Biotechnicity 2.0: Computation-enabled Philosophical Advance in the Epistemology of Human Biology and the Ontology of Bioidentity

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Abstract

The accelerating rate of technology development and its ubiquitous proliferation is leading to a shift that technology can no longer be seen as merely an external object, but rather its new presence must be acknowledged as becoming increasingly and inextricably linked with humans and human behavior, particularly in the areas of health and biology. The ultimate end of this linkage is potentially a full integration of organic and inorganic matter. The interrelationship of humans and technology in the health context is helping to reveal more about the reality of biology, and serving as a tool for how humans interact with themselves and the world, a sort of biotechnical interface or biotechnicity. Biotechnicity 1.0, a passive data collection interface, is already evolving to biotechnicity 2.0, an interactive process that humans are having with technology in contexts relating to their own health and biology. From a computational philosophy perspective, biotechnicity 2.0 can be seen as emergent computation-driven philosophical advance in both epistemology, as knowledge is questioned and generated, and in ontology, as new ways of being are created. New computational tools in the form of hardware, software, and human computing networks are allowing knowledge to be developed and the definition of health knowledge to be questioned through participatory health initiatives, and

ontological shifts are occurring through the impact of this new knowledge. Biotechnicity 2.0 is an important tool for practical advance in medicine, and for philosophical advance in truth elucidation, human agency, and the re-conceptualization of the subject-object problem.

Keywords: computational philosophy, computation, philosophy, philosophical advance, philosophical discovery, technicity, bioidentity, biotechnicity, health, participatory health, epistemology, ontology, metaphysics

Introduction

From a human standpoint, the rate of growth of technological advance seems to be accelerating in many different fields simultaneously. This is impacting the human experience at different levels extending from immediate visceral reactions that might include overwhelm, to a more studied reflection of how technology may be changing what it is to be human, and what it is to be a living being in this world of increasing technicity. Further, technology is not just an external object, it is becoming increasingly linked with biology, both revealing the true nature of human biology and serving as a tool for how humans interact with themselves and the world, a sort of biotechnical interface or biotechnicity. Whereas biotechnicity 1.0 could be defined as the general idea of applying technology to biology, biotechnicity 2.0 could be seen as the interactive process that humans are having by engaging with technology in contexts relating to their own health and biology.

The central claim of this analysis is that the use of the computational tools of biotechnicity 2.0 (hardware, software, and human computing networks) is leading to computation-driven philosophical advance, in epistemology as knowledge is questioned and

generated, and in ontology as new ways of being are created. New kinds of knowledge about human biology are being developed through participatory health initiatives such as preventive medicine, and ontological shifts are occurring through the effects of this new knowledge. The paper is structured in five parts: discussion of the relevant computational tools, epistemic advances, ontological shifts, limitations of the analysis, and future implications. Figure 1 provides a summary of the relevant computational tools, epistemic advances, and ontological shifts. Figure 2 demonstrates the use of a computational model by providing a word frequency analysis of the manuscript, allowing the gestalt and areas of emphasis to be observed at a glance.

Figure 1: Overview of biotechnicity 2.0: computational tools and philosophical advance.

