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5PERSPECTIVES

The Omega Point and Beyond: The Singularity Event

We're a crowd, a swarm. We think in groups, travel in armies. Armies carry the gene for self-destruction. One bomb is never enough, the blur of technology. This is where the oracles plot their wars. Because now comes the introversion. Father Teilhard knew this, the omega point, a leap out of our biology. Ask yourself this question: Do we have to be humans forever?

Don DeLillo, *Point Omega*[1]

As the universe evolves toward its maximum organized complexity, it is said to reach the Omega Point. "Omega Point" is a term coined by Pierre Teilhard de Chardin to describe the evolution of our universe.[2] A Jesuit who later abandoned the traditional teachings of the Roman Catholic Church, Teilhard de Chardin was a philosopher who also trained as a paleontologist and geologist during the first half of the 20th century. He extrapolated the concept of a spiral galaxy to include the entire universe and out of this forged a unique philosophic viewpoint. His universe was compromised by 2 fundamental forces: tangential or rotational (which he also called matter) and radial or centripetal (also called love). Centripetal forces lead to involution—that is, transforming a state of disorganized complexity into a more organized one. The end result of this involution is the Omega Point or the end of the world as we know it. At this Point, the universe finds itself in a state of organized complexity. From the center of the spiraling universe, mankind serves as a conscious observer or one can also conceive it as each person being the center of his or her own universe, which, as time goes by, becomes more organized.

Reaching the Omega Point may not be possible without possessing the 5 attributes assigned to it by Teilhard de Chardin. These are pre-existing, personal, transcendent, autonomous, and irreversible. We humans are getting closer to the Point, particularly with the aid of computers and related technology. The Omega Point is the final step before "Singularity" takes place. Once we achieve (or cross into) Singularity, which will be the first and truly major evolutionary step in mankind, we cease to be humans.[3] In the near future, computers will surpass our collective intellect, and our only way to maintain our place in the universe will be to merge with them. When transhumanists speak about the Omega Point, they refer to the point when our use of science and technology will improve our human state, making conditions such as disability, suffering, disease, aging, and even death a thing of the past.[4]

When I was a young teenager, the first time I became aware of transhumanism was watching a television series called *The Six Million Dollar Man*. In that series, after a crash in an experimental airplane, astronaut Steve Austin was fitted with 2 legs, 1 arm, and an eye, all "bionic" and resulting in superpowers that he used in his new job as a secret agent. The series was very successful, and it was not surprising that NBC decided to create a "bionic" woman (with implants in all 4 extremities, 1 eye, and an ear). This female transhuman was not well-accepted by audiences, and the series folded soon thereafter. These 2 cyborgs lacked a true improvement in the way their brains worked, so they were not true examples of Singularity. Transhumanism comprises 2 fundamental changes: the incorporation of technology directly into the brain and/or body (like the 2 previous examples) to improve our functions and performance and/or genetic manipulations to improve biologic processes. True Singularity may not occur with only 1 of these because creating a superintellegence without the superbody to maintain it may not be feasible. Many of those opposed to transhumanism see it as "playing God."[5]

It is interesting to think that it may actually be easier to attain intellectual Singularity than corporal Singularity. Although we know the structure of the human genome, understanding how it works and how to alter its workings favorably may not be feasible in the foreseeable future. For many transhumanists, intellectual Singularity may be as close as 45–50 years away, and it will serve as the gateway to corporal Singularity.[6] The only thing between unlimited human progress and the way we are now is, paradoxically, our brain and its apparently limited capacity (contained as it is in the cranial bones, it cannot develop more volume and accommodate more than the already present 100 billion neurons and its 100 trillion connections). Through amplification of our native intelligence and/or the addition of artificial intelligence, Singularity can take place and progress becomes fast and unlimited. Unleashed, these "human machines" will work to create new and more powerful, perfect ones.

I think that unfortunately, Singularity will be not democratic and will be available only to those with means to acquire it. Can mankind truly evolve if millions (or billions) are left behind as mere biologic humans? Will we create a dual-tiered social system of superhumans and humans even more restrictive than our current social and economic models? The idea of Singularity also reflects the fact that it may happen unexpectedly and that we humans will have trouble understanding what to do with it, creating the opportunity for individuals or groups of individuals to profit from it. An intelligence explosion will cause our current social orders to become disrupted before leading to reorganization and development of different socioeconomic systems (reaching their Omega Point) but not before some chaos takes hold.

