, conceptions of a vitalist-reductionist opposition have been merged with concepts of “emergence, complexity, artificial intelligence, and with approaches such as information theory and cybernetics” (Greco 2005: 16). Interestingly, vitalism that once sought the “whole man” and was used against an image of mechanistic reduction of the human organism can now been seen as *animating non-human complexity and agency.* One might go one step farther to claim that late-modern information theory in medicine has proposed a new form of vitalism that has infused the treatment of the sick with new objects that may be both biologically *living* and synthetically *alive*.

As synthetically alive, an informatics body is built upon a history that demonstrates mathematical amenability, enhanceability, parts and cellular forms; all taken together, flowing-forth among machine agencies with properties may not abide by bodily integrity. Another dimension of an informatics body comes in the form of its ubiquity: it can be everywhere, can be broadly accessed by specific users and correlations, and can be archived as code across various media. It may abide by computerized code, but its social effects have not been calculated in advance. When such a body fails to fit such informatics, models and errors, I argue, are sites of unpredictability that may serve as a reflexive reminder of failed systems of care while providing opportunities for their betterment. In the context of biomedicine, an informatics body reflects-back the human limits and aspirations of the systems it has become dependent upon and constituted by.

In setting aside and building upon native cultures' ways of seeing the agencies of disease, Osler was opening American biomedicine to a certain kind of information exchange that would only accelerate in later decades. The *aequanimitas* mind of early 20th century medicine was an announcement that as scientific data grew in quantity and complexity, the physician would have to interact with data in unforeseen ways. American physicians would not only technically tabulate and communication on new levels, they now would have to interact with systems, systems of large variety and variation beyond individual mind and bedside manner.

IV. Case Study of Biomedical Informatics Objects: Concepts, Implementations and Aspirations

> When I first meet with preclinical medical students, I make a point of asking them what they believe will receive the greatest focus of their attention once they are in clinical practice. The most common response, not surprisingly, is patients, and yet it is clear to experienced practitioners that the correct answer is information—in the service of their patients.
> (Shortliffe 2010:1227)

Introduction to Ethnography of BMI–Overview of Problematic: What are BMI objects?

My problematic in this Chapter is to examine objects of informatics as everyday system implementation and representations of biomedical knowledge. Here, I examine embodied encounters with informatics technologies, both as imagined and through forms of development and implementation. These everyday systems are made manifest in clinical software systems, computerized data models, and diagnostic algorithms that are at times conceptualized for larger data correlation. I explore 1) BMI objects and specific clinical field sites and their composition; 2) method of field work in clinical settings and among informatician representatives; 3) field sites as they have related to BMI artifacts and notions of users; 4) how informatics organizes the way medicine is conceived and practiced among a selection of clinicians, informaticians, and business leaders.

Specifically, these kinds of BMI objects are hybrids of efficiency, promise, unanticipated effects, and clinical engagement. They are embodied and experienced by those who occupy different ends of the spectrum of BMI conception and implementation, which means those who actually build such data ontologies and systems and those who experience them in their applied form as clinical software or machine-based decision steps. I examine such objects as constituent organizing dimensions of BMI.

My field sites: General notes on locations. One of my field sites has included a Community Health Center outside New Haven Connecticut. The Center is a Federally Qualified Community Health Center that has 75,000 patient visits per year, a 9.5 million dollar operating budget, a staff of 140 employees, a main facility and six satellite sites. The focus of my investigation is a nurse practitioner and the Chief Operations Officer whom here I name Irene. She was responsible for the evaluation process and purchase of an electronic health record system (EHR) for 65,000 patient files and for developing a strategy for implementation, training, and future growth of the clinic. As a practicing clinician, she was learning the challenges of clinical practice while bringing about technical change in a busy clinic that served thousands of patients and their families. On another level, Irene was charged with being a "rainmaker." This meant that during an economic recessionary period, she was to purchase and integrate expensive and ill-understood software that her clinic could not afford to purchase and, in some respects, could not afford to withdraw from its possibilities of clinical improvement. Irene was in a difficult position of improving her clinic's efficiency while larger healthcare structural problems were refashioning the community-based care the clinic had been founded upon.

From my encounters at the Community Health Center, I came into contact with the informatician Ethan who went on to develop a diagnostic system for pathologists. I regularly interviewed Ethan as he shared his observations on representing pathologists' medical knowledge into clinical terminology SNOMED CT.[2] Ethan takes us to the inside of the diagnostic and identification process. We can regard Ethan as moving us within scientific

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[2] Clinical Terms (SNOMED CT) is the most comprehensive, multilingual clinical healthcare terminology in the world. See URL: http://www.ihtsdo.org/snomed-ct

method and Irene as moving us within political-technical change in an era of the collecting for and organization towards Big Data.

My third field site was a busy thoracic surgery practice in New York State. A group practice of thoracic surgeons, a Chief Executive Officer offered their perspectives on medical decisions and a changing clinical landscape of computerized data. CEO Andrew is an important character in this story. Andrew takes us on the inside of software implementation projects at hospitals, networked computerized systems, and their residual effects among healthcare changes. Samuel takes us along a kind of Deleuzian transition between disciplinary and control modes of healthcare restructuring in thoracic medicine.

A fourth field site that I will call a kind of fluid site runs throughout my other field sites. This fluid site has given me observations among personnel of computerized system implementation including clinical and non-clinical participants I have come to know over the course of my experience in the field. Participants come from a range of hospital IT departments, clinics, and software companies focused on delivering computerized biomedical data systems for the improvement of patient care.

Method of fieldwork. My methodology has been aimed at capturing the experiences of people in their working lives as informaticians and clinicians. My method has focused on conducting structured interviews followed by open conversations. My interview format quickly evolved from asking a series of structured questions to holding an informal conversation that focused on the informants and their perceptions of their place within and outside their professional role. Such interviews took on lives of their own with people's telling their own stories through emails, phone conversations, and onsite interviews that often took place in groups.

What this all meant was that a typical interview was messy and thus had to be untangled through later reflections on what had transpired. The best way I can describe this untangling is by bringing attention to different moments: a thoracic surgeon would express that his margin of error was exceptionally thin; informaticians whose pathology stains upon cellular anomaly required accurate knowledge representation would express confusion of terms; business leaders who foresaw financial gains in IT implementation but had very different understandings of how BMI objects touched them individually and organizationally would be defensive about what or whom an interview was to serve. Interviews could carry insight and contradictory opinion upon the same clinical or informatician experience.

Connecting Issues across Field Sites: Artifacts, Effects and Notions of Training and Use

In this section, I provide scenes in which implementation and effects of BMI are realized locally. These are moments in which informatics arrives as an idea of improvement and also as a set of new problems that must be faced by people struggling with training-fatigue and their characterization as passive "users" of software.

Andrew, the CEO of a thoracic surgery group, was often vocal about his experience of IT and its implementation in hospitals and outpatient settings. He provided the following description of informatics, its artifacts, and its organization of people:

> Picture a huge IT department in its own separate building, gray cubicles of analysts, directors, engineers, CIO, CTO… When I was there, they were voted one of the most "wired hospitals" in the country and their CIO had taken them from a basement of punch-card machines[3] to server farms and a robust network of clinical [software] applications. Not everything was working well at the same time. Facilities looked worn. Things needed painting. Carpets needed replacing. Our plumbing did not work as it should. Employees at the hospital punched in with time cards. In the IT

[3] Punch card tabulating machines were developed by Herman Hollerith (1860-1929) for the tabulation of the 1890 United States census. Such tabulation machinery evolved into several iterations in the censuses of 1900 and 1910 and continued in modern use through the 1980's.

> department we used biometrics that misread our fingerprints regularly. Some things were cutting edge and others were kind of shoddy. The ICU had problems with connecting [to the internet], in some of the nursing stations phones didn't always work and sometimes would have so much static that a [internal call] would just get drowned out, I remember taking a friend to the ER and the head nurse triaging patients wore white running shoes which were almost falling apart, one part of the radiology system was sometimes up and sometimes not sending images from the CT [to the reading stations] so patients were delayed. In my short time there I noticed that a lot of the computers [used for radiology reading] had open access to the Internet. Firewalls and security were not keeping up software virus [development]. No one wanted to listen and [I] asked for these computers to be locked down so you couldn't [mistakenly] download a virus. Then, one day, sure as the sky is blue, we had a wrong-side surgery because the [digital] x-ray markers were switched on the image. We weren't sure how it happened–it wasn't technologist error or surgeon error. When we checked [the server] we found a computer virus and replicated the issue. It seemed at the time that the Internet was safe but really we all knew better–we all knew the vulnerabilities but somehow didn't think… it would happen to us. (Anderson, interview with author, December 3, 2011)

Andrew later indicated that the IT department that found the computer virus was expert at parlaying blame and responsibility back on individual engineers and analysts instead of looking-over the entire department to identify the types of decision-making that allowed such errors to occur and proliferate. The organization that formed around this rapid infrastructure build-up was one of secrecy. From another angle, IT management was not learning fast enough to update software or provide proper guidance on security policies, so they projected responsibility for these things onto lower level employees or malicious code. As Andrew expressed, one of the country's largest medical centers responded to the unanticipated consequences of a computer virus affecting patient care as an exercise in shifting responsibility and medical harm to technical others: software, software vendors, and faulty security policies.

As a possible corrective to such a culture of blame, when it came to proper software training of new systems that would proactively guard against mistakes of IT security management, such training was prematurely deemed successful by hospital or clinical administration who may not have had any experience at all in training. At a certain point, clinical software was then supposed to just work and was deprioritized against clinical duties. As Andrew noted, newly implemented clinical software and the labor associated with its maintenance and use was supposed to quickly recede into the background, but it rarely did. Instead, it would take-up a larger portion of peoples' time while being in a constant state of partial implementation. The informatics of everyday clinical medicine that Andrew described was comprised of quasi-implementations, quasi-communication, quasi-"go-lives," quasi-software-updates, quasi-success, quasi-patient safety, quasi-responsibility, and quasi-modeling of physician thinking. Software vendors would come and go, and I saw continual turn-around of information technology personnel in the clinics and practice environments of my field sites. These turn-arounds were so frequent that they became an expected reality.

During the implementation of computerized clinical systems that Andrew described, there often was little shared understanding of what *level of change* is in play at a given time, what things will be changed, and what the effects of the computerized change will bring to modes of work and thinking outside repeated promises of efficiency and instantaneous information. My point is that when informatics gets embodied in subject and organization, such orders of change in busy clinical settings are paradoxically deployed for precision and yet often left open to unanticipated effects. The idea of clinical *improvement* remains unsettled as timelines and budgets are met and patients are seen by doctors in a kind of transition between electronic and paper-based forms of software implementation.

The picture that Andrew was rendering had a specific tempo and purpose. It focused on the pace and interruption inherent in informatics objects. They come as updates, releases, partial implementations, circulations of blame, novelty, "most wired hospitals," security breach, ongoing security fixes, shifting code, and competing levels of organizational and clinical change. These are not processes of IT automation at a certain stage of development but rather a kind of existential state of organizational life in hospitals and clinics in an "information revolution."

