

Coincidence + Accidence + Variable = Chaos Theory (and Life!)

On my highly anticipated field trip to the ice skating rink in the eighth grade, I broke my leg within five minutes. I waited in a daze on the ice, thinking I had just sprained an ankle, until I felt the bones in my leg jiggling. The ambulance immediately came, I was shipped off, and put to sleep. When I woke up, Dr. Martin, a renowned orthopedic surgeon, announced to me that I had a “broken tibia and fibula, both in multiple places, and am bleeding internally. We cannot delay this operation. You’re scheduled to undergo surgery immediately.”

...so much for the romp on the middle school field trip to the ice rink...so much for falling on each other like dominos...at this ridiculously inappropriate place...

My face was masked and my IV flushed with intravenous anesthesia. I had no recollection of what followed until I awoke with an excruciating pain in my knee. I breathed slowly and deliberately, but why was I awake? My knee was being torn open, and I couldn't open my eyes or wince! Then I recalled waking up from my surgery sobbing, surrounded by nurses cooing and repeating, “Everything will be all right.” I had acquired a 16" titanium rod and 4 screws in my leg through a 2" slit in my knee, and I was conscious for a part of it!

Feeling lost in the weeks that followed, I was absent from school, and being bedridden made me fret.

My vision of playing varsity sports was a confirmed pipe dream. I was letting my world become dull,

so I tried to keep as much color from slipping through my fingers as possible. I wrote a poem or drew a picture of personal significance everyday for purely selfish reasons. In the silence around me, I found a presence whose choral chant lifted me up. My heart was buried under layers of vibrant colors, imagery, and fanciful reveries that I had been oblivious to all this time.

Next to keep my bitterness at bay, I confronted anesthesia awareness, not as a litigator but as a researcher... How is pain perceived ... what is consciousness ... is the use of anesthesia ethical if its effect isn't certain? I desperately searched for answers but discovered a lack of explanations. Instead, my Intel Science Talent Search project on human consciousness titled *Chaos Theory, Fractal Dimensions, and the Human Cerebrum*, evolved.

I didn't know where to begin. The summer before the incident, I had visited my grandparents in Beijing, who have been professors at Tsinghua University for over forty years. My grandfather gave me a book on the dynamics of behavior, and this book was the first idea I thought of when I thought about consciousness. I began researching a little, but I had no aspirations to submit anything to any formal competition or fair until the last moment I could feasibly finish. Chaos Theory and Fractal Dimensions are both applications to the mathematics and physics taught in the high school curriculum, but the complexities of both made outside research completely necessary. The deeper I delved, the more I realized that math and science had never been so alive to me, never so connected with the reality that I know. I started having email conversations with a professor of cognitive science at Johns Hopkins, a professor of philosophy and neuroscience at Washington University in St. Louis,

and a professor of bioengineering at Arizona State University to figure out what was a feasible topic for the Intel Science Talent Search. I was met with much more ambivalence and dissuasion than encouragement, all saying how human consciousness is not something a high school student should tackle, but nevertheless I was led to books by notable people in the field. My research became a culmination and synthesis of theoretical ideas, but that wasn't enough. I had to bring in a base in mathematics to be able to call this a science project and not mere editorial whimsy. I had known about the multi-disciplinary nature of chaos theory and fractal dimension, so I delved into the mathematics and physics of that, self-taught using online encyclopedias and tutorials, and combined the new science of the brain with an older science that exists in nearly everything.

Explaining neuroscience in terms of mathematics and physics was a surprising turnout for someone who had received less than an A in more than one math and science course. The Intel Science Talent Search gave me a personalized chance to learn more about behavioral science, physics, and mathematics. Furthermore and much more importantly, this project presented me with a unique opportunity to learn about myself, about my willpower, level of dedication, and weaknesses that I would otherwise not know until many years down the road perhaps at a time too late.

I started the Intel Science Talent Search project officially during the summer before my senior year. My parents were encouraging at first, but a few weeks down the road after watching me retreat back to my room immediately after dinner to continue reading out of scientific journals, and spending days of my summer in the library, my parents became more and more vocal about ISTS being too

much for me to handle. Many of the students who submit projects to the Intel Science Talent Search begin during their freshmen year of high school and devote thousands of hours to working in labs and communicating with mentors. I started five months before the project was due and I had neither lab nor mentor to speak of. On the bright side, I now have a cool procrastination story to tell.

In this serious state of procrastination, in a state of frantically completing college applications, studying for Academic Decathlon, having band rehearsals early in the morning, and trying to fulfill officer roles for a few on-campus clubs and volunteer activities, I stumbled through life for a couple months. Somehow, my grades had never been better; I finally became the lead chair flute player; I was accepted into my first choice college under the early decision cycle, and I had finished my Intel Science Talent Search Project after grueling days and nights of research, writing, and cramming the delicate details of quantum mechanics, brain anatomy, biological evolution, and chaos theory. Divine intervention being truly divine. My generation is criticized as being the most apathetic generation in American history, and my fear of becoming proof to the claim drove me on. However the case, the bottom line I've learned is to never forget that under high pressure, dirt can be turned into diamond.

When I sent off my application package for ISTS, I expected to feel a tremendous weight having been taken off my shoulders, that my months of theorizing and testing myself would dissipate into thin air and my senior year of high school would become overweight with senioritis. A few days later, it seems, I had completely forgotten about ISTS, and I was already thinking about what new research opportunities college would bring. Honestly, I never thought about placing or winning anything when

I embarked on my ISTS project. It was something beyond me that I was couldn't bring myself to dream. When I mailed off my application, I felt closure and was happy.