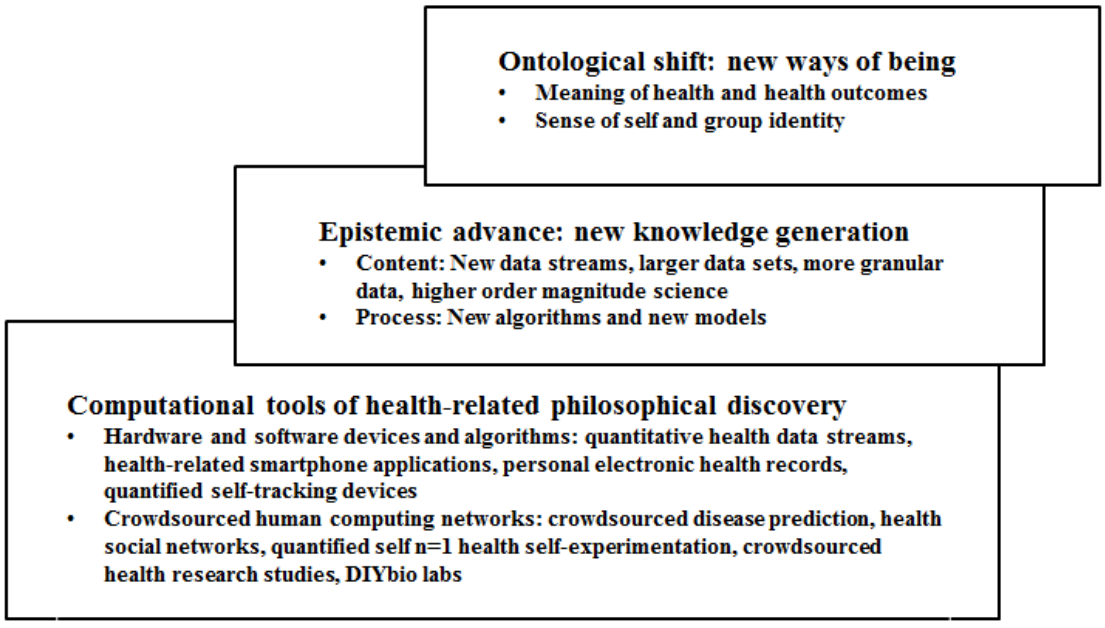


Figure 2: Word frequency analysis of this manuscript.

Terms and definitions

Western philosophy is organized into the broad categories of metaphysics, axiology, and epistemology (Cronk 2008). Metaphysics is the philosophical investigation of the nature of reality, being, and existence, and includes the categories of ontology (being in general), cosmology, and theology. Axiology is the philosophical investigation of the nature of values, and includes the categories of aesthetics, ethics, and social/political philosophy. Epistemology is the philosophical investigation of the nature, source, and limits of knowledge and truth (Cronk 2008). Ontological arguments may be used to discuss the problem of the existence of God (Oppy 2011), but are used here exclusively in the context of investigating the nature of being human and biological.

The computational tools of philosophical advance

Technological advance is the key catalyst of current philosophical discovery in health and biology. There are two relevant categories of computational tools: hardware and software, and human computing networks. Biology has become an information science as the contemporary discovery process relies upon the digitization of data through high-throughput automated hardware tools, and the subsequent quantitative analysis of these data. Some fields such as genome sequencing have seen a rate of 10x improvements per year as compared with traditional Moore's law improvements (1.5x per year) experienced in semiconductors and other hardware industries (Proffitt 2009). Research professionals use hardware and software tools to elicit and analyze a variety of biological data including genomics, gene expression profiling, microbiomics, and metabolomics. Health data tools are proliferating in the consumer-based market as well with over 7,000 health-related smartphone applications as of April 2011 (Boulos 2011), and millions of individuals using personal electronic health records and quantified self-tracking devices like the myZeo sleep tracker, Fitbit activity tracker, Scosche heart rate monitor, Telcare glucometer, and Withings scales. Health data streams could reach one billion data points per individual (Hood 2011) and exabytes of health data overall in short order.

One result of having large data sets and analytical tools on the internet is that individuals using these tools serve as computing networks themselves, both as individual nodes and through mass collaboration (Swan 2012a). The human community computing model may also be known as crowdsourcing. Crowdsourced models have resulted in otherwise impossible novel discovery, for example in the contemporary biology challenges of protein folding and RNA synthesis where final structures are non-canonical and difficult to predict. Some examples include determining the crystal structure of the M-PMV retroviral protease (Khatib 2011), using Markov state models

to discover new folding pathways (Lane 2011), predicting previously unreported signaling interactions (Prill 2011), and finding that human-designed RNA sequences were superior to algorithmically-designed sequences (Lee 2011, Allday 2011). The trend in collective intelligence community computing is demonstrated in participatory health through crowdsourced disease prediction models for influenza (Todd 2011), health social networks, n=1 self-experimentation communities, collaborative group health studies, and the advent of local DIYbio (do-it-yourself biology) labs providing a venue for citizen science biology education and experimentation.

Epistemic advance

A key epistemic concern is understanding the nature of knowledge. A claim can be made that new knowledge, new kinds of knowledge, and new questions about knowledge regarding human biology are being developed through the computational tools of participatory health (hardware and software tools, and human computing networks). The new knowledge is both content-related and process-related, and can be analyzed through both traditional notions of knowledge derivation (e.g.; rationalism, empiricism), and more recent propositions such as knowledge being a context-dependent process (Williamson 2000).

Content

Ubiquitous computing and the computational tools of participatory health allow a wider variety of biological data to be collected for more individuals. There are several novel and valuable aspects that include new data, differently available data, and richer data: the data streams may be information that was previously unavailable (e.g.; genomics, microbiomics), the data may be available now in an on-going, high-volume, cost-effective manner to large numbers

of individuals on demand (e.g.; sleep-tracking data), and the information may be of higher value due to meta-attributes collected about the data (e.g.; time, location, physical state, mood, etc.). These data are contributing to knowledge generation at the basic level in areas such as preventive medicine and wellness maintenance, and at the systems level in the phenomena of aging, disease progression, and neural processes. The more granular data allow research to be executed in cohorts with much greater specificity than in the past, for example directly targeting individuals with certain genomic, biophysical, and prescription drug use profiles.