Andrew wanted to be clear that his previous employer had ushered-in other uses of clinical and hospital efficiency with a radiology system, a Picture Archiving and Communication Systems (PACS) that made diagnostic imaging and interpretation much more widely available to onsite and offsite radiologists. The hospital's clinical laboratory software had cut-down on contraindications and therefore adverse effects upon prescribing medication for complex patients. This existential state that brought such efficiencies also brought the increased storage of complex clinical information that hospital management was redeploying as metrics on doctor efficiency, time of arrival, and numbers of patients seen. The malleability of hospital intake and discharge data began to circle around the movements and productivity of doctors.

Cases of Andrew, Samuel, Ethan, and Irene: Organizing Dimensions of Computerized Clinical Information Systems

In this section, I wish to provide more background on Andrew and the other people I interviewed at their clinics and in their capacities as informaticians and doctors. Andrew experienced the challenges of implementing informatics in very particular ways. He was articulate and engaged during our interviews, and yet he was remote. It was as if he were speaking about a troubled relationship when he spoke about medical data's computerized presence in his practice. Speaking with Andrew made me reflect about how the "things" of our lives and the systems widening around us can open-up different subject positions and how our relations to and with machines hold deeply personal tensions.

Andrew was a personable and active man in his mid-forties. He carried himself in an affable manner and was nearly always well-dressed. Of medium build and sharply attired, he seemed to possess an easiness in his approach to difficult situations unfolding in his clinic. He seemed to possess the capacity to lift the spirit of the practice at a time of declining insurance reimbursements and for the treatment of high-mortality lung cancers. He was quick to greet you and quick to exit the meeting. His role was to develop the practice into a multi-specialty and expanded diagnostic center nationwide. His role was also to upgrade the practice and its facilities with new EHR, PACS, online video conferencing, and other technological devices that facilitated the clinic's collaboration with Canadian scientists working on the development of lung-based Computer Aided Diagnostic software (Lung CAD) system. I got to know Andrew through a series of meetings to select an EHR and PACS system and during a period implementing these systems into the practice's clinical workflows. The office staff of five supported Andrew; clinical staff included a radiologist and three other surgeons.

Myths and ideas of systems – the case of Andrew. Andrew liked the *idea* of informatics but had daily operational issues to contend with, and he seemed to have little time for reflection. His small office sat at the corner of the practice and surrounded by exam rooms. His desk was simple: a computer, printer, a wire-meshed tray with paper clips and an old 1940s relic, a tin metal poster that one would see at an American drug store or in a Norman Rockwell painting—a woman in a wind-blown red dress lighting a cigarette with the latest lighter of the time still alight in the wind. Post-its were scattered around with scribbled notes, and a few computers that had been retired and ready to be sent for recycling were set-off to the side. On this day, he was concerned that we had, in previous interviews, confused the idea of what a "system" was. He wanted to define what the term meant for him:

> If you ask me, there's no "systems." No such thing really. I see interoperabilities, interfaces, emails, texts, phone conferences…all these things trying to be a system. Hope you know what I'm driving at—"systems" are a generic idea like Sony or the L.I.E [Interstate 495] and a idea that doesn't do much for me. "System" should be replaced with another word, any word would do at this point–it just doesn't mean anything anymore. Now, when you think about it a *clinical* system is something that's interesting if you leave out all the other [expert] stuff. If you build something that demands everyone's attention among very talented people towards some kind of clinical goal, now you have a *system.* But a *good* system goes [even farther]… people working to make people better. That's a system I want to be a part of. (Anderson, interview, May 11, 2012)

Andrew carried with him a small grey nylon bag that held his computer and notes. One day, he opened his bag and pulled-out some notes and wanted to know if I had considered what healthcare would be like in 100 years. I said that no one can know for sure. It went this way sometimes with Andrew: he asked questions that seemed to have no correct answer; he shrugged and that was the end of our interview.

On other occasions, however, I would meet with Andrew and the conversation would continue in a more sustained direction. One time, we met at a seafood restaurant in Port Jefferson, New York, a small seaport near the eastern side of Long Island. He began the interview by saying that "the art of healthcare organizational growth and stability" was a collaboration between management and clinical expertise. But he continued to describe "management" as an open term of very different people in charge of, mostly, centralized areas of care such as hospital, large health systems, growing accountable care organizations, and private-equity-owned wellness and longevity care entities. The shifting types of management of care and health of people were focal points for a new metrics for determining improved clinical outcomes. One type of metrics hidden in the language of healthcare organizational “growth” and “stability” was how insurance carriers (health plan administrators) could consolidate computerized information as massive data correlated for disease and genetic risk factors around “members” and “subscribers.” Andrew pulled-out some papers and read the following as an illustration of how this insurer-to-data metric placed an enormous consolidating-value on the insurance company, which could now assemble a “complete record” of disease functions and health information. Andrew emphasized terms like “value-adding” and “synergies,” and he clearly pictured the patient as a “subscriber” to such metrics.

> As health plans shift their roles, they will need to accumulate more and more member health information… Moving to maintain a complete [health] record is a logical next step. A consolidated, accessible, verified medical record yields health value benefits that are very much in the health plan’s interest, and which support its other roles as well. Medical integration over the full care cycle, improved disease management, and more effective disease prevention are all core health plan functions. Indeed, maintaining a complete record at the health plan would create major synergies because the plan will need much of the information anyway to play… value-adding roles… And because health plans will also be measuring provider [physician] results, there are synergies in validating the quality of the record. The member, however, must own the individual record so that the right to privacy is clear, and so that the integrated record will be transferred on a timely basis under transparent rules and guidelines if a subscriber shifts to another plan. (Porter et al.:273)

Andrew ended his reading as if I were to understand the key words he was highlighting. From his perspective, the notion of information *privacy* was based not on unique protection of a patient data but on the potential accumulation of data by health plans. Patient ownership did not close the doors to such accumulation but rather opened them to plan administrators who could mine a patient’s record and transfer it to the insurer “on a timely basis.” Andrew was less concerned about informatics as a set of technologies and more concerned about informatics as a set of actuarial algorithms calculating insurance plan financial loss-factors and risk models contained within expanding networks of insurance relations. Andrew was presenting another side of BMI. Such administrative language produced occasions to reduce physicians to *providers* and patients to *members,* thereby shifting the idea that clinical and patient information are used exclusively and privately for the improvement of the care encounter between actual people. Improvement across clinical outcomes included capital flows. The notions of provider and member implied the commoditization of medicine as a service transaction that flattened these hard-won clinical and emotional dimensions. By highlighting the accumulation of member clinical information, Andrew was marking how highly regulated patient information could still be used by corporate stake-holders and networked systems for "value adding roles."

The anxiety that Andrew pointed-to were shifts between units of population and individual calculation that Foucault accurately suggested were dimensions of biopower. Andrew had not referenced Foucault or to my knowledge had any idea of biopower, but he was concerned with reductive language being used to describe and calculate doctors' and patients' relations and productivities. I take biopower differently here: to *order life* through providing essential and perhaps life-saving medical services (providers) and *to order data on lives* (members). Biopower in this context orders medicalized life by ordering data. By sharing the language of "value added" healthcare, Andrew was expressing that such orders were being redistributed *away* from doctor and patients to actuarial calculation: "measuring provider [physician] results" and the "synergies in validating the quality of the [data] record." This shift based partially on "a consolidated, accessible, verified medical record" was a big red flag for Andrew who was puzzling through how life and data were being reorganized through the reevaluation of patient information imagined as, and strategized for, Big Data correlation within "plan functions."

Notions of efficiency and medical efficacy: the case of Samuel. Andrew and Samuel worked together on a daily basis. Samuel was a tall and broad-shouldered man with solid white/gray hair and chubby cheeks who commanded a deep and assuring voice. His patients carried with them a reverence for his thoracic surgical care. As a thoracic surgeon, he often went beyond the typical 15-20 minute period, well into an hour, in his consultations. He had another idea of the efficiencies brought on by BMI. He would lose money with each consult in order to gain and maintain an understanding of his patients in their course of treatment and follow-up care.

For Samuel, the pervasiveness and installation of informatics systems made visible the tensions between efficiency and efficacy in medicine. As he saw it, he was losing ground in treating the *whole* patient. He implicated electronic health records in this erosion brought on by hospitalist-based primary care, but he also voiced that he was unsure where to point the finger. Seeing informatics from a very cautious perspective, Samuel feared that a certain kind of information efficiency tied to larger problems of making a clinical decision with haste led to a degradation of the face-to-face contact with the patient. From Samuel's perspective,

> People have the wrong concept in medicine that efficiency is good. In fact, efficiency is bad. In the same way that efficiency in government decision-making is bad. To dispatch something quickly, usually means the wrong decision or maneuver will be done. I'm not saying that you want to delay diagnosis, that's not efficiency. Efficiency is making the wrong decision for the sake of time. That's what happens when you try to be too efficient in medicine or when you try to get x-number of surgical procedures done in the shortest amount of time. Believe me, it's so much easier to operate on someone who does not have the problem than it is to operate on someone who actually has the problem. So you are actually giving credit to those who misdiagnose or fake diagnose or treat only the lesser illnesses and call them efficient. People that take on the toughest cases take the longest time to do them. So you have to be very careful what [or who] you judge as efficient in medicine. So the internist who sees 60 patients a day verses the internist who sees 10 patients a day is not necessarily more efficient. He may be just dispatching his patients with carelessness and not efficient. On the other hand he may be the most efficient guy in the world and may be a genius, you don't know. Everything is individualized, but there's no one way to judge. Unfortunately that's what the whole

> hospitalist system is based on. The whole hospitalist system is based on efficiency of care. And that's why so much gets missed. And one leader of the hospitalists told me, that it's no bad hospitalist medicine *to miss the diagnosis of lung cancer, it's just hospitalist medicine*. It's not their job to make a diagnosis of an elective disease. It's their job to treat the patient for what they were admitted to the hospital for, and no more. It's the primary care physician's job, once they're back in their care, to make that diagnosis. It's not the [hospitalist's] responsibility. That's what most leaders of hospitalists' medicine practice. In fact, their hospitalists colleagues are chastised, penalized, and frequently fired because they called in too many consults. Because they're afraid it will keep the patient in the hospital an extra day, two or three. When in fact, the hospital can be the most efficient place to treat someone. Because you can find all six problems the patient has and call in all six specialists at the same time, within that week's period you get the patient treated, and a treatment plan formulated for the rest of his life. Whereas if patients have to travel back to their internist their problem or problems may never be discovered until it's too late to really treat. (Goldman, interview, April 2, 2013)

Efficiency and efficacy can "go in opposite directions" when you begin to redirect your energy towards computers," admitted Samuel. Hospitalist medicine was changing the patient referral patterns he had relied on and built his practice upon. The hospitalist relationship to the computerization of private practice was, he expressed, a "consolidating" influence. His practice was plugged into hospital software clinical "portals" and hospital information flows. Information access was becoming essential for patients to receive improved care. Hospitalists were becoming the primary care for many patients both inpatient and outpatient care. Therefore, the consolidation of computerized medical data by hospitals further reinforced such closed referral patterns. Hospitals were becoming data magnets focused on building-up IT resources in the name of information "efficiency":

> Efficiency and efficacy [in hospitalist medicine] of a patient's wellbeing are contradictions. For example, there is the efficient care for the reason [patients] were admitted to the hospital. Diagnosis for pneumonia went up three hundred or six hundred fold compared to pre-hospitalist medicine because it was the easiest thing to call any abnormality on a chest x-ray and get paid well, it's a JCAHO[4] mandate that a pneumonia gets treated quickly with antibiotics, its easy to get bonus points from JCAHO for quickly treating something that they're actually monitoring to make you a *good* hospital. And the

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[4] Joint Commission on Accreditation of Healthcare Organizations (JCAHO). A regulatory body that audits hospitals for patient safety and effective care.