A major exponent of Singularity is Ray Kurzweil, an author, scientist, and entrepreneur. He has received honorary doctorates from 17 universities.[7] Kurzweil has been called the Thomas Edison (though that may not be a great thing) of our times, and now in his mature years, his research concentrates on electronic music technology, voice recognition, educational aids, and health supplements, and he even manages a hedge fund.[8] As he gets older, he is understandably preoccupied with death and conceives Singularity as the answer to mortality. Kurzweil bases some of his thinking on the concept of Moore's Law. This law describes the long-term trends in computer hardware and its power.[9] The law is named after Gordon Moore, a cofounder of Intel. Basically, it states that computing power growth is not linear but exponential and that because of this it will become a driving force in technological and social change, something that is already happening (think about how we use our iPhones [Apple, Cupertino, California] to check what we say or where we are going constantly). A doubling of capacity every 2 years and of performance every 18 months has been noted for all computer-related hardware, including transistors, power consumption, storage capacity, network capacity, and so forth. As Moore has stated, this exponential growth can be assumed to continue forever. Kurzweil also believes that the development of new technologies will assure that Moore's Law will not come to an end. Because Moore's law applies to all activities of digital computers and these are the same computers being used to study the human genome, our understanding of it may also follow the principles of that law and allow us to manipulate it more efficiently in the future. Moore's Law, however, does not predict the point at which Singularity will occur. Nanomachines housing intelligent power must be developed and injected or implanted in humans before a superintelligent hybrid being is created. Kurzweil seems to think (following the principles of Moore's Law) that the marriage between artificial and native intelligence will start occurring as early as 2050 (of course, to him this is too late because by that time, he will be dead).

Artificial intelligence is only 1 of several ways to enhance our native one. Others include brain-computer interfaces, biologic manipulation and augmentation, and genetic modifications. It is unclear if 1 or more of these will be needed to reach Singularity. If human intelligence is the highest we know, it is difficult for us to conceive of intelligence beyond it. Future computers themselves will be smart enough to build better machines beyond those that any human may conceive. Neuronal transmission spikes at about 2 Hz per second, and modern computers already spike at 2 gigahertz per second! Experts are aware that a faster intelligence may not mean a better one. A better brain must make smarter, faster, and self-improving features that are difficult to come by with our current ones and may take centuries to achieve by just normal evolutionary changes. For me, it is difficult to think that with our current intelligence, we will find a cure for cancer or, let's say, Alzheimer disease. Perhaps by creating a superintelligence, these problems will be easier to solve. Increasing intelligence, health, and lifespan are the goals of Singularity, but at this time, it is difficult for our brains to conceive how this utopia will be achieved. To solve our problems as humans, we need to use new tools and not old ones. Einstein said, "The problems that exist in the world today cannot be solved by the level of thinking that created them." Thus, it is also true that with our current levels of technology and knowledge, it is not possible to predict future ones. This trap is quite obvious once one regards the sad state of the World's economy, which we are trying to solve by the old "true and tried" methods of capitalism and free markets.

Conservative thinking may try to impose regulations on changes in intelligence. Just imagine what will happen if the US Food and Drug Administration attempts to regulate Singularity. Singularity can only occur in free forward-thinking societies, with well-thought regulatory methods and no interference from self-interested parties. If we create laws that block or obstruct Singularity, it will happen in other countries and societies that do not have these restrictions. This is the same principle that we see now with our medical research, which has become so difficult to do in the United States (15 years ago, 20% of articles published in the *American Journal of Neuroradiology* came from outside the United States compared with more than 75% today). Forward-thinking bodies of research that address these issues have been created. The Web site of the Singularity Institute for Artificial Intelligence makes for fascinating reading.[10] In 2009, Kurzweil, among others, helped to establish Singularity University. Physically based at Ames Research Center in California at the National Aeronautics and Space Administration, it was funded by industry leaders such as Google.[11] About 40 individuals serve as teachers at the University, which offers courses costing about US $25,000 (the least expensive, a 10-day "executive" program, costs US $15,000). For the first course in 2009, the University received more than 1200 applications from which only 40 were selected.

Their current Web site states that 4 yearly selections occur, resulting in an acceptance rate of 25%. They offer courses in the following tracks: technology (which includes biotechnology, medicine, and neuroscience among others), resources, and applications. Each track follows a similar class schedule: week 1, understanding the field; week 2, learning about exponential growth; and week 3, actionable output.[12] Of the faculty, only Christopher de Charms seems to have some relationship with neuroimaging (in his case, functional MR imaging) among those listed in the Medicine and Neuroscience curriculum. The part of the curriculum directly related to imaging gives the following description, "Medical diagnostics and imaging: increasingly powerful and rapid imaging modalities, point-of-care medical diagnostics, nanomedicine and biomarker technology."[13] To someone like myself, an academician educated in public hospitals and traditional university structures, their ideas sound a bit commercial and certainly make me wonder about conflicts of interest (how can you earnestly teach something when you own stock in companies that produce it?), but maybe I am being too old-fashioned.

