

The Lore of Biomedical Science Policy; The Case of Brain Science.

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Part 1. The folklore of biomedical science policy

Folklore, an accumulation of popular myths and beliefs relating to a particular place, activity, or group of people, plays an important role in the creation of community with shared values and culture. So while it is understandable that the creation of a folklore is an important component of sustaining a sense of a shared culture of all those who hold a vested interest in the biomedical research enterprise, folklore might not be the best way of guiding the substantial investment made by the US government and private funders in biomedical research.

Yet, it is common for the leading voices of biomedical research (for an example see the 16 February 2016 Wall Street Journal interview with NIH Director Dr. Francis Collins) to advocate a desperate need for increases in biomedical research. The calls to increase biomedical research funding rely on a number of assertions comprising a folklore repeated in most, if not all, public discussions about biomedical research funding including media coverage and op-eds in national newspapers.

A compelling component of folklore is the promise of *a* magical solution to a complex human dilemma and appears in stories as, among many others, the sword in the stone, the Holy Grail,

Aladdin's lamp, or the silver bullet. The common thread of magical solutions runs through the promises of the War on Cancer, the Human Genome Project, the Cancer Moon Shot, the Decade of the Brain and the BRAIN Initiative. Scientists will publicly support these initiatives but know that short term infusions of cash for slogan-ed, big push efforts are not going to magically solve our ills. Disease advocates know all too well that over the past 5 decades biomedical research has claimed much but delivered little value to patients with the most serious of diseases. Each of us knows someone struggling with neurodegenerative disease. Each of us has had a family member or friend die of cancer. So why do scientists and advocates rely on the language of hype and hope when talking publicly about sustaining the research enterprise? One answer is what other choice is there in light of the way US politics determines science funding and the unscientific way the pie is sliced.

In my conversations with academic scientists and disease advocates it is clear that they believe spinning folklore is necessary to keep "the public" enthusiastic and supportive. Research advocates, particularly those representing patients, also believe the messages at the roots of biomedical funding folklore (we are on the right track, progress is nigh) is essential for convincing donors and legislators to remain supportive. But is this talk good for biomedical science, itself? Does the launching of large targeted initiatives and the rhetorical baggage they carry with them to garner public support exert adverse effects on research? What are the consequences of scientists who repeat folklore so often they start believing their own stories? Progress against messy, complicated problems involving diseases and health requires a willingness to question and analyze assumptions and claims. The un-skeptical acceptance of

folklore's assertions is at its core unscientific – shouldn't scientists be scientific about the data and arguments of research funding decisions?

We all have a stake in the health of biomedical research. The acquisition, replication, validation, and ultimately the clinical translation of new knowledge requires adequate and sustainable funding and a smart, motivated, well-trained workforce. However, it is clear from the growing body of reports concerning irreproducibility, statistical misinterpretations, translational dead-ends, and clinical trial failures, that a serious effort to evaluate the ways and means of biomedical research investment and its role in improving health and well-being is overdue. Biomedical scientists, funders, disease advocates, and “the public” need honest, authentic dialogue about the funding and conduct of research. Such discussions will likely mean difficult and necessary conversations on what progress in biomedical research means for the different stakeholder communities. Confronting biomedical research funding folklore is a necessary first-step. Some of the core messages of biomedical funding folklore include:

The answer to every question is “more.”

An unquestioned belief among scientists and advocates is that biomedical research is woefully underfunded and desperately needs “more.” But how much more? I call this the Goldilocks Dilemma – how can we ever get the funding just right? The total funding available for biomedical research is higher today than it has been in the past 50 years. Why do biomedical researchers feel underfunded? Why do many advocates believe their disease is getting

shortchanged? Part of the difficulty is that biomedical research is space, personnel, technology, equipment and disposable supplies intensive. Increase funding a bit and academic medical centers and research institutes build more labs, hire more faculty (typically into soft-money, grant reliant positions), recruit more students and postdocs, and buy and upgrade equipment and technology in an endlessly expanding and ascending spiral. The constant physical and personnel expansion yields the shrinking funding ratio – the percentage of funded to submitted proposals. The decreasing *percentage* of grants awarded becomes *de facto* evidence of the need for more. But the funding ratio is dependent on the value of both the numerator and a denominator and the biomedical research spiral assures the increase in the denominator will always outpace that of the numerator.

Patient advocates contribute to the lore of more by equating the amount of money allocated to a disease with the likelihood of a cure. Focusing on ‘how much’ distracts from asking “for what.” Focusing on the money issue derails any effort to have sophisticated and nuanced conversations about the values by which we could meaningful measure the societal return on what is, in reality, a fairly sizable public investment.