> patient gets discharged in two or three days, when they really didn't have the problem to begin with, they had another problem. Without calling those consults, you're never going to find that other problem. So, you were very efficient in treating that pneumonia that didn't exist, or even if it did exist you were very efficient at treating it, but the efficacy in treating the patient's life was a failure. Whereas if you would've taken that extra three, four or five days of consultants seeing the patient because there was something that just didn't jive, everything would have been worked out, the patient now would have been set on a course of diagnosis and treatment for the things that were found and they wouldn't be lost anymore, and time would be saved. Lets just say a seventy year old comes with pneumonia with a 30-pack per year history and obstructive lung disease. And let's for the argument's sake say it's a real pneumonia. Big upper lobe infiltrate. That patient is a high-risk patient, Bing! She needs to come back to get a CT scan. But here's the rub, that patient comes in and their creatinine is elevated and their B.U.M. is elevated, and their white count is off a little bit and their platelet count is low, they have early diabetes, and when you elicit a good history they may have had a T.I.A. a year ago and they have an occasional floater in their eye. But you didn't call the neurological consult, the renal consult, the pulmonary consult because the patient is going to be gone in a day and a half if you treat them for pneumonia, and would be there for a week if you called those consults. And the odds of that assessment and that concise assessment making it to the discharge summary and recommending those follow-ups with the internist the patient's going back to, is only 50/50 at best … it's only 50/50 that the discharge summary is ever going to make it to the chart in the internist office by the time they see the patient…for them to put two and two together. (Goldman, interview with author, August 30, 2012)

In Samuel's case, the hospital's electronic health records were internal to inpatient care and in their external use were not designed for supporting efficacious referral patterns for the diagnosis and treatment of high-mortality lung cancer.

In a meeting between Andrew and Samuel, the issue of computerization was discussed. Samuel brought-up that he would, if he could, stop using computers altogether. Andrew joked that Samuel actually loved such challenges and was merely having a bad day. Samuel responded, "I *don't* want to be challenged in this way"; he wanted to challenge himself as a doctor. Computers were not assisting Samuel to solve problems. He described computerization as a kind of noise that one had to work through. For Andrew, it *was* computerization that would enable them to advance their clinical mission. They both sought to preserve, based on their modes of practice and expertise, the care of the whole patient with long consultation times, extended surgical follow-up visits, and the personal touch of knowing patients' families and their extended networks of care. However, the ways of achieving the piecing-back-together of the whole patient appeared threatened by forms of efficiency and siloed diagnosis and carved-up patients into diagnostic codes, limited clinical roles, and data consolidation efforts. Informatics was not a stand-alone cause of such reconstitutions of the patient, but it was part of and amplifying other healthcare system change.

An example of this amplification was Samuel's commentary on the private practice of thoracic surgery. Samuel expressed that private surgical practice has been decimated, or soon would be, by a series of systemic moves on the part of government to shift reimbursements for physician services to hospitals at a higher rate than private practitioners for the same surgical consult and procedure. Insurance companies were changing their policies for payment to out-of-network surgeons, which meant hospitalists held a financial advantage over private practitioners. What 'out-of-network' means is that an insurance company is obligated to offer out-of-network coverage if patients find themselves falling sick in an area that is outside the insurance plan's participating network of physicians. Out-of-network reimbursements for surgical care were fair compensation for services rendered; however, such reimbursements to physicians were often higher. As an example, in-network reimbursement would be four to five times less for the same surgical procedure. Surgeons who were in-network were held captive by the insurance company, and their compensation was determined by the insurance company and what they would pay for a particular procedure. In this way, the insurance company captured and in many ways controlled the flow of patients through the doors of physician practices.

Samuel's experience and his idea of "systems" grew more complicated. A surgeon who used to be paid fair compensation to save the life of a patient would now be sued by the insurance company for "overpayment" after the fact that the insurance company paid for surgical services rendered. The insurance company would ask for such funds to be paid back minus the in-network payment. A $250,000 complex surgical procedure would be reduced by $210,000 to $40,000 in compensation, more than an 80% reduction in physician compensation. If a surgeon was not in-network, he or she was punished, according to Samuel, for rendering care outside the insurance plan's network of chosen physicians and chosen flow of patients. Costly litigation would ensue, forcing the physician into arbitration and eventual settlement even though such fees were fair and customary and the insurance company had consistently paid them before. On this larger corporate level, insurers, according Samuel, "changed the game" at will. Such legal expenses could bankrupt practices like his. Samuel expressed that his idea of *systems* of wide variety was set within this financial and macroeconomic environment that he described as forcing thoracic care back into the hands of hospital management.

Systems in this regard were both clinical and data-driven: thoracic circulations, legal discovery documentation, depositions, consolidation among hospitals, fee schedules, late nights, legal fees, catheters, biopsies, and pulmonary function tests, 120-hour weeks, and lobectomies. These were not events or moments, but financial-administrative systems that perhaps were not changing at the same rate or in the same manner, but were exhausting his clinical time and demanding that he was always communicating, being legally deposed, rushing-off to the next surgical case, and attempting to keep-up with larger governmental policy shifts through texting, emailing, and attending seminars on the restructuring of healthcare. Samuel was always engaged with processes around, between, and for the patient, while not dealing directly with actual patients.

On another register, we can frame Samuel's anxieties about keeping his local surgical practice alive by looking at it as a particularly Deleuzian struggle. What I mean is that Deleuze suggested that we have left the enclosures of hospitals and clinics as disciplinary forms even though we may be periodically drawn back into such enclosures. We now may be experiencing new forms of cybernetic and computerized forms that demand our constant attention through informatics. The enclosures of old institutional forms have given way to open "cybernetic" systems. From this perspective, in disciplinary forms, one is constantly engaged with machines. In control forms, one is always engaged with modes of communication with functional mechanisms. These functions may appear machine-like and are not mechanical but are highly flexible data at the level of *subject* and *possibility*. Disciplinary society suggests interiority through physical or conceptual boundary; control society suggests exteriority through digital communication and digital circulations at the deepest level of the subject. On this level, we can regard Samuel's scramble to balance multiple demands as a surgeon as part of a control society in which he has great freedom of physical movement (he is affiliated with eight hospitals), and yet he has little freedom to imagine and gain a perspective on the possibilities of thoracic surgery beyond the overlapping legal, clinical, and administrative burden.

Another symptom of systems of control is the fact that such systems are "too big to fail" and yet their effects are highly localized: debt, litigation, ongoing communication.[5] On

[5] "Too big to fail" is a term coined to by Congressman Stewart McKinney in 1984. It was popularized in the 2009 book by Andrew Ross Sorkin *Too Big to Fall* that described the scale and size of certain corporations that could not be allowed to fail or go bankrupted. Such

the level of politics, Samuel's struggle was expressed as the fact that "doctors are poor advocates for themselves"; they, as he said, "missed the boat" when it came to collective bargaining for insurance reimbursements. Instead, doctors were becoming "heads in the sand" buried in clinical dedication while sometimes missing the larger structural changes happening to their incomes and modes of practice. In other words, doctors, according to Samuel, were puzzling-through how to imagine a different kind of medicine that did not objectify patients further through shortened visit times, codified diagnosis, and the centralization of patient data in hospitals. To "communicate" among systems had a different meaning in this context, "to manage the debts you would soon have, the sins of omission that you would soon see in patients' follow-up visits [due to hosptialist care], and a future you would not know how to build" on your own (Goldstein, interview with author, August 17, 2012).

If we can frame Samuel's comments in terms of a struggle between disciplinary and control forms, perhaps we can begin to draw a deeper respect for his insights. He was not saying that a future did not exist for thoracic surgery; rather, he was saying thoracic surgery was in transition, and he was sketching-out a figure of a physician that was being refashioned in the rise of macro governmental and insurance-based financial data transactions. We can see Samuel's puzzling-through his role as a surgeon as a kind of splitting-up of his expertise into three reductive figures: clinical data as massive financial transaction, the loss of a kind of surgical body that once mobilized local specialist expertise, and instant communication across growing systems of "quality assurance" that required his constant attention and

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effects upon the U.S. and global free market economies would be too disastrous. Therefore, being "too big" meant financially unaccountable at a certain level. It also meant being deeply connected to global systems of finance, accounting, real estate and computerized transaction.

created constant anxiety in the form of a perceived threat of electronic audit from such systems that could intrude upon his patient database from any distance, from any direction, and for any future purpose.

In control forms of organizing healthcare, instant communication should not direct us merely to texting, emails, phone calls, prompts or alerts on mobile devices. Instead, in this Deleuzian scene, "control" means a *psychic interruption* to the biomedical imagination and its efforts to envision certain forms of practice. I take Deleuze as referencing this deeper interruption not only to *how* we imagine the future but also to *what* kind of *thinking* becomes allowable in future forms of healthcare. We may be lost to imagine certain worlds because certain forms of thinking subjects are obsolete. In other words, certain thoughts, in control form, *are interrupted* on a deeper level than what and do not even come to Samuel. Yet he struggles and pushes forward. What I am pointing to is the operation of being immobilized by questions of how one might practice medicine in the near future. How was Samuel to hope, engaged in the possibility of, or plan for a kind of independent life in thoracic surgery that was, according to him, anxiously moving beyond his hands and into systems of computerized communication, Big Data, and robotic surgery? I am not rendering a negative picture of thoracic surgery and its practice: I am highlighting Samuel's attempt to retool his thinking among attendant imaginaries of the machine that offered both possibility and a threat to his livelihood as well as a way of caring for his patients.

On the level of metastatic disease (non-small-cell carcinomas of the lungs), Samuel's struggle appears differently. Lung cancer is typically characterized as a "silent killer." It is often associated with the smoking of tobacco. Medical stigma circles around lung cancer and patients who "did it to themselves." The stigma of self-harm, according to Samuel, leaves the patient with fewer resources for early disease detection and treatment at a curable stage. Lung cancer does not announce itself symptomatically until late-stage and often is incurable; therefore, periodic screening for the disease for those at risk is to be advised. Such late-stage effects have often blocked life-saving diagnosis and treatment. Silently, the imagination of thoracic private medical practice is being refashioned. At the same time, data consolidation and computerization are being announced by hospital representatives and IT leaders as improved efficiency and communication among physicians, insurers and hospital administrators, and shifting diagnostic orders. Samuel was deeply aware that computerized data represented and organized particular healthcare markets and did not guarantee such efficiency. The valued ore of computerized and correlative data was not evenly distributed or deployed and the same clinical data could be put to use for very different administrative reasons and clinical outcomes.

