

The necessary changes have been made

“The past beats inside me like a second heart.”

— *John Banville*

Jack uttered a loud cry of rejoice which reverberated through the crimson-painted ceiling, up into the extolling tower of scientific discovery. The incessant shuffling of bright green text output on the screens behind him and the barely perceptible glow in the monkey’s dull friendly eyes were the unequivocal signs of his achievement.

The algorithm has done its job, irreversibly, irrevocably. And it worked precisely as Jack had expected. In his mind, this step was the sweeping leap towards success and prominence. Ever since he had received the grant, he had been developing and improving the algorithm in a deliberate, rigorous, and sleepless fashion. Everything else was just details – replicating the finding in further experiments; analyzing the vast patterns of various biomarkers; writing endless progress reports; convincing hard-nosed sponsors, philanthropists, and shareholders of the utility of the enterprise – the imminent chores and daily hassles of scientific work.

All of a sudden, a glimmer of skepticism overshadowed Jack’s initial excitement. The cold, rational part of his brain began to cool down the hot, animalistic arousal. He had to double-check the output; had to anticipate the emergence of potential side-effects. Most important of all, he had to prove that his ground-breaking algorithm did indeed elicit the amazing effects he had been overtly professing and covertly hoping to elicit.

But first, Jack had to convey the birth of his brainchild to one more person. “Ellipsis, call Dr. John Young”, he issued his command to the global neuromorphic network with the standard keyword.

A moment later, a sleepy voice chimed back at him:

“Good evening, Jack. Do you have any idea what time it is?”

“No, I must admit. But one thing I know for sure, John....good times await us. My...our algorithm is working! It’s working, John!”

“Good bytes! Have you been working on your own all those nights? Wait...I have to see it. I’ll be there in fifteen minutes”, stuttered John. The connection terminated. Jack stood still, his thoughts partly in his head, partly up onto the crimson ceiling.

“Unbelievable. An error rate of under one billionth”, whispered John, contemplating the summary statistics, “and you are saying that the speed of execution was less than two hours?”

“See for yourself”, Jack pointed at a small entry in the enormous processing time table. “It appears that your solution for finding shortest paths beats Dijkstra’s by far.”

“The math never lies”, smiled John thoughtfully.

“Well, the human brain has a little more cortical neurons than the chimpanzee’s. But this should only increase the running time by a fraction”, asserted Jack.

John looked concerned. It seemed as though his skeptic mind were also struggling to fight back against the overbearing force of his pride. Eventually, it managed to raise its voice.

“We shouldn’t be too hasty in our rejoicing, though. We might fail to replicate...”

“There is no reason to be pessimistic either”, responded Jack. “As soon as we run it on ten...or maybe twenty more monkeys without encountering any complications, we can write a proposal, ask for a human volunteer.”

“But before that, we have to make sure our guy here really improves on a bunch of cognitive and memory tests”, reminded John, glancing at the wired-up chimpanzee, as it was scratching vigorously its nose.

“We are not supposed to do the animal psychologists’ homework. Besides, I still doubt their old-school tests are reliable enough to capture the magnificence of what we’ve done. What we have here is the first working neuromodification nanoalgorithm. And I bet those wisenheimers in Chinokorea would need a couple of more years to come up with something as elegant as our implementation!”

“I am curious about what Bucky would have to say right now. Does he even know what’s just happened to him?” wondered John, who had stepped nearer the cage.

“He seems to me pretty oblivious about the whole thing...”

“Well, instead of trying to read the monkey’s mind, let’s put it to sleep and celebrate!” suggested Jack, the mesmerizing final output line of the algorithm reflected in his blue eyes:

The necessary changes have been made.

At this point, you might be wondering, justifiably, what exactly this groundbreaking invention was and how it worked. Admittedly, the precise mechanisms seemed like dark matter even to the creators of the system. By that time, the work of physicists and engineers was markedly reminiscent of the practice of witchcraft. However, the very basic operating principles were the following: The entire physical system consisted of a vast population of nanobots, which were to be injected in the bloodstream. Each of these nanobots was an individual pathfinder, aimed at reaching the central nervous system of the organism it inhabited by means of chemical tracers. It comprised a tiny parallel processing network with enormous computing capabilities. But their relative independence notwithstanding, all nanobots represented nodes in multiple networks governing the synchrony and local dynamics between them. These networks, in turn, comprised yet another, higher-order network, imposing global control over all components. In a sense, the whole was greater than the sum of its parts; but the parts, each having its own nanogoals, were also greater than the whole.