The lore of more can also appear in the guise of the “lore of less.” The lore of less provides a pre-emptive answer to the question why biomedical research has failed to deliver on the promises it has been making for more than 50 years. Any lack of progress is the result of biomedical research getting “less” than other national investments such as defense. The lore of more and the lore of less depend utterly on the belief that biomedical research is doing all the

right things needed to improve the human condition and the key to success (however defined) is doing more of the same.

Questioning the lore of more publicly is difficult because anyone doing so is branded as both uncaring and anti-science. Diseases that have large constituencies (cancer, autism, and dementia) - garner broad and bi-partisan support limiting the opportunities for engaging in policy discussions concerning whether or not the current funding is enough and invested where it is likely to yield the most good for patients.

You never know where the next breakthrough will come from.

Serendipity, the chance occurrence of beneficial events, occupies a central place in biomedical funding folklore. Much the way a gambler stays at a slot machine because a win is “due” – biomedical researchers and advocates are reluctant to shift support away from a line of research even when the available evidence indicates persisting is unlikely to hit the jackpot. Considering its strong belief in the serendipitous nature of scientific discovery, the biomedical research community also believes in the power of peer review to pick winners and losers. If we really cannot know where the next breakthrough might come from could it not as likely emerge in the course of a badly designed series of experiments as from well-designed ones? Does it make sense to launch top-down, expensive, targeted initiatives? The lore of serendipity makes it almost impossible to question the wisdom of investing in lines of research where there has already been significant investment and where there is a community of researchers and advocates

convinced the next pull will ring the bells. I think it could be possible to make principled decisions about how best to use federal funding to achieve health goals, but doing so will mean broadening what needs to be known about human diseases and on how to determine measurable outcomes that include the public good.

If we are not ahead then we must be behind.

The fear that the US will lose its leadership of biomedical science creates a lore that geography is destiny. Often, I read that a justification for the US to increase biomedical funding is because “X Country” is doing so, when in truth what Country X is actually doing is increasing research funding at a higher rate than the US but still the actual dollars invested remain lower than total US investment. Still, the lore of competitiveness is a strong element of biomedical research funding folklore and exerts strong influence on science funding policies. Research practices are increasingly global and collaborative. Why would we think that knowledge has to be created in the US to benefit the US? The generation of fundamental and translational knowledge that leads to treatments and interventions seems more likely to arise from a strong, creative, global biomedical research enterprise where people and ideas seamlessly cross borders. Diversifying the biomedical research community might be a way to enlarge the works space and diversify the questions, the approaches, and interpretations brought to the problems we are seeking to solve. Knowledge is not a zero-sum game.

Are there alternative conversations that researchers, advocates, and policy-makers could engage outside of the folklore of more, serendipity, and competitiveness? Can the biomedical community think of alternative ways of organizing and sustaining research on human health? In my opinion, this conversational change will have to be driven by the “moral-suasion” of patients and patient advocates and by leading non-for profit organizations sharing the philosophy that investments in knowledge generation should serve as social venture capital invested for public good. The conversation can be helped and supported by policy scholars developing tools and metrics by which the ROI on social venture capital could be assessed by different stakeholders. Journalists too, could contribute significantly to the conversational change by investigating the claims of biomedical folklore – not in the spirit of ‘gotcha’ but in the sense of uncovering new ways to tell a story.

Part II Case study: Brain science

“Brain science” serves as a case study for exploring the adverse impact that can occur when the folklore of biomedical science and all its good intentions lead researchers, funders, and research advocates to unwittingly or deliberately overstate or misrepresent scientific findings to achieve a mutually beneficial agenda – in this case more funding for brain-related research so problems can be solved with brain-related solutions. (Private funders join researchers and advocates because fulfilling their own objectives often depends on the leverage provided by government funders.) The political culture of government funding for scientific research, with annual appropriations divvied up among competing interests, means that to be successful

lobbyists, the constituencies with shared interests in advancing research on brain-related research have to bond together with a unified (and ideally) simple story. The simple story behind “brain science” is: science is revealing the deepest mysteries of human nature by studying the structure and the function of the brain and with this knowledge comes cures for neurological diseases and for long-standing social problems. As a neuroscientist I am completely onboard that studying the brain is exciting but I am baffled by the claims of “brain science.”