The case of Ethan: informatics representations in Pathology. In the following, I introduce you to Ethan, whom I met through my work in a community health center in which he served as supportive advisor to the Center's COO Irene. Ethan was at the Center for a short time and then moved-on to other projects. One of these projects was the development of clinical decision-making software in a pathology department. His background was as follows: from the 1990s, he worked in medical billing services and then with GE in applying software in ambulatory practices and then with various companies in clinical software programming. During the period of my fieldwork, he began working with a health information exchange (HIE) company and took on a Ph.D. in health informatics in which he focused on developing and applying an international standards language called SNOMED

CT to pathology.[6] His father had been a physician, and he had started medical training but decided he wanted to move in another direction. His knowledge of programming and medical data ontologies was extensive, and he was open with me in sharing his technical and clinical perspectives on BMI as he had encountered it in the field. Ethan's story specifically focuses on his efforts at using SNOMED and applying it to pathologies and micro-invasions of the breast. He worked to *represent physician's thinking* in the case of pathology. What this means was that he sought to make implicit physician thinking explicit so that it can be used again and again and consistently linked to disease phenomena. In Ethan's words, he was identifying the points when a "pathologist has as a finding…[in order to] make his or her thinking explicit and set in a language that can be repeated for the same outcome," a problem that he expressed "can be very difficult" (Thomlinson, interview, August 11, 2012).

Ethan spoke of certain problems in "building ontologies and languages that function for a certain domain of clinical knowledge, but may not fit with others" (Tomlinson 2012). Ethan was basing his informatics research upon SNOMED terminologies that have been widely accepted internationally. He expressed that he did not want to create a new ontology and language but instead modify an existing (ontological language) What does this mean? for new purposes. In observing how a pathologist reasoned, he was able to "break down the way [the pathologist] was thinking" (Tomlinson 2012). As he encountered pathologists in their reasoning, he began to ask, "What does he [the pathologist] mean by "nodular focus?" (Tomlinson 2012). From my perspective, Ethan entered a world of language and cognition

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[6] "SNOMED CT (Systematized Nomenclature of Pathology) was created in 1999 by the merger, expansion and restructuring of two large-scale terminologies: SNOMED Reference Terminology (SNOMED RT), developed by the College of American Pathologists (CAP); and the Clinical Terms Version 3 (CTV3) (formerly known as the Read codes), developed by the National Health Service of the United Kingdom (NHS). The final product was released in January 2002." Retrieved June 21, 2013 http://en.wikipedia.org/wiki/SNOMED_CT

that resonated anthropologically. Through the use of SNOMED, he was questioning how native thinkers think and symbolize their world:

> What terminology of consistent language can I possibly put…[nodular focus] into? So, [part of my research] is to put that into post-coordinated SNOMED. What I'm trying to do personally: [is to ask] can I represent his knowledge explicitly using SNOMED CT. But SNOMED in a pre-coordinated fashion would never work – we would have the proverbial combinatorial explosion of terms. But there seems to be enough expressivity in SNOMED to cover some of this, so how much of it can I cover?
>
> (Tomlinson, interview, July 27, 2012)

Even though Ethan was using one of the world's most comprehensive ontological languages for pathologists applied to informatics, SNOMED CT, no ontological languages existed to fully cover diagnostic expression of breast pathology. Working with limited expressivity, Ethan would observe pathologists saying, "*this* is a suspected region, and this is *why* [the pathologist] is saying *that*" (Tomlinson 2012). As he followed the way a pathologist named and identified, he was searching how to make these movements and decisions explicit. "If I can make [the clinical problem] very concrete," he could set out to find "the variant of the problem" (Tomlinson 2012):

> Was this ductal carcinoma in C2 or was it ductal carcinoma with micro invasion. And if he's asking that question then he or she would order up a particular set of stains and try to determine is there micro invasion into the epidemial cells into the stroma of the breast. And, so all of those are discrete thought processes and to the experienced pathologist these things have become just this implied thing that they know inherently. So how do I break it down, and that's what I call knowledge representation. I'm going to break that down. And I'm going to use SNOMED to do that. I am going to take the SNOMED syntax as fully defined in a post-coordinated sense as a clinical finding, and I need to know there's a location – [to find this location I ask] are these the ductuals, is this the stroma – what areas are defined anatomically to find this [particular] location. Is this in fact in the lumina of the duct and that's defined [enough], how do I define that? And what were those conditions under which I found that, and what were those qualifying events or descriptors of the findings. So if I find… let's see, if I were looking at a kidney I would be looking for a proliferation of a certain type of cell, or in this case I see a substance that's in one of the tubuals in the kidney and under a certain stain I see if that's either protein or lucidic or puss and those two things make a clear cut decision as a pathologist. By capturing their descriptions of what they go through on a normal basis I try to translate that, because now as I translate that, the computer can begin to think, not

> necessarily doing a computer aided diagnostic [CAD] yet, but if a pathologist could look at a digital slide they could highlight an area and call a [digital] descriptor out, and let's assume they got to the bottom level and they see it's a carcinoma status questionable for invasion that would trigger a clinical decision event, to say you need to pick out of these handful of stains to determine categorically or discretely is this in fact micro invasion or not. (Tomlinson, interview with author, September 28, 2012)

Ethan was designing the steps of decision-making and the predictive events that a pathologist deploys to properly diagnose carcinomas of the breast. He was aware that having medical terminologies of SNOMED limited him but also opened-up the possibility building an international collaboration of medical terms and processes. As he made me aware, he was not after perfection but in pursuit of a technical step forward. He was not looking for a perfect computerized ontology but a better ontology to perceive and ultimately diagnose breast cancer. Conceptualizing in an informatics of decision-support meant for Ethan to explore physician mind as a particular process of building and feedback:

> If we go into a…meeting and throw a potential concept out there in the general direction we want the group to go, we know we'll get all sorts of feedback. Because we've thrown something on the ground and given something objective to think about and it'll elicit their opinion, and it elicits their feedback. So, if we go at knowledge [the same way] and if I have SNOMED in the back of mind, I have something to start with, as opposed to starting with my existential white sheet of paper. Sometimes you have to go at a problem with an existential white sheet of paper because it's that new. Other things might not be so new and you know if we represent something that people are relatively familiar with, we can elicit all sorts of opinions on how it could be better, and in fact, it'll get better.
> (Tomlinson, interview with author, October 3, 2012)

His notion of clinical betterment was to work with and not against existing medical knowledge and codified syntax. He knew that many new ontologies were being created by informaticians, but as he stated,

> None of them are physicians, and how do they know, whereas here comes this whole body of pathologists internationally who have created some sort of [ontology]… they've defined their world and agreed on it, kind of. At least they know what their assumptions were when it was discussed. We can build off that and assume their knowledge and try to take that knowledge and form it into the categories we need them to be formed into, that really represents this *particular* area of knowledge." (Tomlinson 2013)

He acknowledged that there were terms lacking in SNOMED, but in his project at a diagnostic level, he was willing to work with that and build upon it:

> You've diagnosed the patient now, but we need to figure out ahead of that, and make it more translational. For example, it wasn't until the seventies that [such] stains were applied in pathology. And now [stains] are very prognostic of estrogen and progesterone receptors but then there are several [stains] that are diagnostic [that can help detect] where there's epithelial markers and myoepithelial markers typlfying micro invasion – these, there are not a Snomed expression for them …. there's not an expression for a CD34. There's not an expression for a smooth muscle myosin stain. Depending on the stain in which you use, really does determine how confident you can be in your diagnosis and differential diagnoses. (Tomlinson, interview with author, October 4, 2012)

The flip side is "there are terms people don't like," and they are excluded. For example the "term *lumen of something;* that's an empty space, [and] how do you put a definition on an empty space?" (Tomlinson 2013). Everything defined has already been included; everything that cannot be defined is set aside as an outlier and later encoded. What this means is that you code "by exception," he stated. Ethan was building upon pathologists' work, and yet he was creatively taking such medical data ontology to another level of representational efficacy. "Who's the guy that said perfection is the enemy of the good? If we go down the perfection path, we'll never get off ground zero" (Tomlinson 2013). Ethan was aware of the political challenges of building upon an existing ontological language; however, to highlight how informatics forges new alliances and organizational change, we now turn to the case of Irene.

The case of Irene – bargaining and negotiating a future of a Community Health Center. Found just off a busy Interstate, the Community Health Center seems like an outpost, a clinic that had set-up services in an area that had been undervalued and perhaps forgotten altogether by larger hospitals and an expanding healthcare system. However, now that health informatics had come into larger deployments and integrations across outpatient and inpatient services nationwide, the Center had become one of the key interests of a major academic hospital that has set-out to integrate the Center's regional coverage into a larger electronic health record. The Center had been attempting to evaluate and select an electronic health record system since 2008.

Irene was a dynamic woman in her late 30's with strikingly attentive eyes and the ability to multi-task while remaining upbeat and on top of her various roles as registered nurse and operations director for a busy clinic. Irene projected an ease in swimming through interruptions of phone calls, repeated knocks on her office door by staff, overhead announcements, and interns coming and going. Looking out the windows of her office (she often moved between offices), I could see families pulling-up and carrying their children up the steps of the clinic.

Outside Irene's office door was always a buzz of administrative and clinical activity, a kind of white noise, loose and disorganized on the surface. I came to learn that what appeared disorganized was in-fact very purposeful. This context of loosely organized tasks among busy clinicians and staff became the background to our conversations about EHR and informatics. Ideas were interrupted and picked-back-up, phones rang, clinical staff entered and exited. Our discussion had an openness to this ebb and flow. Clinical care in a CHC environment was a patchwork of colliding technologies, minute-to-minute clinical crises, cell phones constantly ringing, striving to meet state and federal funding deadlines, triaging of cases, and daily care to those who would otherwise be excluded from hospital medicine. In this spirit of interruption and urgency was something internal to each clinician, staff member, and physician: everyone had decided to work on the front lines of community clinical care and serve those who had no or little access to care. People loved what they did even if they complained about being exhausted and underpaid. No doubt there was dissatisfaction. But it was apparent that the RNs and MDs had chosen this course of work and saw the world of biomedicine differently from who or what, as a worthy struggle and advocated for their patients and families.

Such community centers might have struggled to keep their doors open in the 1960s and 1970s but were now multi-facility organizations servicing millions of patients nationwide. In this context, CHC was steeped in a history of struggle over bringing medicine to a community that did not always bringing themselves to the doorsteps of out-of-reach major medical institutions. Migrant workers, the homeless, members of marginalized communities, and those whose chronic conditions fell outside typical insurance reimbursements were the patients this CHC reached daily.