Increasing computational capability both technically and through human online connectedness means that science can be conducted at orders of magnitude greater than before. For example, recent studies were able to recruit thousands of participants (versus hundreds) in months (versus years) (Do 2011, Dufau 2011). Both the quantity and quality of scientific knowledge is improved as not only is more knowledge being generated, but the knowledge has the quality attributes of greater certainty and specificity. Another epistemic advance is the increasing ability to manage health at the n=1 level, predicting that a certain drug may work for a particular individual, rather than employing the traditional trial and error prescription method where drugs have a 20-80% chance of working depending on the drug because they were tested in a population which may not be representative on the relevant dimension (e.g.; age/gender as opposed to the presence of a certain genetic mutation).

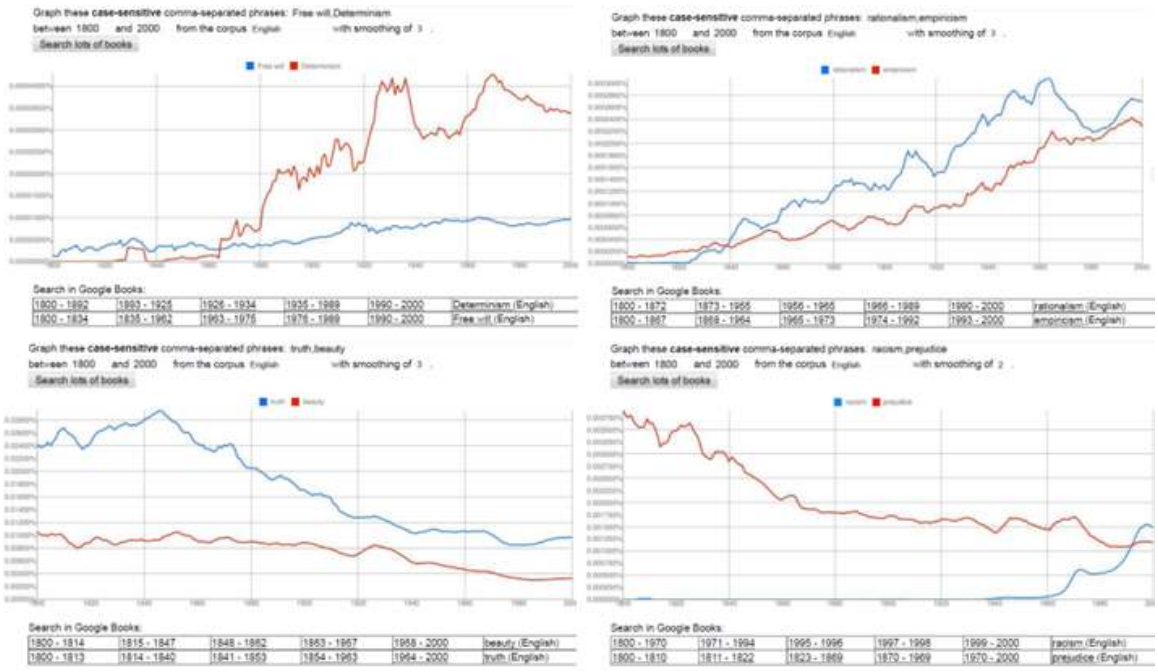
Process

A second category of knowledge generation is process innovation in participatory health computation through new algorithms and new models. The modern era of larger data sets and improved computational tools is helping to advance many fields, including artificial intelligence

and public health. Some examples include machine learning, anomaly detection (e.g.; fraud and spam), and natural language processing (e.g.; question answering systems like IBM's Watson). A quintessential example is Google's success in spelling correction and language translation where progress in natural language machine learning allowed statistical methods to be applied to large data sets (Halevy 2009). Simple data analysis techniques were successful after decades of specially-designed algorithms showed little progress; a key point was finally having a very large data corpus.

A recent example of computational epistemic advance though the application of straightforward algorithms to large data sets is the 'culturomics' project which engages in the quantitative investigation of cultural trends (Michel 2011). The project team generated a 500 billion word data corpus from 5 million books (4% of those ever printed) and analyzed word usage frequency. The resulting tool, the Google books Ngram Viewer, is available on the internet (http://books.google.com/ngrams/). The tool provides a means of measuring cultural and linguistic phenomena that allows unprecedented quantitative inquiry in the social sciences and humanities. Regarding public health and philosophy, the project found that peaks in the use of the word influenza corresponded to dates of known pandemics, and that Freud is more deeply ingrained in the collective human consciousness than Galileo, Darwin, or Einstein (Michel 2011). In a simple computational philosophic application of culturomics, Figure 3 finds that determinism occupies more thought than free will, rationalism and empiricism are somewhat correlated but rationalism is more volatile, truth and beauty have become devalued over time, and racism and prejudice remain entrenched as a cultural concern.