Is the “brain science” portrayed by public relations effort and by the media, providing the needed solutions to the problems afflicting the most vulnerable among us (and for whom funders and advocates often claim to speak) – individuals suffering from neurological impairments, children growing up in poverty or stuck with marginal educational opportunities, the aging and persons with disabilities coping as best they can in unsupportive environments?

If we abandoned the simple story of “brain science” could we find new ways to talk about and invest in the knowledge generation and knowledge applications that might offer a different path to solving the difficult health and social issues tied to a better understanding of brain, mind and behavior? How might the scholarship of SCISIP contribute to fostering and supporting such change?

The invention of “brain science?”

“Brain science” is frequently used by scientists, policy makers and research advocates (including private funders) to describe research linking brain to behavior. “Brain science” does not represent a field of research, but is a social construction arising from, in my opinion, misdirected good intentions. “Brain science” employs the public’s fascination with all things “brain” to increase the visibility and funding for research seeking cures for devastating neurological

diseases and interventions aimed at important social-behavioral issues. The creation of “brain science” derives in part from a desire of neuroscientists and cognitive psychologists to connect their research with important societal concerns (aging, criminality, poverty, violence) and from the belief of policy makers, funders and advocates that re-framing social-behavioral problems as brain problems would be more likely to grab attention while providing support for (often pre-conceived) solutions with new evidence from a “hard science.” Unfortunately, “brain science” as constructed, promulgates misconceptions concerning what we actually understand about brain, mind, and behavior and creates obstacles to fulfilling the expectations of those most invested in its success.

The variety of important societal and health issues pinning the likelihood of solutions on the hopes and promises of rapid progress in “brain science” is mind-boggling. Researchers interested in linking their work to important problems and advocates seeking hard science support for their policy recommendations are coming together around the idea that understanding the human brain is key to designing effective strategies for diseases interfering with brain function and issues that were previously the realm of the social sciences: criminality (<http://www.sciencealert.com/childhood-lead-exposure-has-been-linked-to-aggressive-crime-later-in-life>), addiction (<https://www.drugabuse.gov/publications/drugs-brains-behavior-science-addiction/preface>) and educational disparities (<http://www.economist.com/news/special-report/21688592-practically-all-young-people-now-go-school-they-need-learn-lot-more>).

In my readings, it was in the popular press and in advocacy documents that I first noticed the use of “brain science” to represent something other than what I considered a small part of the diverse landscape of academic neuroscience (much of neuroscience has very little if anything to do with

the study of the brain). “Brain science” appears as an amalgam of neuroscience and cognitive science, psychology, behavioral social sciences and pop culture. The big tent of “brain science” welcomes (and somehow finds linkages), across basic cellular neuroscience, systems neuroscience, comparative cognitive and behavioral psychology, economics, ethics, and the vast field of computational science/artificial intelligence.

While “brain science” touts its sophisticated new technologies visualizing brain functions at multiple temporal and spatial scales, its ability to observe and manipulate neural circuits and networks in creatures with simple nervous systems, the power of *in silico* computational research, and futuristic bioengineered smart prosthetics – it maintains a somewhat unsophisticated, folk science relationship with behavior. The claims made for “brain science”, by both scientists and non-scientists are reminiscent of historical (eugenics) and contemporary (genomics) promises that biological science offered fairly straightforward salvation from the perceived intractability of human (e.g. mental illness) and social (e.g. poverty) conditions. As philosopher of science Helen Longino discusses in her elegant book *Studying Human Behavior*, attempts to link from biological sciences to social behaviors rarely make an effort to consider how our assumptions, values, and folk theories are deeply infused into research concepts. Researchers, funders, and advocates need to be as careful with just how deeply our concepts of behavior influence the conduct of research – even to the way we shape the most basic of questions.

Distinguishing advances in neuroscience from progress in “brain science”

In 1990 the Decade of the Brain was declared by Presidential Proclamation 6158 because:

...a new era of discovery is dawning in brain research. Powerful microscopes, major strides in the study of genetics, and advances in brain imaging devices are giving physicians and scientists ever greater insight into the brain.

Research may also prove valuable in our war on drugs, as studies provide greater insight into how people become addicted to drugs and how drugs affect the brain. These studies may also help produce effective treatments for chemical dependency and help us to understand and prevent the harm done to the preborn children of pregnant women who abuse drugs and alcohol.

Augmenting Federal efforts are programs supported by private foundation and industry. The cooperation between these agencies and the multidisciplinary efforts of thousands of scientists and health care professionals provide powerful evidence of our nation's determination to conquer brain disease.