Irene's Center had modeled itself against larger medical institutions, and those very same institutions were now coming back in the form of data-sharing and shared system implementation. The medical data of front-line community health centers are now a valued digital commodity. Even though such a shift had not yet taken shape, Irene was attempting to figure-out how to communicate the data's revalued *potential* to her very busy executive staff. What was her CHC to do to address this incoming system change that computerized data announced but did not fully cause? Irene put it this way:

> How do I, a committee of one, convince my colleagues to hold onto our data when *communication, cooperation, interoperability, disease registries and population health* require us to openly share our patients with much more powerful institutions that have the resources and money to use our patient [information]. Sometimes I feel we are that place in Kansas, which probably never existed, but in my head it's a place that everyone suddenly sees value in, and they want to buy your land and home and give you a new life, and you wonder "what new life?" What am I bargaining away? What are we gaining for the clinic that will help us catch that next missed immunization or prevent that next diabetic? If we are that small patch that has been revalued by those who have the big IT departments, then what's our future when we lose Kansas?—when [computerized] data moves away from our control? (Cardoso, interview with author, January 26, 2012)

A few months later, I waited in the lobby of the clinic to see Irene. A couple with their baby girl and two young boys were waiting to be seen. At the front desk, a staff woman moved between phones and black sign-in folders that contained visitor's times of arrival. The lobby was not as busy as usual but still nearly full. The morning was cold and the radiators clicked and popped. Upstairs, one could hear footsteps, heels, and noises from clinical staff. Down the hall, the pediatrics department ran like a subway station—only a few minutes for a visit and yet families and their children were not treated as numbers. One of the boys approached me, held out his hand, announced that he was Joseph, and asked my name. He said that I was too well dressed (I was in a suit). But after scanning me with his eyes, he decided to say, "I like your jacket." His mom apologized and said to "leave the man alone." I said it was fine and laughed at his precociousness. He wore a dark blue shirt and tan pants. He sat down next to me and began thumbing through pictures in a pamphlet on influenza and annual flu shots. On a pale blue wall behind us hung clinic announcements. He ran back over to his mom, grabbed something, and ran back to sit next to me. He held a small portable gaming device and asked me to play. At that moment Irene came down the stairs and greeted me. The boy was disappointed and asked, "one more minute, pleeease." Irene smiled and stood there. I held-out my hand to shake his, but he looked at me with head tilted downward and said, "You don't' care what I like, only what *you* like." I said that was not true and if he was there when I returned, I would play his game with him. He was not convinced. Later, after meeting with Irene, I looked for the boy and wondered how he would one day share his likes and dislikes about the medical and healthcare devices of his life. What would his notion of care be when someone turned away from what he intimately held to be a valuable part of his authentic sense of self and wellbeing? Could the notion of health require intervention from devices to authenticate our likes and perhaps our likeness? Joseph's sharing of his gaming interests was a sweet and poignant moment. I didn't have time. I had to research other people who didn't have time either because of information overload or exhaustion from lifting-up a part of the American healthcare system that operated in the margins of care access. Informatics as deployed here was somehow close to the withdrawn but expectant hand of this child. Perhaps what the child was coming to represent in the realm of community medical data consolidation was that there was always enough time for data correlation and not nearly enough time for certain kinds of patients.

Irene's puzzle: Big Data. Irene's puzzle was how to articulate community-based clinical care in the face of Big Data collection and consolidation. The term "Big Data" is an accepted term for the growth of massively structured and unstructured archives of information that can be correlated. From a healthcare perspective, one of the goals of Big Data is to produce analytics that produce better clinical decisions. One definition of Big Data is "volume, velocity and variety" (Laney 2001). This means that as the amount, speed, and the types of data used (images, voice files, emails and financial transactions) grow, the applications of Big Data are realized. In other words, Big Data is realized through computational speed and availability of a wide range of data. Companies as wide-ranging as UPS, Facebook, VISA, the CDC, and Kaiser Health System as well as well as the National Security Agency (NSA) use Big Data and analytics to understand subtle correlations among events, people, behavior, the movement of things and transactions. Big Data is part of the IT revolution, but it can also be seen as an amplified Cartesian project to measure, document, and examine the world by mathematical extension.

To give further context to Irene's quandary with her colleagues, Big Data rolls-out as billions of bits. Small data roll-out like petroleum derived from conventional drilling methods. Big Data moves as today's "fracking" of information. By diving deeper into computerized information, Big Data shapes out of small data correlative potential for multiple and long-term purposes not always foreseeable in the present. Irene had a sense of Big Data but struggled to translate its long-term effects to her community health center colleagues focused on the day-to-day of their patients.

Irene had a puzzle before her: how to open her clinic's patient records to experts who may abide by all privacy and confidentiality laws, but who may not share in a common clinical future with her patients. Irene was skeptical not about the immediate life of her clinic's data but the future life of such data. In the hands of a healthcare system that did not know her patients' neighborhood, drive down their streets, walk their sidewalks, and attend the festivals held in the area, what kind of future was she being forced to reckon? Clinical care here did not shut-out the documented or undocumented person: it was open to all, but data could exclude and include. To *datafy* clinical information in a CHC setting may have different consequences beyond "data-sharing" with the local health system.

But what does *datafy* mean? In the language of Big Data, to "datafy" means to take a single point of information and give it multiple implications and uses; for example, the immunization records of Irene's clinic, alongside the clinic's visitation information, could always be used, if released in particular ways for insurance metrics on chronic care, for the purpose of redistribution of medical services. Once computerized information becomes data, the community clinical services provided over decades could serve for the exact opposite: to redistribute clinical care away from the poor and towards wealthier patient populations. This would leave Medicaid and sicker patients to be cared-for by overworked CHC physicians. Such computerized potentiality was not driving this possibility *per se*. However, it was suggesting to Irene to reconsider the idea of "community" in relationship to flows of computerized data.

Looking at the value of Big Data for community healthcare from a different perspective, there is no reason that the idea of *community* could not include sophisticated data-gathering processes based on the historical, neighborhood, transient, and familial aspects of a patient's life. But Irene saw her problem differently: for her, it was a matter of poor timing. It turned the notion of community as a form of belonging between patients and doctors into anxiety about clinical *survival* in a time of budgetary cutbacks.

Within a year of the health system's EHR implementation and data-sharing initiative, the Center had its 40^{th} anniversary. Its founding director had begun operations with a staff of three. When they stepped-down, there was a staff of over 200. As Big Data was tapping on the door, the executive management was changing. The new executive staff had preexisting experience and affiliations with the larger health system's data initiatives. In this regard, Big Data may not have caused such organizational change, but it shifted aspirations and the potential future plans of the staff and executive management to larger health system data aggregation. To be organizationally effective and clinically efficient, computerized data required changes in community care, even if incremental. The Center today has a new Director, Chief Financial Officer, and Director of Operations, and many clinical personnel have shifted roles or have left to make room for new personnel. What this means is that computerization as a set of tools never addressed this structural change in thinking, personnel, and which patients are to be transacted as large-scale data. What Irene had seen as potential change came in the form of real change through electronic health records and data-sharing as a set of "tools" that was explained to her as having no more impact than to assist in clinical reporting and clinical improvement:

> When we sit down with the board and the team and ask what is the involvement of the [health system]? Trying to understand implicit effects of this computerization effort [she mentioned] that the EHR was not "just a system," it was a way forward. "To a certain extent because of culture, and I mean *culture* [as] our institutional culture…. I can see them [the board] saying alrighty then…. this is our only lifeline. So they are going to use our data, and then okay, yes, in reverse we can use their data as well. But can we? (Cardoso, interview with the author, February 4, 2012)

She described in her communication with the health system that her Center could use the health system's data; but as part of its IT service agreement, her Center would have limited access to data and the health system would have "unrestricted access" to all patient data. But "at least" she said, "we're at the totem pole…we're here" and not left out of the clinical informatics revolution. "We need to keep our eye on this," a potentially unequal and long-term exchange of data and know-how (Cardoso 2012).

Concluding Ethnographic Observations. I have selected three separate examples that do not complete the picture of BMI today; they are ethnographic pieces of a much larger picture of massive late-modern informatics change wrapped-up in a healthcare system undergoing change. Specialist medicine and restructurings of community healthcare cannot be separated from informatics development. When we bring the machine, tool, and person back into a textured understanding of the effects of computerized data in medicine, a different picture of improvement emerges. Ethnographically, people are not being replaced with machines or computerized algorithms. Clinical minds are not being dumbed-down by the massive intelligence of Big Data diagnosis and targeted genomics as might be feared. Instead, people are attempting to make their worlds more effective and making their patients well. The context of community healthcare and thoracic care were occasions to reexamine the local effects of informatics as software systems being deployed among people and their expectations for bringing in new sets of tools when, in fact, they encountered a different level of transformation around and through the promises and functions of medical data. In Ethan's project of rendering pathologists' thinking explicit, he was not only finding a scientific object that he would fashion but also was refashioning pathology norms as they would be deployed diagnostically.

When Andrew earlier mentioned that a "good system" was one of "people working to make people better," he was suggesting complex systems that are sometimes partially conceived and understood and yet continue to be promising for biomedicine on many levels. In my ethnographic experience, when things fall-off project timelines, medical ontologies are built-upon and structural change comes to a community health center, a very human unfolding takes-place of people taking up medical data and science and shaping it to human ends.

V. Conclusion: Configuring Futures of BMI-Ongoing Emergence and Sites of Informatics

…if a machine is expected to be infallible, it cannot also be intelligent.
(Alan Turing 1947)

BMI's Continued Emergence and Organization

Within the widening influence of BMI on the American biomedical imagination, I have focused on how medicalized minds and bodies are refashioned through the concepts and technologies of Biomedical Informatics (BMI). My goal has been to make visible the larger organizing dimensions of BMI's continued emergence, or what has been termed *super convergence* accessible to anthropological investigation (Topol 2012). I have argued that the objects of informatics mark the human a digital machine with networked and correlative potential.

My point has been that BMI is currently restructuring modes of care and in so doing is reconstituting the earlier forms of medical informatics of the 1970s, 80s and 90s, pushing these modes of care in different directions by increasingly digitizing the human. Here, I have insisted that contemporary BMI has a wider constituting dimension upon medicalized bodies and minds than previous forms of informatics have suggested. The emergence of this new, highly digitized informatics body calls into question established notions of the human.

Post-Human and figures of informatics. As a precursor to BMI, cybernetics has presented ideas that medicine has attempted to incorporate. As social theorist Katherine Hayles has stated, cybernetics opened-up the body and subject to being "emergent rather than given" and "it is not a question of leaving the body behind but rather of extending embodied awareness in highly specific, local, and material ways that would be impossible without electronic prosthesis" (1999:291). The idea of "extension" and "prosthesis" here forges different consequences for biomedicine which challenge the fashionable turn in academic discussions about the "post" or "after" human. I imagine extensions of human differently, not as digital parts or large systems *per se*, but instead as positioning the human as occupying those spaces found *between* "organism and machine." It is perhaps Marilyn Strathern who best reminds us that we are not linked-up in "part/totality" relationships (2004). As humans, we are not extended into machines of Cartesian parts and added to an original and essential whole but humans experiencing specific anxieties in the relationship between the appearance of informatics objects and new kinds of bodily presences.