Upon injection into the bloodstream, the nanobots were programmed to rush directly into the central nervous system, specifically into the cortex and limbic system, through the multitude of gap-junctions between glial cells and neurons. Once they had arrived at their starting vertices, the actual fascinating choreography took place. Based on a complete description of the brain’s gray and white matter, the nanobots traversed billions of neural pathways, beginning to estimate and record innumerable mental representations from functional connectivity patterns along the way. In other words, traces of stored memories were retrieved in a bottom-up fashion and reconstructed as visual and auditory images using sophisticated statistical procedures. These patterns of memory contents were then processed by a hierarchy of deep artificial neural networks deciding on whether the memory was relevant for the efficacy and well-being of the animal – and was therefore to be enhanced – or

represented merely cognitive or emotional junk – and was therefore to be discarded. The deletion and enhancement were achieved by electrically dissolving or strengthening the synapses involved in the respective mental image. Inevitably, the algorithm was bound to make a mistake every now and then, so a special error rate was used for the estimated proportion of incorrectly discarded and incorrectly enhanced memories. No one really understood how the final step of the process, namely, the memory selection part, came to a decision. It was developed and progressively refined by running countless simulations on diverse virtual brains until they exhibited a significant improvement in performance on a number of measures in a simulated world. In order to tackle complexity, one had to sacrifice some tangibility.

Jack clicked the Scotch icon on the touchscreen embedded in his table. His order immediately arrived, and an informative message appeared on his screen: “No more drinks allowed. Thank you!” John was taking a sip from his glass of Dry Gin, his eyebrows betraying unspoken anxiety.

“Do you remember how those guys from Elgoog screwed up with the thought propagator?” grinned Jack. “The idea was, indeed, spectacular! No one had ever succeeded before in developing an algorithm which verbalizes thoughts. Yes, it would’ve been great to control your holovision, or car game engine with your brain. It would have been ever greater for the deaf who could’ve finally been heard. The only problem was, that the algorithm had no social awareness at all. It picked all verbal thoughts. Even the nasty ones. The wife of one of the deaf volunteers divorced him, after he started discussing his affection towards another woman. Other volunteers got fired. The final blow came when it started translating the project coworkers’ opinions of each other. They never teamed up again, and the project was abandoned,” recounted Jack in a condescending voice.

John was silently emptying his glass, his mind drifting off in the milky way of uncertainty.

“What bothers you?” asked Jack.

John put the empty glass on the table. He too had reached the designated limit of alcoholic beverages per night.

“I have some doubts, Jack. Suppose thousand chimpanzees become better problem solvers. Even then, how do we know that the thing hadn’t messed up something more important? They can’t tell us, Jack, they can’t tell us anything!”

“Well, maybe the Elgoog geniuses could build us a propagator for monkey thoughts. At least no monkey will have to deal with its lawyer after that.”

“Don’t be sarcastic. We don’t know how the memory selector works! It’s a black box.”

“But we know *that* it works. We just have to convince them with more substantial evidence.”

“Anyways, we can only rely on objective indicators. Before we try it on a real human subject, we will only have measures of some behavior or other. But to rule out any *subjective* dangers, we first need a human subject. It’s a damn circle.”

“I see your point. But I find the error rate of less than one billionth pretty convincing. Besides, most useless memories are only retrieved once or twice during a lifetime. Trust me, there is nothing to be lost *subjectively*”, contended Jack and stared decisively at his equally empty glass.

Tuesdays, Jack always left the lab before his colleagues, as opposed to every other day. Since he was an extremely withdrawn and unidirectional man, and even with his immediate partner – John – all conversations revolved around work, no one really knew his other plans and purpose. Some hypothesized that he secretly worked on another project, others surmised that he was playing some demanding virtual reality game.

The day after the breakthrough happened to be Tuesday. Amidst the elevated mood in the lab, Jack arranged for the assistants to start training new monkeys for further testing, and do the remaining dirty jobs. After that and a brief round of cheers, he left even earlier than usual.