Twenty five years, the recently announced BRAIN Initiative sounds an eerily familiar note:

In the last decade alone, scientists have made a number of landmark discoveries that now create the opportunity to unlock the mysteries of the brain, including the sequencing of the human genome, the development of new tools for mapping neuronal connections, the increasing resolution of imaging technologies, and the explosion of nanoscience. These breakthroughs have paved the way for unprecedented collaboration and discovery across scientific fields.

The striking similarities in design of these two national public relations and funding efforts to propel “brain science” forward include 1) an appeal to making good on the great wealth of

progress recently made and 2) a future dependent on large collaborative networks of researchers, funders and advocates. I encourage interested scholars to read and compare the original announcements and subsequent press coverage each has received. However, I find the differences introduced by the intervening 25 years even more interesting on closer examination. Leading up to the Decade of the Brain, the development of the tools of molecular biology and biochemistry had ushered in the era of neurotransmitter pharmacology. A dominant focus of research was elucidating the function and dysfunction of signaling chemicals in brain disorders, neurodegenerative diseases, and mental illness. Once we just got our neurotransmitter and neuromodulator ducks in a row – balanced our serotonin and our dopamine – all would be well. Both researchers and funders talked about the brain as a though the chemicals were what mattered even though a fair amount was known about the rich cyto-architectural structure of the brain and its complicated wiring. Two decades of disappointing clinical trials based on the basic science and pre-clinical research findings ensued. Today's BRAIN Initiative is proposing to tackle the same problems. This time around the quick solutions will come, not from chemicals but from tools: the technological advances of neuroimaging, network science, computational modeling, big data, and nanotechnology. Maybe. To be clear, the progress in neuroscience has been astounding. Thanks to remarkable advances in molecular biochemistry, genetics, and imaging technologies neuroscientists have exquisite descriptions of neural organization and functions. The sheer volume of research published since the launch of the Society for Neuroscience in the 1970's is staggering. What about the progress promised by "brain science" on the issues funders and advocates care about? How much progress has been made in the effective treatment of serious neurological diseases or mental illness? Where are the promised advances in education, rehabilitation, and poverty? Has the significant

investments, both human and capital, in “brain science” yielded meaningful return? In my opinion, the answer to the foregoing questions is “no.” To be fair, the human central nervous system is complicated and complex; we should not expect that research will provide answers quickly or easily. Unfortunately researchers, funders and advocates are not willing to engage in authentic conversations about why the past 25 years (and the 25 years prior to that) saw little progress against the serious multi-level, multiscale problems needing to be solved. Why? A cynical response might be that funders want impact, advocates and policy makers want evidence, and scientists need funding. A less cynical answer to the why question is that funders want to contribute to the common good, advocates care passionately about finding solutions to their issues – be it health-related or societal, and scientists need funding to carry out the research that contributes to human knowledge. Unfortunately, aligning knowledge generation with identifying meaningful solutions and serving the common risks gradually eroding efforts to engage in authentic communication.

Below I describe five obstacles “brain science” poses to progress against important health and societal issues that will not be overcome until researchers, funders, and advocates develop an authentic way of talking about the complexities governing brain, mind, behavior, health, and societal issues.

Five obstacles

1. Using “brain” to mean “mind.” Much of what is presented as “brain science” is actually cognitive science or cognitive psychology. A closer reading of the funder’s or institutional press release, the scientific paper, or the advocacy report proclaiming that “brain science” has now demonstrated something new about (insert your favorite

behavior) reveals that the findings discussed are psychological. A careful analysis of the experimental design often reveals that if there is any brain data (or appeals to brain data) such data adds no new information to the behavioral or psychological phenomenon of interest beyond the claim “that the brain does it.” Claiming the brain plays some role in behavior is only interesting if there had been credible suspicion that consciousness and cognition were carried out by an organ other than the brain and implemented independent of the nervous system. Writing in the Guardian in 2013, neuropsychologist Vaughn Bell provides what I think might be one of the best short summaries of how using replacing mind with brain leads to serious misconceptions about what we understand about ourselves <https://www.theguardian.com/science/2013/mar/03/brain-not-simple-folk-neuroscience>.

2. The exquisite sophistication of the technological capacities for measuring and monitoring different components of brain function using imaging, “omics”, and computational neuroscience constantly butt up against scientists’ and nonscientists’ (especially research advocates and journalists) lack of conceptual clarity concerning the target of “brain science” investigations. One important misconception is that there is such a thing as *the brain* to be studied. Brain structure and function can be studied and described at temporal and spatial scales ranging from milliseconds to years and from micrometers to meters. Typical levels of analysis in brain science include molecular, cellular, circuits, networks, and systems. Integrating across these levels and making sense of data obtained at different levels remains a major theoretical and technological challenge for which there is not an easy solution. Reductionist approaches do not work for complex systems.