In considering such extensions and anxieties, I would like to share with you a few images that represent the tradeoff of too easily extending post-human ideas to BMI imaginaries. Paul Valery wrote in 1941 about two sets of ideas expressed by Socrates and the Hippocratic physician Eryximachus. As will be seen, each carries a very different implication for contemporary biomedicine. In Valery's story, Socrates represents a *form of living*. By living, he suggested intensity, or to live-out one's life completely. Living with intensity was not the living-out of one's biological destiny but an instance of self-awareness that extended beyond the person to others. The physician's passion was different: he was "interested solely in phenomena," refuting Socrates reflection on the art of living. Self-reflection prolonged his patients' suffering "each word uttered *here* adds a tiny grain of unbearable duration *there* to someone else's anxious waiting." To waste the physician's time was to delay him and increase someone else's suffering. The doctor tells Socrates to come down from his metaphysics to consider his own corporeal mortality, to function like the machine in him. Mortality is the ultimate functional reality, and we naturally, like biological machines complete with ticking clocks inside us, must breakdown. Socrates' passion to live grates against Eryximachus's passion for function. When Socrates has had about enough of this, he implores the physician to listen:

> Now you're causing me to entertain great fears about the very substance of my principle and my hope. If you can show me that you know me better than I myself, and can even predict how I'll be feeling next, seeing me already cheerful and full of life when I actually feel quite low and down in the mouth, there is surely only one conclusion–that my whole effort is puerile, that my intimate tactics fade away in the face of your entirely exterior art, *which envelops both my body and my mind within a finely woven web of exact knowledge, thereby seizing the universe of my person in one fell motion.* (2003:237)

In the above, we see Socrates' attempt to expose this finely-woven web of exact knowledge as an attempt to take back from medicine historically an ability to know self and from such knowledge come to know and gain meaning from changes within one's own body and mind. Gaining and holding this meaning brings-about an affective intensity for living. One lives with suffering and does not seek to flee from it or project it upon others. Socrates was resisting a massive enterprise that turned the experience of being into logics of a finely woven web of exactitude and correlation. The physician's exterior art was more than beneficent: it was a form of envelopment reducing the person to the organization of functional phenomena. Here, personhood was torn between indivisible human value and codifiable objective knowledge. When Kurzweil states that the complexity of the non-biological world has been exponentially increasing and "will match biological systems including the human brain (along with the rest of the nervous system and the endocrine system) within a couple of decades," we may begin to wonder if digitizing humans has Eryximachus's potentiality to seize mind and body in one fell motion or in Kurzweil's terms, in one "Singularity" (2005:475).

As I have observed ethnographically, such users of informatics as managers, physicians, and informaticians reach-out like Valery's Socrates to mark their place in the healthcare continuum while living with intensity. At the same time, they find themselves participating in Eryximachus's "exterior art" that risks reducing or redefining their efforts and patients' own experience of pain and illness.[7]

On another register and to provide more ontological and social depth, I introduce you to an imaginary patient I will call 'Irma.' She is a figure of BMI and very real in the world of Big Data, which means she produces rich digital information for future monitoring, observation, research, and biotech development. She is a patient undergoing lung cancer diagnosis and treatment. She could be you or I, facing the anxieties of walking into a surgeon's office and waiting for answers to very pressing questions. 'Irma' can be further considered a figure of computerized algorithms and medicalization: she is composed of varying degrees of acidity in lung tissue cells, properties of squamous cells, lung nodule calcification and volume, enzymes that enhance biochemical reaction—all archived in digital data repositories, 1-b lung cancer staging, greetings and co-pays with receptionists who are scheduling patients.

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[7] Eric Topol has suggested that a model of such digital convergence or homo digitus in medicine can be found by simply plotting out the recent development of our cell phones. Although our cell phones were a vague idea in the late 1970's, today nearly 70 percent of individuals sleep with them and that statistic increases for those under the age of 30. Cell phones have surpassed toothbrushes and toilets worldwide according to Topol. Cell phones will cover the planet by an unprecedented magnitude. Echoing a kind of Singularity of machine-human convergence in medicine, Topol creates an image of unprecedented technological distribution that has no historical rival except "other than human observation." Our cell phone resembles an active and generative biological entity: it images, sends, receives, learns, stores and we share our memories with friends and text our loved ones through its functionalities – we grieve when we lose one, we celebrate a new kind of kinship of mobile functionality upon a new major release. In parallel with such exponential growth, billions of bases of the human genome have been sequenced serving as a ground for personalized and targeted therapies (even if such usefulness of the human genome is debated). The Internet and online social networks have become an embedded and everyday part of people's lives, even if individually rejected by users. Health monitoring and diagnostics are becoming commonplace. According to Topol *super convergence* favors a kind of informatics body as our trust in large-scale medical institutions continues to wane. (Topol 2012)

'Irma' as an ethnographic figure. Walking into the lobby of a private surgical practice, one sees a group of patients. Some have gathered in chairs next to small end-tables; others are flipping-through magazines; some are staring at the bare waiting room walls; and a little boy is exploring the knees and shoe buckles of his aunt. Magazines are lined-up neatly on simple wooden tables. Rows of purple nylon upholstered chairs end abruptly at a sliding glass window with a sign that says "Co-pays are expected at time of appointment." Behind the glass sits a receptionist. Next to the magazines, a woman of stately features named 'Irma' pulls her blue purse close to her and flips through health-related magazines of young-faced celebrities. A diet pill miracle is announced in images of Miami estates and interview excerpts by a recent reality show star. She picks through front cover stories of exercise miracles and adjusts her posture, checking her cell phone that vibrates and chirps. She holds it out to me and says, "Can you make this thing stop?" I suggest she touch "this" button on her touch-screen to take incoming calls. She considers this for a moment and says "Don't bother" and returns to stories on exercise regimes and diet programs. Next to her, a man in his mid-70s with a portable oxygen tank tracks the glass entrance doors with this eyes. His eyes search the room as if expecting someone he can engage in debate, perhaps about sports. He is hardly a prisoner of the apparatus he wheels behind him. Irma's ringing-vibrating phone set catches his attention but he says nothing. Next to him a stout woman slightly younger, probably his wife, whispers affectionately to him, redirecting his attention to something they were previously discussing.

Across the hall, CT scans are being conducted with patients rolled in and out of a large donut-shaped machine. No cloud murals on the ceiling; just oyster-colored walls and shelves. A radiologist waits in the adjacent room for the scans to appear at his 3D Vital

Image workstation to render a clinical interpretation of lung-related disease. The patient's lungs are rendered visible against a black LCD screen—a grayish vascular system is separated from spongy peach-colored lung tissue. Here, the computer-displayed veins of the lungs appear root-like, branching-out into increasingly small capillaries. As the radiologist manipulates the images, producing various views of the lungs, he receives a call from his wife as the CEO comes in and informs him of technology updates and other pending business transactions. All this happens as the radiologist's computer screen is scanned to check lung nodules rotating on the screen in three-dimensions. An unwrapped tuna sandwich and diet coke sit to the side of the keyboard. Sheets of research on the early-detection of lung cancer are scattered among CDs containing software upgrades and files containing the sagittal and axial views of multiple patients' lung nodules and scare tissue. The toll taken by tobacco-use is visible in all the majority of these images. Work is ongoing.

Across the hall, the surgeon, a prematurely white-haired man over six feet tall, greets 'Irma.' They enter the exam room together and the door closes. I am right behind them and take-up a place in a small office adjacent to the exam room, waiting to interview the surgeon. I can hear phones down the hall ringing at the front desk and patients being ushered in and out of exam rooms. The wall between office and exam room is thin. During pauses, I can hear 'Irma' asking: "Doctor, is there hope?" and the surgeon responds warmly, "There's always hope for you." Distantly, papers are shuffled and faxes sent-out to referring physicians, and Valium and Ibuprofen are prescribed—movements that move along the warmth and trust that has settled upon patient and surgeon.

Later that week, 'Irma' returns and waits outside in the hall while her husband, a retired city manager in white windbreaker and baseball cap, slowly approaches the reception window. The receptionist's window squeaks across metal tracks as it opens. The receptionist asks, "May I help you?" He asks if his daughter might see her mother's medical records on her iPhone: she wants to send them to another doctor for a second opinion. The request seems reasonable. Everyone has a smart phone these days. However, the conversation becomes confused: Robert turns and begins walking away, asking "Who is HIPAA anyway?" Before walking out, he turns and walks back, knocking on the glass window. It slides open again. "My wife's records *are hers*, *right?"* he asks. The receptionist calmly says "Of course" and if he could "wait a moment," she'll have the doctor speak with him. He adjusts his cap mumbling "Never mind" and slips his wife's arm through his and walks her out to the hallway where they discuss something and then decide to take the elevator. 'Irma' looks back as if she's trying to remember something.

After her surgery, 'Irma' has returned for post-operative consultation. She is a little thinner than before. Taking the same chair as before, she waits with a straight back, attentively flipping through magazines. We know very little about 'Irma's inner world. Her pain and individual response to her operation go unremarked. She's a good patient, which means she asks the right number and types of questions. She does not confront those in charge of her care. As she *receives* care, we know very little about her life and how she lives through her post-op recovery. We know very little about her living with intensity through the phenomenon of her disease. We know absolutely nothing about her suffering and fears. Her illness narrative has been reduced, and yet we have a great deal of information about her physical states. We know that 'Irma' as a physiological machine has been quite sick. As her speculative patient history goes, she is

> A 71-year-old female with a history of diabetes, smoking, hypertension, hypothyrodism, chronic kidney disease, CAD, MVA, prolonged hospital stay at the local hospital for

> osteomyelitis of the right heel status post debridement with IV antibiotics x3 prior to this admission, bilateral pleural effusions requiring thoracentesis, pericardial effusion status post window. The patient was intubated, extubated, and found to have a left breast mass, sent to rehab after a near syncopal episode and post diarrhea, found to be hypoxic and admitted to the County hospital from rehab. Chest x-ray revealed bilateral pleural effusions and pulmonary edema. She was placed on BiPAP, given IV Lasix with improvement in her symptoms initially, but continued to have persistent effusions. She was evaluated by Interventional Radiology, had bilaterial chest tubes placed during her hospital stay here, and eventually chest tubes were removed. The patient continued to have reaccumulation of her left loculated pleural effusion. After multiple evaluations by Cardiothoracic Surgery and moderate-to-severe mitral regurgitation and that repair of her valve would help her CHF status. The patient is now being transferred to another hospital for mitral valve repair[8]

From this hospital discharge summary, we can picture 'Irma' with multiple life-threatening conditions. From a biomedical and surgical point-of-view, 'Irma' was a picture of systemic breakdown, needing to be repaired, intubated, and transferred to various hospitals for further evaluation and treatment. 'Irma' the disordered machine was being brought back into functional order through surgical interventions. All information here was essential to her hospitalization and treatment. She needed not one but a flurry of technologies and clinical coordinations if she was to remain alive. Passing our gaze over this picture, we say we would never want to be in this situation with so much costly invasive techniques entering our bodies, as Socrates would claim (Valery 2003). We may also say, should the occasion arise and we find ourselves in 'Irma's' place, that we would be thankful that biomedicine could save our lives, as Eryximachus would insist. We are not machines but have no problem deploying them, transferring their functions to us and ours to theirs and relying on them when they can make us better

'Irma' as a site of informatics and Big Data correlation. As information, 'Irma' will be shuttled back and forth between a new research project on lung cancer reoccurrence and her

[8] Complied from anonymous operative reports in collaboration with thoracic surgeons.

ongoing post-op and follow-up care. But as computerized *data,* 'Irma' will be demographically stored on databases and parsed for clinical outcomes based on newly arrived matrices on the effects of smoking-related illness on a generation of previous smokers. Information will also be stored on the efficacy of intelligent algorithms on the visualization of non-small-cell endocarcinoma and on robotic-guided surgical consoles, both of which were part-and-parcel of the care she has received. Similarly, the person 'Irma' who has entered her car and pulled onto a network of parkways as she heads home has entered into another kind of computerized system of data-relations that will be transacted, examined, archived, and assess fines and charges if she unwittingly violates a traffic law. Her car uploads data onto digital network via satellite that charts the durability of its break linings and rotors.