It is becoming clear that radiology and interpretation of imaging studies will be altered by new forms of intelligence. In February 2011, an IBM computer named Watson beat several previous champions at *Jeopardy,* demonstrating that artificial intelligence is no longer a thing of the future. Watson is capable of understanding the nuances of spoken English and answers faster (and better) than humans. So, in a mostly visual specialty like radiology, a machine could be much better at analyzing the images and pinpointing the abnormalities. The industry is already starting to think about developing such machines for this purpose. Very soon we will have to incorporate millions of individuals into our existing health system and utilize our imaging equipment more efficiently. It is clear that there will be a significant lack of radiologists, resulting in a very complex situation. So first, we need to reach our Omega Point and organize the complexity of our specialty. Then we could have all studies screened by a computer and just look at the abnormal ones. The last step would be to achieve Singularity with one of these computers and still be radiologists, only better and faster ones.

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EDITORIAL

Point: CFD—Computational Fluid Dynamics or Confounding Factor Dissemination

Stimulated by our ongoing uncertainty about which unruptured cerebral aneurysms to treat brought about by a near-complete lack of meaningful clinical trial data, facilitated by substantial increases in computing power, and promulgated by scientists and engineers facile in generating massive amounts of data on estimated flow in virtual tubes, computational fluid dynamics (CFD) now holds a prominent position in the endovascular research community. Physicians see color displays generated by CFD and hope that we are starting to gain insight into why some aneurysms rupture and others do not. Journal editors have welcomed the field of CFD because of its captivating color schemes perfect for cover material, prompting some observers to propose that "Color For Doctors" represents the true meaning of CFD in the clinical realm.[1] I, on the other hand, propose a different perspective on the emerging field of CFD: confounding factor dissemination.

By way of full disclosure, I am not a professional computational scientist. However, I did learn in college how to calculate a Reynold's number. By way of a little investigating, I also know the following: 1) that most published CFD articles apply boundary conditions on the basis of idealized flows from articles published in the late 1980s (rather than individualized patient flows), 2) that the walls of the vessels are assumed to be rigid, and 3) that estimated numeric outputs can vary as much as 50% on the basis of whether geometries used CTA or 3D rotational angiography.[2] Finally, I know that the simple mathematic definition of wall shear stress (WSS) is simply the slope of the line from a curve plotting velocity as a function of distance from the vessel wall.

I have been told by computational scientists that we clinicians do not really need to know all of the gory details anyway, just as we do not really need to know all of the details about how the x-ray equipment works to perform angiography. I beg to differ. For example, many or most computational articles at least mention WSS, and in numerous articles, WSS represents the prime focus and the potentially "bad actor" in aneurysm rupture. However, there are as many, or more, definitions of "WSS" as there are types of intracranial aneurysms. WSS can be averaged with time ("time averaged" WSS) or over an area (the inlet zone, outlet zone, or dome) or can be maximal (typically at peak systole) or minimal (at end diastole). It can be oscillatory (oscillatory shear index), can be normalized to the parent artery flow or not, or can be a difference of 2 WSSs (WSS gradient). Thus, to say that WSS is correlated with a specific phenotype may mean a lot of different things to different people, and it is no wonder that, in turn, both elevated and diminished WSS has been associated with rupture in various studies.[3,4] Moreover, of course, correlation does not always equate to causation.

Unfortunately, defining WSS is just the beginning of the confusion. Each new computational article seems to introduce a new index or 2. We now need to learn, in addition to WSS, terms related to kinetic energy, vorticity, impact zone size, aneurysm-size ratio, aspect ratio, nonsphericity index, relative residence time, energy loss, and gradient oscillatory number[5]—and the list goes on and likely will continue to get longer. Given the rapid expansion of the number of potential CFD "outcomes," it is highly likely that many new "correlations" between these outcomes and rupture will be found—that is, the more comparisons you do, the more likely you are to find a spurious difference.

Perhaps a key problem with CFD research is that it is generally performed by isolated groups analyzing data from a very small number of cases. Relatively small studies provide substantial value in screening potential indices but, in my opinion, are as likely as not to identify confounding variables rather than the true agents of harm. Moreover, this is even assuming that aneurysm rupture is hemodynamic rather than biologic, which remains unclear to say the least. To really figure out what, if any, clinical utility CFD has, we need collaboration across specialties, including but not limited to statisticians, endovascular therapists, and clinical trialists. Performing statistical correlations between dozens (now) and hundreds (soon) of computational indices with aneurysm phenotype (typically ruptured versus unruptured) likely will require extremely large clinical datasets and sophisticated tools such as machine learning.

Until now, neurointerventionalists have marveled at the aesthetically pleasing color images that CFD provides, hoping that someday soon they would lead to clinical application. Clinicians would love to have a CFD button to push that provides a "treat/do not treat" decision for a given patient, but that is probably not going to happen soon. To help define what, if any, flow-related parameters really matter clinically, CFD researchers will need to do a lot more work to close the gaps in information and address the conflicting information and confounding variables.