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Writing 50

14 September 2012

Teleportation and its Consequences in Light of the Transporter

From *Star Trek: The Next Generation*

One of the most captivating futuristic technologies from Gene Roddenberry's *Star Trek* franchise is the transporter: a teleportation machine used to "beam" people and objects from one defined point to another. The original series left the mechanics of the transporter as seemingly magical, making viewers believe that the technology is something beyond their comprehension. However, with the succeeding series, *Star Trek: The Next Generation,* twenty-one years later, a more sophisticated form of science fiction entertainment has arrived. *The Next Generation* favors scientific theories over make-believe ideas more often than its predecessor. For instance, the transporter used in *The Next Generation* is detailed: the series' technical advisors provide blueprints that include the transporter's parts, the parts' names, and the parts' functions. Furthermore, the blueprint has a step-by-step description of how the machine transports individuals from point "A" to point "B." Much of the transporter's information refers to actual terms used in physics and engineering today. This is not to say, however, that everything in *The Next Generation* has scientific evidence, for there are still elements of futuristic and technological magic.

If the series did extrapolate all of its information from science, then perhaps today, 25 years after the premiere of the series, we would be teleporting across the world with ease. In that case, the mechanics of teleportation would become as interesting as the mechanics of an everyday car. Currently, though, teleportation is defined by the Oxford English Dictionary as "[the] conveyance of persons . . . or things by psychic power; also in futuristic description, apparently instantaneous transportation of persons, etc., across space by advanced technological means" (*OED Online*). The skeptical tone of this definition reflects how society views the concept of teleportation. However, both modern findings in quantum mechanics and computer-based technological advances over the last three decades have very promising applications for future teleportation. These discoveries provide us with a good idea of how teleportation will work in our future.

1. The Mechanics of Teleporters and Transporters

In order to create a teleporter, we will need to apply electromagnetism, engineering, quantum physics, and information theory to its design. Now, suppose we want to teleport a human from point "A" to point "B." At point "A," an individual walks into the teleporter chamber, where the teleporter will deconstruct the individual's matter down to his subatomic parts. (Without loss of generality, assume the individual is male.) Deconstruction involves instantaneously heating the body past the phase-transitioning point to break his protons and neutrons into their elementary particles (Krauss 88-93). At the same time, a program on a quantum computer will record his information as data, using powerful magnets at point "A" ("How to Teleport"*).* The individual's data will describe how his subatomic particles are configured and where these particles are located relative to each other in the space of the teleporter chamber (Krauss 95). The data will then be encrypted to avoid third-party interceptors and sent to a satellite. The deconstructed matter itself, however, will be converted into energy; we know this is possible because of Einstein's famous equation $E=mc^2$, which tells us that energy E is related to the mass m of an object and the speed of light c. The individual's energy will be transferred to another teleporter, point “B”, by a wireless energy transfer; the energy will be required in order to bind subatomic particles together in the configurations and relative locations recorded by the quantum computer (“How to Teleport”). Then, the teleporter will construct a quantum duplicate of the original individual at point “B.”

Gene Roddenberry's model of the transporter from *Star Trek: The Next Generation* was created around the same time as our theoretical teleporter. According to *Star Trek: The Next Generation Technical Manual*, in order to transport an individual from point “A” to point “B,” the transporter “dematerializes” the individual's matter at point “A”, converting his matter into energy while simultaneously recording and storing the information of the object's “pattern” in the “pattern buffer” (Okuda and Sternbach 103-106). Then the transporter transmits the energy in the “annular confinement beam,” which transfers the energy and its pattern to point “B”; there, the energy and pattern are used to “rematerialize” the object (103-106).

Amazingly, for a fictional model of a teleportation device, the mechanics of the transporter are remarkably similar to that of our nonfictional teleporter. But, there are two major differences: first, while the transporter is not required to be at either point “A” or point “B” in order to transport an individual, our teleporter requires that there be a teleporter at point “A” to teleport to the device at point “B;” second, while the transporter transports the individual's atoms from point “A” to point “B,” the teleporter deconstructs the individual at point “A” and creates a quantum copy of him at point “B.” Thus, in concept, our teleporter is more like a theoretical quantum duplicator.

In *The Next Generation*, transporter malfunctions are a common theme. Over the course of the series, the *Star Trek* writers illustrate some of the more worrisome problems that the transporter can impose on the Starfleet crew aboard the space cruiser *USS Enterprise-D*. These challenges and malfunctions not only make for good science fiction television, but they also give us insight into some pressing issues that will occur when we bring teleporters into our reality. Similarities between the mechanics of the transporter and the teleporter suggest that we should carefully review the fictional considerations and malfunctions of the transporter in *Star Trek: The Next Generation* when we design a safe method of teleportation in our future.