'Irma' also has other invisible lives as DICOM (Digital Imaging standard and format), as HL7 (Health Level 7, a standard for exchange of codified patient demographic information) and a series of laboratory tests and patient history, data models, and algorithms. 'Irma' is alive and archived in another kind of way through networked databases and always-ready clinical access. This "always on Irma" flows through Cisco network switches and spinning discs. There is no "off" button. 'Irma' is exchanged across hospital and private practices as is medically necessary, her fate realigned as another health system is leveraged by a private equity firm and moved on to convert Irma-data into outcome management algorithms, which is not medically necessary. The person 'Irma' owns no data models, algorithms, tests, or histories. As part of a research program, however, as a site of informatics, 'Irma' will continue to be aggregated as part of a novel long-term study of lung cancer survival and mortality rates. We will find her anonymized CT scans appearing in a powerpoint presentation given at a weekend conference about statistics and early detection rates. 'Irma' in the form of data for research, represented by axial CT and 3-D reconstructed images of her adenocarcinoma on spinning discs, is not 'Irma' who received her husband's greeting and support while leaving the doctor's office.

From the perspective of informatics, Irma's person may appear beside-the-point. After all her information has served its purpose in assisting physicians to improve her operative and post-operative care. However, her data keep *giving* as the surgical practice is purchased by a larger healthcare provider and Irma-data become part of larger databases. Now her data serve as a source of income and further money-generating transactions. Beyond this acquiring practice, the regional health system has been "restructured" by private equity, which has an interest in Irma beyond her thoracic surgery. Irma-data recirculate through private practice and health system, correlated to analytics which are used for adjusting life insurance and health insurance premiums. In the information-value chain, Irma's data-life begins to resemble a perpetual effervescence. The National Cancer Institute, American Cancer Society, and Mount Sinai Medical Center all have traces of 'Irma' to compare base-line chest CT's to routine scans to determine cancer rates among women born before 1940, married, and previous smokers with a per pack-year rate. On another level, 'Irma's data-life has left traces within the Bureau of Transportation and Pfizer who together have entered into a joint partnership to understand driving habits connected to smoking and other high-risk health behavioral norms. Irma's grandchildren have opened a Facebook account for her and rendered opinion on lung cancer treatment, which has left a secondary trace that follows 'Irma' in other ways. The Lung Cancer Alliance has read "her" posts on Facebook and has asked to interview her and her family. The machine of medical data speeds-on even though 'Irma' as a human must eventually slow down. Or will we?

As a site of Big Data, Irma's past determines her future. Potentiality is erased by probability. Irma will serve as data-points among other points of inference, social security numbers, tax files, insurance premiums, GPS location, and smoking behavior and per-pack a year rates. Major tobacco companies have secured her data and used them to redesign their delivery devices for optimal burn-time. Paradoxically, the Society of Thoracic Surgeons has included Irma in its STS National Database for quality improvement based on over 4.5 million surgical records. To use the figure of Irma as predictive correlation means that our healthcare and the predictors for disease may not be based on actual acts we commit in our lives but on probabilities that our *behavior implies*. The most innocuous and the most critical data become mixed and realigned in the free market of information gathering and exchange. The irony is that predicted behavior may prove more important than actual behavior in the projections of health and wellness. For Irma, her lung cancer was not *caused* purely by smoking but *correlated* via her widening relationships, Facebook "likes," connections, social media tags, interactions, predispositions that her genetic testing has revealed, and the National Cancer Institute's data-mining initiatives. Causation has buckled under correlation. Irma's data are *close-enough* to exact, but massive correlations are inexact but *large enough* to compensate for little errors. Now, under the god of probability, Irma has been projected beyond any possible life she might have led for the sake of agentic liveliness.

Here, 'Irma' as a site of informatics and Big Data splits-off into other directions. This splitting spans across BMI, from bench biology to clinical care and research to public health.

From a social theorist perspective, Patricia Ticineto Clough would place 'Irma's' condition within a certain kind of "machine" presence. As she wrote, "…I am drawn to the machine,

Because I am drawn in by the machine
that draws me out,
that draws me apart,
I am afraid that you will see that it excites me
being drawn out,
being drawn apart,
being drawn out into parts (2000:21).

This kind of imaginary has pointed to a human constituted by non-biological agents. In the case above, this imaginary has celebrated "being drawn out" into forms of BMI mechanisms of wide variety. Informatician Shortliffe has stated that the future of BMI will continue to expand along the lines of "incompatibility between the historical… and what is likely to occur in the future" (2012) which resonates with the Oslerian gap between the "possibilities and actualities" of scientific medicine.

As the figure of 'Irma' indicates, the use and reuse of medical data cannot be conveniently contained in time, place, or body. It is lively. As Michel Foucault in his apt description of biopower has written, "Power no longer recognizes death. Power literally ignores death" (2003:128). Our medical data live beyond us—some of the most intimate data about or sicknesses and health— and now runs ahead of our bodies and the institutional protocols put in-place to protect our privacy.

Anticipation and Consequence of the Continued Emergence of BMI

I have felt at times while conducting this work like Descartes' figure of a sleeping child who has had the sensation of being tickled and who has struggled to find the objects of the sensation. What this means is that I have felt that feather of BMI's promise of providing better and more efficacious and personalized health care run itself over my lips, and I have wanted to drift into a kind of future of wellbeing in which I would be cared for not by computerized systems beyond me but by someone who had the time to make sense of all my medical data and my intimate exchanges with my doctor.

In attempting to make sense of the uses and possibilities of medical data, I am reminded that there has always been a trade-off between freedom and the implementation of new medical technologies. Through the invention and uses of new medical technologies, we may often engage in a devil's bargain that promises extended life but with compromised mental capacity, the freedom from behavioral disorders at the cost of giving-up creativity or spirit and the freedom of choice with therapies that confuse the border between what we can gain on our own and correlations programmed to achieve forms of happiness and wellbeing in the brain (Kukuyama 2002). Such is also the case with using Big Data to establish the correlations necessary to providing healthcare. BMI has operated among such borders as bodily integrity, cell-line, data privacy, freedom of data-mining personal information, and ideas of information permanency and access.

One of the technical futures for BMI will be to expand translational analysis based on massive amounts of data from genomics, proteomics, metabolomics, and public health information. The idea from base-pairs to bedside will shift to correlations beyond biomedical domains including vacation spots, seemingly random keystrokes, epidemics, extreme weather, Google flu trends, health product purchases, infant mortality rates, and chronic conditions, to name only a few.

Furthermore, BMI has not determined what kind of bodies and minds have been selected to receive, for instance, data updates for "intracardiac electrograms recorded by…implantable devices" (Jiajia et al. 2013:1-2). When we think of what "implantable" can imply, we also see suggestions of its opposite, monitoring of ICDs (implantable cardioverter-defibrillators) that have the capacity of "*automatic or semi-automatic* data transfer" enabling ongoing "patient monitoring" (Muller et al. 2013:460-462). "We" as bodies and minds may be more updatable than we think, but our informatics systems and devices certainly are. The difference between a medical "me" and an informatics "me" may be increasingly difficult to establish in the growth of translational informatics and the turn to Big Data. In this way, an informatics body has been made possible and available by the tensions and anxieties of BMI's continually expanding place in American biomedicine, or what poet Rae Armantrout has expressed as

> The spray
> of all possible paths.
> Define possibility (2011)

What kind of medical care is at once deeply embodied, machine-like, and "composed of dimensionless points"

> which nonetheless spin,
> which nonetheless exist in space,
> which is a mapping
> of dimensions (2011).

The BMI that I have found, however, is not infinite, nor does it easily unify or enable the care of patients to be comprehensible. The tension that presents itself in BMI is *what* and *who* will be responsible for establishing unifications across the technium of intelligent algorithm and expanding database. Physicians have consistently provided needed resistance to the impersonality of computerized systems while at the same time adopting them and making them their own. Their medical knowledge and know-how, or aequanimitas mind as Osler proposed, or the puzzling-through tensions of efficiency versus efficacy of a thoracic surgeon, or the everyday trials of a nurse-practitioner in a busy clinic cannot, however, be reduced to rational mechanics. It appears that informatics does not anymore truly approach medical decision-making with such crude mechanics.

I wish to provide a quote from informatician Ira Kalet, who instructs students how to think and conduct themselves when creating projects that can make a difference in medicine. Though the ambition here may be large, he advises his cohorts to keep their scale of projects small and hold-fast to creativity of mind.

> I implore…[you to] keep things small, avoid building horrifically complicated user interfaces, or alternatively, keep the user interface code completely isolated from the really interesting code. Write code that you would be proud to have others read, that is clear enough that others actually *could* read it. Pay as much attention to the quality of the code you write as to prose.
>
> ….the great breakthroughs in biology and medicine, as in physics, will not come from automated procedures but will come from a strong dose of imagination. Sometimes, it is the imagination to put old ideas together in a new way. For a lucky few, it will be a truly great new idea. It is essential, however, to be able to take such ideas and make them precise, put them in computational form, to squeeze out of them their entailments, to then measure their worth. If that seems poetic, then you should write computer programs that are poetic. [As in] the words of Theseus, from the beginning of Act V of *A Midsummer Night's Dream:*
> *The poet's eye in a fine frenzy rolling, Doth glance from heaven to earth, from earth to heaven, And as imagination bodies forth The forms of things unknown, the poet's pen Turns them to shapes, and gives to airy nothing A local habitation and a name.*
> (2009:605)

If we find a future of care "that bodies forth the forms of things unknown," we must investigate our assumptions pertaining to clinical improvement across computerized effects that are massively shifting *who* and *what* has access to care as well as access to care data. Technology does not fix or repair technology—although this has been the most common way of patching together broken hospitals, reviving clinical expectations, and masquerading worn ideas as novel treatments. In an informatics based medicine, we as anthropologists have a remarkable amount of work to do to examine the figure of the human and non-human in a contemporary that will no doubt grow more complex through the uses and potentialities of computerized biomedical data. This human and non-human interplay is less a battle that can be won *for* or *against* human: it is a form of awareness of the freedom from, and threat of, becoming machine-like in caring for and responding to others.