Figure 3: Linguistic and cultural trends as measured by word use in simple philosophical concepts 1800-2000.



The other area of process innovation in participatory health knowledge generation is in the development of new computational models. Collective intelligence human computing communities have arisen in the form of health social networks and collaborative health studies. Health social networks are online communities where individuals can discuss and inform themselves about conditions, symptoms, and treatments, provide and receive support, self-track data, and engage in health research studies. Crowdsourced health research studies (e.g.; those that obtain participants from health social networks and other internet-based means) are emerging as an important resource for public health knowledge creation. Studies are being run by both professional researchers (e.g.; PatientsLikeMe, 23andMe), and citizen science participants (for example through communities like DIYgenomics, Genomera, and the

Quantified Self). One emergent phenomenon is the professionalization of crowdsourced health research studies into large-cohort protocol-rigorous controlled blinded studies (Swan 2012c). The different kinds of crowdsourced health research studies are helping to stratify the public health research ecosystem and offer important complementary methods to traditional clinical trials as a computational mechanism for generating human biological knowledge (Swan 2012b).

Ontological advance

Ontological and metaphysical concerns focus on the nature of reality and being. A claim can be made that new meaning and new ways of being are arising from the new knowledge. Not only is new health knowledge being created, but humans are relating to it in different ways, which gives new meaning to the knowledge, and meaning to how the knowledge relates to humans and the notion of being human individually and in society. Figure 4 shows the three levels at which new meaning may be being generated as applied to two examples of the new knowledge that has been generated.

Figure 4: Ontological framework of the meaning of participatory health knowledge.

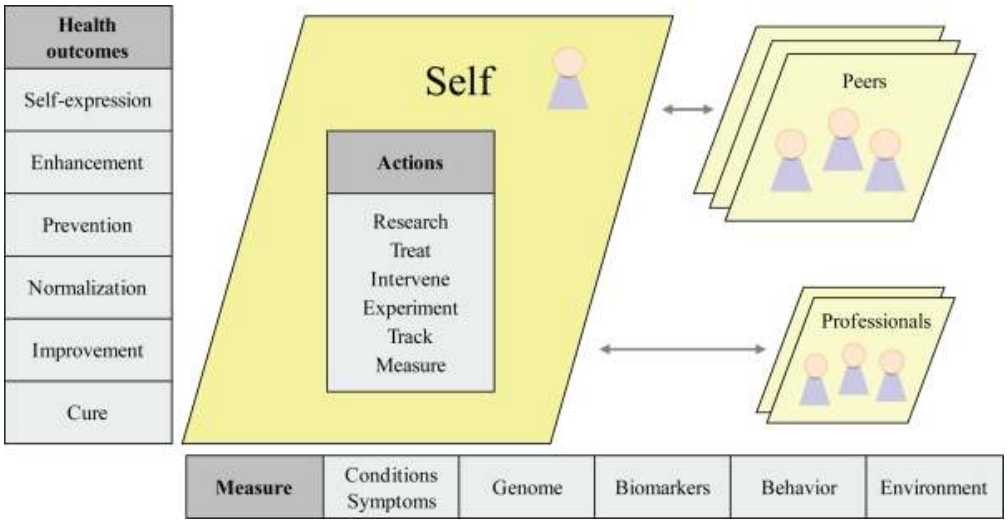
The new knowledge…	**Example 1: Whole Human Genome Sequencing**	**Example 2: Crowdsourced Health Research Studies**
What it means (generally)	Finite data regarding the 3 billion allelic base pairs in human DNA has been obtained	Indication that groups of individuals are interested in participating in collaborative health studies
What it means to personally to an individual	Ability to look up the presence of mutations in certain SNPs (single nucleotide polymorphisms) in a personal genome	Ability to participate in a health study of personal relevance and possibly obtain an individually-meaningful outcome
What it means to the sense of being human	Ability to address disease in new ways with greater specificity, possibility of humans not having disease	Model for how groups of individuals can work together collaboratively towards a scientific goal

While ontological shifts may be occurring at the three levels specified in Figure 4 in the case of any specific new knowledge element generated, there are also at least two global participatory health ontological shifts which may be identified. These are changes in the meaning of what it is to be healthy, and in the sense of self and group identity that an individual may have.