3. The study of non human “model organisms” when it is not possible to study the phenomenon of interest in humans results in what might seem a paradoxical mix of anthropomorphism and anthropocentrism. Problems of distinguishing what we know about the functions of the human from what we know primarily from studies of non-human brains introduces errors that are both anthropocentric (other species are only interesting in what they reveal about us) and anthropomorphic (assigning human characteristics to the behavior of other organisms). Attending to surface similarities can cause scientists to ignore deep differences in the many ways the nervous systems of species generate behaviorally appropriate responses to the challenges proposed by the environment. Louise Barrett provides a detailed discussion of how endowing other species with human characteristics in her 2011 book *Beyond the Brain*

<http://press.princeton.edu/titles/9425.html>

The slow or non-existent progress against some of the most devastating neurological diseases is one consequence of relying on studies with model organism, primarily rodents, with an anthropomorphic and anthropocentric approach. Human neurological diseases including autism, depression, or Alzheimer’s do not naturally occur in non-human animals and attempts to create models of human disease in rodents or other model organisms must fail to capture the full scope and context of the disease processes. By pursuing for model organism research that does not honor species differences researchers are often responding to 1) the need for the simple story and 2) the demands for cures made by funders, and advocates. In reality, no one is truly getting what is most wanted –

a deep understanding of human neurological diseases processes and what could be done to alleviate the suffering.

4. Both what scientists and non-scientists think they know about brain, mind, and behavior are heavily influenced by our intuitions, pre-conceived notions, and folk theories about how our brains work. Contributing to the development of folk understanding is the accessibility of “brain science’s” scientific language. Many “brain science” terms are equally at home in the laboratory and in colloquial contexts. Having a common language makes it easy for “brain scientists” to discuss their work with non-scientists and for non-scientists to fall prey to thinking that because they can attach names or words to complex phenomena that they understand the phenomena (what psychologists call the illusion of explanatory depth). For example, the word attention can be used in reference to cognitive abilities measured by psychophysical laboratory based tasks completed in milliseconds or to the ability to sit still, possibly for many minutes if not hours, in class. The sensorimotor transformations by which a worm moves directionally along a thermogradient, an organism’s ability to complete a forced choice reaction time task, and the deliberations a family makes about whether or not to buy a house can, in scientific papers and popular press reports, be called “decision-making” but doing so does not, by itself, make it so.

5. An important concept in “brain science” is plasticity, the capacity for the brain’s structure and function to alter in response to experience across the lifespan. However, the influence of experience and prior knowledge tends to be discounted in the claims by

scientists, research advocates, policy makers and journalists when the findings of “brain science” are used to rally support for social messages ranging from the benefits of universal pre-kindergarten to the lack of inhibition in teenagers. “Brain science’s” use of accessible language to describe changes in brain function (lighting up, switching off, effortfully, automatic) belies what we can actually say about how the biological activity of the brain gives rise to cognition and behavior. That the brains of children taught specific information and then asked to perform tasks dependent on knowing the taught information “look different” (measured with relatively insensitive brain imaging techniques) than the brain measurements obtained from children not taught the information but asked to perform the same task is evidence for the role of experience and or prior knowledge in behavior but not evidence that there is something fundamentally different about their brains. Jeffrey Bower’s critique of educational neuroscience, published recently, in *Psychological Review* provides a comprehensive analysis of the kinds of misconceptions and mistatements often made by the claims of “brain science.”

Needless to say, “brain science” is also susceptible to all of the usual problems inherent in research (lack of replication, difficult publishing negative findings or findings challenging the status quo, favoring and promoting research findings that agree with intuition and common wisdom assumptions) but the reinforcing interactions of scientists, funders, advocates, and policy makers created “brain science” so there could be neurobiological evidence supporting policies and interventions that, have at their core, nothing to do with the functions of the nervous system but are conceived and designed to be operationalized at the behavioral, institutional, or societal level. Researchers and funders who call for restraint in the claims-making of “brain science”

more often than not find themselves in the awkward position of defending their views as though they are putting forth the argument that they do not want to see advances against devastating diseases or to improve the lives of children in poverty. Intentions, never mind how well-intentioned, backed by folk science could very well lead to mis-informed policies that fail to achieve goals while squandering precious resources.