Anthropological Relevance: Machine-Human Interaction

In this section, I wish to offer a few thoughts that I share with anthropologist Veena Das and ethnographic notes from my encounter with CEO Andrew of a thoracic surgical practice. These are musings about the nature of machines that we imagine may save us from our human vulnerabilities by promising new bodies, new medicines, and new ways of mending and augmenting the human body and mind. Bodies are not machines or non-machines although we have seen historically that the biomedical imagination has consistently taken-up the challenge to show the difference. The representation of humans as machines can make appearances in the form of rote subjectivity (a machine-within) that can turn our world lifeless and "drain us of life" (Das 2010) and change our relationship to what constitutes the human. I have often wondered, and continue to investigate, how we, as researchers, scientists, informaticians, physicians, and patients may arrive at bodies that are available to the deep forms of care made possible by a deeply machine-like medicine. Is this possible? And if so, what bodily experience are we moving toward? I share Das' anxiety:

> The being-machine is one instance of non-life embedded in my experience; that I could become machine-like or mechanical is a bodily experience for me. It is not just that I have skeptic[al] thoughts that make me intellectually wonder "what if I were a machine?", it is about a deep embodied experience of myself becoming mechanical in certain situations, producing machine-like reactions, which I fear (2010).

As may be assumed in such informatics-based medicine, we do not lose our humanness or the touch and care of a physician; instead, as patients we begin to take on, as subjects, a different ontological relationship, a different kind of fusion with things and medico-informatics effects. And, as a result, the *inside* and *outside* cease to have stable signposts. Classic philosophical ontologies that set boundaries between people and things begin to breakdown under the pressure of informatics objects and systems. An informatics body mathematically codified and engineered as computerized locations is not *the, my,* or *your* body. Here, bodily limits are always potential for informatics revision and suffering.

Similarly to Veena Das, CEO Andrew puzzled over a *machine within*. Andrew's optimism was mixed with deep caution for the unpredictable behavior of informatics objects: servers in which spinning discs failed, claims of seamless software application, promises of better patient data, and massive networked adoption data across bodies and disease broke down. Andrew was calling for a certain kind of fortitude, optimism, absurdity, and quickness of thinking when considering informatics-based medicine. Conveying the pace of things was very important to him as it brought-out contradictions in established ideas about the human as a machine:

> I have seen physicians pound cafeteria table tops over software updates; a software engineer come down to check on [computerized] systems when upstairs his father was in the ICU; love letters scrolled across HIPPA compliant computer screens; patients on gurneys for hours in ER hallways in highly "wired" hospitals; I have left wine tastings that turned to shouting matches between medical directors and administrators arguing over the cost of wine versus the cost of remote monitoring; I have seen insurance company reps claiming they're providing *everything* for physicians and the value of a human life could not be higher, then a physician rising from her chair and stating that they pay her pennies for a consult with a dying patient in hospice care; I have seen paper work-arounds for electronic records in a so-called paperless world; internists hording paper records in their office and orthopods hording x-ray films because as they said they have a difficult time remembering from a [computer] screen, they need their hand in the game; I have watched patients ecstatic for their negative and thorough diagnosis and depressed it was offshored telemedically; I have found patient satisfaction surveys on the

> floor in a palliative care wards; I have come to feel that when someone uses the word "broken" to describe U.S. healthcare they're sure it doesn't apply to *their* doctor; I have seen [medically] successful low-tech solutions in high-tech settings crossed off of budgets because they lacked 'marketability.' …. I remember after my mother passed away, that my father handed me a trunk full of photographs and I saw my mom in one of them with me probably a year old held up in front of a television set and some gadgets on a table that my father had taken apart, and as far as I know I'm still over that table of gadgets and screens that'll leave my hands… managed someday by others.
>
> (Anderson, interview with the author, May-July 2012)

I believe that BMI would not have this wider potential "leaving" our human hands were it not for the fact that sites of biomedical care are becoming ontologically revised and revisable.

Conclusion: Computing the Incomputable and Homo Digitus

In my encounter with BMI the "machine" as a condition of massive data correlation, I have investigated realms of puzzling through the computerized in everyday modes of care. I have sought a tension in medicine in which figures of binary and quantum expressions impinge upon the value and kinds of medical interventions we imagine and bring into being. I have suggested that agencies of supra-human forms represented by Native cultures that modern scientific medicine had apparently surpassed have returned through new circulations of computerized error and benefit.

First and foremost, I have proposed a conceptual space to reconsider "machine" as a tension in informatics-based biomedicine. Our strong preference for the natural over the artificial, as Hahnemann has suggested, provokes questions: what acts, human and computerized, have liveliness and will stand in for and continue to possess the possibility of therapeutic improvement?

Secondly, we can treat the objects of informatics among Big Data as a move away from tool-building *per se*, as is commonly stated in the discipline, and instead to a kind of mind that is open to understanding how particular forms of *knowledge* flow, not identified only as experts, patients, physicians, and engineers but also as “individuals who can make creative contributions,” as Friedman has stated (2004:170). It is precisely here that Osler was calling for a new form of thinking and feeling in scientific medicine. For Osler, if you were to be an effective physician, it was not enough to be a tool-builder; it was not enough to be full of scientific instruction that “becomes cold and lifeless” in the lab; it was not enough to be experienced in “second-hand information derived from books”; and it was not enough to be steeped in scientific precedence. Instead, he promoted “elasticity of mind” through reading poetry “after a worrying subject in physiology” or a mental-emotional attitude deployed in the act of diagnostically observing, with uncluttered attention, to a patient’s sufferings (1904:214). He properly saw that a kind of new medical expert *as subject* had to be born based upon the “mental status”… particularly in his outlook upon nature” (1913:1). In seeking-out such flexibility of mind, Oslerian empiricism sought to build a figure of the “whole man” who had a computational appreciation of scientific data, deeply-held compassion for patients, and a steady capacity of mind.

In examining BMI, I have taken the machine as an instance *between* life and non-life and as a location of suffering extended into rapid circulations of medical data. I have conceived of such a conceptual space within these agentic flows and computerized algorithms upon the person. On another level, an informatics body suggests a *skeptical* space in which mind and body are an object of ongoing augmentation by computerized code that cyberneticists both called-for and warned against in regard to large systems of *control* that included biological, information and societal systems. Put simply, I have often suggested a skeptical form of awareness among massively flexible and correlative forms of *informare* in biomedicine. On the register of the philosophical, Stanley Cavell addresses this kind of skepticism among machines through which we may “speak of the body as a condition under which we inhabit the world, a condition that might be otherwise” (1994:7).

In considering such a position, we should keep in-mind that I am putting forward a concept that is not a Singularity of the artificial machine-learning or machines breeding upon their own clinical data points but instead an affective space that looks to clinical betterment and the rise of unanticipated effects of computerization upon persons.

From my perspective, this is a deeply human condition that might be otherwise as computerized data impinges upon physician autonomy and individual moral responsibility. This angle of thinking is akin to what poet C. K. Williams has termed “knots of purpose.”

> crossing over boundaries we’d never known were there until we found
> ourselves beyond them

and later in the poem.

> knots of purpose we would touch into as surely as we touch the rippling
> lattice of a song. (2006:383)

Human engagement with biomedicine falls into and out-of knotted relationships with machines. I have constantly offered a conceptual space to consider this wider BMI imagination and to pause on the local anxieties when informatics has come as a kind of rippling lattice of a song.

Decades before BMI crystallized into the sets of promises, practices, and data correlations it is today, IBM scientist and engineer Rolf Landauer suggested that the binary basics of information, ones and zeros, are not *in* our world until they *become our world* in physical form. Information as *informare* is deeply human-constituting and “is always tied to a physical representation—“a spin, a charge, a hole in a punched card, a mark on paper.” BMI emerges from scientific imagination in this conceptual space between the “possibilities and restrictions of our real physical word" (1996:188).

Informatician Ethan wants to be clear about such embodiments: computational forms are not people, and yet we constantly are on the lookout for what they can offer in the form of biomedical improvement. People are not ones and zeros: his colleagues are "humans that are trained who have a professional skill-set but we can't treat them as if they weren't human, because that doesn't make sense. It also does not compute. That forces them into a box." And as he remarked later, the non-computable of informatics was working within such physical limits; it was also working with imponderables and reversals in thinking about biomedical problems that extended outward. As a developer of informatics systems, Ethan was well aware of the possibilities of precise diagnostic algorithms and the effort in working through codified rules in breast pathology. In his case, such problems in pathology had to be computed differently in order to see them and then represent them physically. He had to imagine these rules as *possible and not fixed.* Ethan expresses a larger question that lurks in BMI: "Is there an algorithm for every human decision?"

> In pattern recognition in pathology, people are trying to find… all the tumors [abnormal findings]… Well I would like to say, how about show me all the tissue that is normal and rule that out and show me the stuff that doesn't compute as normal and let me make a decision on what *that* is. Instead of computing for everything that is *possibly wrong,* how about I compute for everything that is right and then show me the things that don't equal right, and then we can get a handle on a clinical decision."
> (Thomlinson, July 27, 2012).

BMI's empire of determination suggests this possibility, and yet Ethan resists this machine image of care for others as fully computable. He would rather work against the abnormal and find what is right, what is missing in the diagnostic normal. He works *back* to human care. He circles around a question I have been circling: that human care does not compute, and yet we cannot retreat from the computable in biomedicine because the human cost of machine would be far too high.

In bringing you the imaginaries and effects of BMI in American medicine, I myself have journeyed into these mechanical and human becomings. No doubt I will continue examining my own machine-like reactions and my wakeful awareness as I discover these experiences anthropologically, and they in someway discover me in my care of others.

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Biography

I come from the arts and sciences. I was initially trained as an artist graduating from School of Visual Arts in New York City and California Institute of the Arts. While at CalArts I investigated experimental film and installation work that deployed computer and audience interaction. I was fascinated with how automated procedures and people commingle in institutional and public settings. My work has included installations in museums, scientific display, and galleries in the United States and Europe. I have wrote screenplays professionally for experimental and conventional feature films and continue to develop projects for online and offline media.

As an anthropologist and informatician I have brought my fascination with machine forms of thought and action to biomedicine. This has been a rewarding process that has spanned well over a decade. As an informatician I have worked in large academic medical centers, community hospitals and private medical practices with the goal of improving the decisions and clinical outcomes in the care encounter between physicians and patients. The artist within has never been far from my mind in seeking better therapeutic approaches. What this has meant for me is that my ethnographic aspirations that continue to move between the arts and sciences will continue to explore new forms of design between people, data, systems and human expectations that are not always evident or currently built-into complex software or biological agents.