The immaculately mowed blades of boundless green grass were faintly stirring, touched by the barely perceptible wind. The muffled roar of the distant highway perturbed the everlasting tranquility of tombstones like an unceasing background whisper. There were scarce flowers reminiscent of randomly colored

paint dots in a child's drawing. There were scarce sheep-clouds in the sky. And there were scarce empty benches along the allées.

A man was sitting on a bench, his glance encompassing the tombstone right in front of him. Beside it, a flower lay on the ground. A shrill sunflower. Her favorite. Inside the man's mind, she was smiling. A smile disarming every sorrow, enflaming every joy.

"We made it, darling", whispered the man. "We made it. Thank you for giving me all the strength."

"I am sorry, Jack", said John.

Jack was still staring at his screen. By now, he had probably read the ethics committee's final decision at least three times, but refused or was not able to say a word. Since John had exhausted his sympathizing lexicon, he simply turned around and granted him some distance. Jack kept staring at the screen. The letter in question read:

Dear Dr. Campbell,

We find Your results very interesting and anticipate promising vistas for You as a lead researcher in our enterprise. We were pleased to hear that no primate subject had displayed any observable side-effects from the application of Your technology. Furthermore, from your progress reports it is evident that all subjects have demonstrated significant improvements on most performance measures, confirming the utility of the procedure.

*However, we regret to inform You, that we are unable to authorize the application of a memory refurbisher on a human subject. We find the procedure inherently **risk-baring**, hiding **unforeseeable consequences** for one's subjective well-being.*

*We hereby declare the project **closed** and invite you to discuss further developments in other areas of research at our regular monthly meeting.*

Yours faithfully,

Prof. Dr. Allan Goldstein

Chair of the United Ethics Commission

Every device in the lab was lit up and ready to run. He had been preparing the stage for hours. Hundreds of wires were going out from his magnetic helm, eager to record and decompose every surge of neural activity. The nanobots were inside his bloodstream, but he only felt or imagined a slight itching from the microneedle's head. Filled with Marshallian zeal, Jack was just about to initiate the procedure, when he suddenly hesitated.

... *they can't tell us anything...*

"There is no turning back now. You have to prove these smartasses wrong.", said Jack to himself.

... *risk-baring, hiding unforeseeable consequences...*

"You have nothing to lose!", he shouted. Then he closed his eyes and dictated:

"Ellipsis, start main procedure mem-enhance-human!"

The search was proceeding at higher and higher cortical depth. Millions of synapses were being traversed and mental images were being recreated each second. In this cortical region, the algorithm found an almost faded proof of the Riemann theorem. Enhance. Could be important for work. There was also the image of an old man yelling at the observer. Enhance. Negative reinforcement from authority. Programming a self-driving car. Enhance. Past experience. Reading a textbook on complex systems and chaos theory. Enhance. Reading comprehension and important knowledge. Playing chess with another teenager. A slight delay. Enhance. Social competence and understanding of game theory. Enhance. Enhance...There appeared a woman carrying a plate of blueberry pancakes. Discard. Enjoyable distraction. Reading *Twenty Thousand Leagues Under the Sea*. Discard. Useless leisure time fiction. The lips of a bespectacled schoolgirl coming nearer and nearer. Discard. Unproductive sentimentalism.

Billions of processor cores were computing and computing. The algorithm was taking longer than expected. Apparently, it had never dealt with such an enormous input of mental images during simulations. The cooling system worked at its maximum. Enhance. Discard. Enhance. A protruding hand holding a sunflower, a

woman smiling. A noticeable delay. Discard. Fruitless romantic reminiscence. Enhance. Discard...

Soon or much later, it was over. Physically, Jack felt completely battered from the whole cocktail of emotions and concerns he had gone through during the procedure. But mentally, he felt exceptionally invigorated. His inner theater was clearer than ever, the contours of his mental pictures were sharper than ever. The ease with which his thoughts came to mind was amazing. He freed himself from all the wires, put on his coat, and headed home. On the main screen, the words of success were flickering: *The necessary changes have been made.*

Some weeks later, an excitement spread out through the lab. Preparations were being made for the first human subject to be tested. Jack had been working with an unseen vigor, producing new ideas on a daily basis. John was whispering to a colleague, and upon finishing, he approached Jack and inquired:

“Jack, it’s Tuesday. Don’t you want to...take a little break?”

Jack lifted his head and looked at him with dismay.

“Why should I do that? I don’t have any time to waste.”