Expanded definition of being healthy

Knowledge derived from participatory health is helping to expand the conceptual scope of health from the traditional focus on disease cure to the personalized and preventive medicine of the future. Figure 5 illustrates this new model of health and health care. Health outcomes may extend from cure to improvement, normalization, prevention, enhancement, and self-expression. The expanded range of health outcomes is achieved though the measurement and integration of multiple health data streams including traditional medical records, genomic, physical biomarker, and self-tracking data. The individual thereby becomes the nexus of action-taking, in collaboration with peers and more distantly, health professionals.

Figure 5: A new model of the meaning of health and being healthy (Swan 2009).



Shifting notions of identity

Participatory health initiatives are also causing the sense of self and group identity to shift. At the individual level, access to computational tools and group collaboration opportunities has enabled biotinkering, health hacking, and agency-taking. The old notion of "my physician is responsible for my health" is being replaced by "my health is my responsibility, and I have the tools to manage it easily and effectively." The transition of biology to an information science has promoted the destigmatization of health issues and a realization that no individual is perfect. Another aspect of identity that is shifting is the false belief that an individual's genetic data is really his or her own, as it is shared with family members and haplotype groups. Identity and policy agendas may start to be expressed by health cohorts with similar profiles rather than disease communities. Further, there is a developing notion of biocitizenry, that sharing personal health information or using it as a currency for gaining access to studies, and being a citizen scientist could be considered acts of citizenship (Levina 2010, Irwin 2001).

Limitations

One of the most obvious philosophical limitations of this analysis is that there may be concerns such as values, ethics, and morals that are outside the realm of science (here including computing) that cannot be addressed in the claim that computational models are leading to epistemic advance and ontological shifts in health and biology. However, other non-computational methods could be used to support the claim, computational methods could be created to more directly probe the claim, and it might be possible that computation is not subsumed in science and in fact may be able to aid in the philosophical discovery that is claimed

to be outside of science. Other philosophical limitations could arise regarding the definition and justificatory standard for knowledge, however a working definition of knowledge and examples of correspondent and pragmatic if not coherent truth for the epistemic and ontological beliefs can be enumerated. Another philosophical limitation is the concern that rising biotechnicity is now in control of man, that man is dislodged and objectified (Harrison 2005). This is a valid concern, however, biotechnicity though increasingly influential seems to bring as an end more control and value to humans by allowing greater individuality, particularity, and subjectivity of experience.

Practical limitations of this analysis could include shortcomings related to computing such as data quality and the computational accuracy of software algorithms. Additionally, there could be validity issues with participatory health knowledge since it is coming from newly derived models which may have initial inadequacies to be corrected over time. For example genetic risk assessment models are yet to be standardized (Swan 2010), and there is concern that scientific rigor is lacking in crowdsourced biology projects (Swan 2012b). Another category of limitations relates to limits on the cognitive capability of humans: humans may only be able to take advantage of a small portion of the vast possibility space afforded by computing due to perceptual limits.

Future implications

The farther future of participatory health could extend to having billions of real-time health data points per person streaming into a continuous personal health information climate that makes ambient behavioral and mental performance optimization suggestions in a fully-integrated way that would be unthinkable to be without. There could be many moments when the then-current present would be sufficiently dissimilar to any previous present, as the world

discontinuously shifts through Kuhnian paradigms and Foucauldian epistemes. The paradox is that on the one hand humans become increasingly dependent upon biotechnicity for mediating and interacting with the internal self and the outside world, while on the other hand biotechnicity is providing a richer, more detailed, more granular, more personal relationship with the world. It is precisely because of biotechnicity that a more profound relationship with and vision into reality can be realized. Further, biotechnicity is helping to open up choice, allowing multiple viewpoints to be seen and biases to be counteracted. This results in increased liberty and consciousness, a clear step forward in the Hegelian progress in the consciousness of freedom.

There is a significant opportunity to explore computation-driven philosophical discovery in the area of human biology more thoroughly. Just as Descartes opened up one's own mind as a self-sufficient subject that contemplates objects, biotechnicity too is opening up a new domain to the individual, the quantitative knowledge and control of one's own physical self. The Socratic ironic inconsistencies in the current conceptualization of human biology afforded without biotechnicity can be exposed with participatory health as a means to a Kierkegaardian understanding where the most important truths cannot be transferred from one mind to another but must be arrived at independently and existentially. This recasting of self-agency could be yet one node in the progression towards being able to understand and direct all biological processes, eventually integrating human and computing platforms into bio-hybrids that are ultimately a merger of subject and object.

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