Luckily, today's society recognizes the disparity between the multiple intelligences and has evolved to appreciate people of all walks of life. Success can be found in the most unlikely corners, and happiness, contradictory to all of science, can be created out of nothing.

Completely healed now from the incident, I have a sticker on my laptop that reads "obstacles are opportunities", and as the years slide by, the pain I have visited can be steadily pushed back to an enchanted distance. And, memory, the mind's great cosmetician, can remove scars, soften edges, and retouch the past in a golden glow.

A few years after the incident, I now volunteer and intern at the hospital where I was treated. Since then, I've developed two missions for life: to become an anesthesiologist or neurosurgeon and to spread the message that no one is alone in pain and that strength of heart, strength of spirit are our obligations to each other. Each step may be hard, but every view is beautiful and every breath is all my lungs will hold.

Every one of us goes through life searching for silence, a state of being and condition of mind that makes us resonate with quiet meditation. Some of us find this silence in music, some during vacations to mountain tops or jogs at night in the dark, and others in spirituality and in prayer. I find

mine in all of the above, but more than anything, I find my silence amidst the noise of daily life, the calamity of deadlines, and the inevitable cycles of stress and relief. To me, there is a necessity in finding joy in ordinary things and in the struggles of life that permit us to achieve our grandest of goals. There is an intrinsic need to value the hardships we go through, because those tests and trials of strength are the alchemists that can morph our sweat and chiseled personalities into gold.

Coming across *Chaos*

The self-referential inquiry, the mind thinking of itself, may be a uniquely human characteristic. Speculations on the nature of thought proliferated, ranging from the spiritual to the anatomical, and the observational to theoretical. Since the beginning of my study, neuroscience has been met with a number of ethical questions about and objections to its pursuit. Is it right for us to understand the brain? Are human beings attempting to play God when we learn about our condition and human nature? These are all valid questions, but during my research, I maintained the prospect that learning about behavioral science is a part of the natural progression of human development. In *Chaos Theory, Fractal Dimensions, and the Human Cerebrum*, I discuss the evidence and development of a model to describe the dynamical processes responsible for consciousness and cognition. Emphasis is placed on chaotic neural activity and its mathematics in fractal dimensions to explain the phenomenon of subjective consciousness using objective physical mechanisms.

At present, there are many definitions associated with the word chaos that the term often evokes an ironical smile from mathematicians. In the 1960s, American meteorologist Edward Lorenz worked in a lab at MIT and had set up a series of equations that modeled and predicted weather. He wanted to see a particular sequence again, so to save time, he used a number rounded off to 3 decimal places, unlike the numbers the computer used that were rounded off to 6 decimal places. The equations for the system seemed to give rise to entirely random behavior, so we say that chaos theory states that small initial changes cause unexpected final results, and that things are inherently random. Now in

reverse logic, it implies that within chaos, there is an underlying formula to explain everything.

Fractal dimensions offer the mathematics behind chaos theory. In space-time, we have the one-dimensional line, the two-dimensional area, and the three-dimensional space. But what are 1.5 dimensions? Or 2.374 dimensions? Look at Sierpinski's triangle. One dimension would be the largest triangle. Two dimensional would be the triangles a size smaller, and so on and so forth. Now it can be seen that dimensions exist in between dimensions. Some but not all of these triangles can be drawn. The official definition of a fractal is something that is self-similar at difference scales. French mathematician Mendelbrot was drawing a map of a coastline, and he noted that while drawing some bays, he was missing the minor bays. He was also missing the individual rocks, and singular grains of sand, and the atoms, and molecules, and protons, and down to quarks again. Where does this end? There is no logical end.

The cerebrum has an enormous number of computing neurons. For energy conservation, the cerebrum cannot directly control the activity of every cell. Instead, it employs something I call "order parameters" to regulate each individual neuron. If the current representation of cerebral networks is based off of this hierarchy, then we can deduce that the brain is limiting chaos in this way. Could the mechanism of thinking, and consciousness, be based off of chaos?

Two and a half thousand years ago, Hippocrates noted that "Men ought to know that from nothing else but the brain come joys, delights, laughter and sports, and sorrows, griefs, despondency and

lamentations.” In essence, joys and sorrows, memories, and ambitions, personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules. It’s belittling, isn’t it? That’s why so many world religions assert that people have souls and these souls live on after the person’s physical death. They may go to heaven, or can be reincarnated into a donkey. Whether these beliefs are true or not, it does seem as if human beings possess a kind of “extra ingredient.” We have free will. I aimed to explain the phenomenon of human consciousness using physical mechanisms. I integrated equations to model the behavior of neuro dynamics and graphs to illustrate the patterns hidden in the equations.

Not surprisingly, the premise of my project, human consciousness is shrouded in religion, politics, philosophy, culture, and other soft sciences. The substance and style of the report departs considerably from those of a more traditional scientific report, and the pages have broached several non-technical dimensions that rarely intrude upon conventional scientific research. This is not just mere editorial prose, but rather, it was a genuine attempt to express the conviction that significant progress in capturing and comprehending elusive phenomena of human consciousness requires the investigator to handle all manner of subjective and interpersonal implications while also entwining them effectively with the more traditional hard sciences.