2. Quantum Duplication

One of the transporter complications that the writers of *Star Trek* illustrate is duplication. In the episode "Second Chances," Commander William Riker meets his duplicate, who has been living as a hermit for eight years in a turbulent planetary atmospheric storm on the abandoned Starfleet vessel *USS Potemkin* .Eight years earlier, according to Lieutenant Geordi La Forge, a second William Riker was created via:

> A massive energy surge in the distortion field around the planet just at the moment [Commander Riker] tried to beam out. The Transporter Chief [on the rescue vessel] tried to compensate by initiating a second confinement beam . . . [which] wasn't necessary. Commander Riker's pattern maintained its integrity with just the one confinement beam. He made it back to the ship just fine . . . [so] the Transporter Chief shut . . . down [the second confinement beam], but somehow, it was reflected back to the surface ("Second Chances").

While the mechanics of the teleporter avoid the formation of two existing copies of the same individual at one time, external interference may induce such an anomaly to occur. Here we would have a malfunction in the teleporters, in which the individual at point "A" sends his data to point "B" but fails to deconstruct into pure energy. Suppose that at the same time, there is a surge of energy from an (incredibly powerful) electrical storm that gets caught in the wireless energy transfer, providing a sufficient amount of energy to create the individual's quantum duplicate at point “B.” Since the original individual is still at point “A,” however, we now have two identical individuals.

An individual and his quantum duplicate are more similar to one another than are monozygotic twins or clones. This is because a quantum duplicate is identical to his originator at the subatomic level. This remarkable level of similarity is discussed between Captain Jean-Luc Picard and Doctor Beverly Crusher as they discuss the biological conditions of the second William Riker, who was found on *USS Potemkin*:

> Crusher: Genetically, he is indistinguishable from Commander Riker.
>
> Picard: Could there be some sort of cloning involved here?
>
> Crusher: I don't think so; there's no genetic drift.
>
> Picard: But it's not conclusive.
>
> Crusher: That's why I compared their brain scans. Brain organization patterns are about as unique as fingerprints. Except for minor, minor differences, theirs are identical.
>
> Picard: But can't brain patterns be cloned?
>
> Crusher: No, they're determined by experience—mostly from early childhood.
>
> Picard: How can two grown men share the same childhood experiences? It just doesn't make any sense. (“Second Chances”).

Doctor Crusher reiterates neuroscientists’ findings regarding the similarities and differences between monozygotic twins: the neuroimages of monozygotic twins' brains show that “[the] grossly defined brain volumes between [monozygotic] twins are highly correlated . . . whereas measures of surface morphology display more variability. . . ” This variability is caused by "modulation by non-genetic influences," which include life experiences (White, Andreasen, and Nopoulos). Therefore an individual and his duplicate will have more correlation than the individual and his monozygotic twin, since the duplicate's brain is subatomically identical to the original individual's brain. However, clones only share identical genetic material because they are raised under different circumstances; since they are not from the same womb and are not the same age at any given moment of time, they are less likely to have as much correlation as monozygotic twins (Lamb). Thus, there is still more correlation between an individual and his duplicate than between the individual and his clones.

Quantum replicated individuals experience a loss of their individuality and uniqueness. As an android, Lieutenant Data often observes other people's behaviors to assess how humans interact; upon watching the hostility between Commander Riker and his duplicate Lieutenant Riker, Data inquires Lieutenant Worf about individual and duplicate interaction:

> Data: Lieutenant, I am curious about something: if you met a double of yourself, would you have difficulty interacting with him?
>
> Worf: I think so . . . I'm not easy to get along with.
>
> Data: Hmm. But Commander Riker and Lieutenant Riker are. Yet they seem to have trouble getting along with each other. I have found that humans value their uniqueness—that sense that they are different from everyone else. The existence of a double would preclude that feeling. Could that be the source of the friction? ("Second Chances").

Data's conjecture regarding individuals and their feelings about their duplicates is similar to that of medical ethicist Dan W. Brock. However, from a philosophical perspective, says Brock, since humans and their clones have different "physical, psychological and personal characteristics" based on non-genetic influences, the humans' individuality and uniqueness is not "undermined" (314). Brock's statement can be reformulated into the following logical sentence: A person's individuality and uniqueness is not undermined if and only if he does not share the same genetic and non-genetic characteristics of another person. The rules of philosophical logic state that the converse of this statement is also true: A person's individuality or uniqueness is undermined if and only if he shares genetic and non-genetic characteristics with another person. We can then say that since an individual shares genetic and non-genetic characteristics with his quantum duplicate, the individual's individuality and uniqueness is undermined. Such an existential compromise is threatening to an individual's unique place in society, making him feel replaceable. Feeling replaceable can also mean that the individual feels disposable. This loss of playing an irreplaceable role in society can lead to an identity crisis.

3. Data Transcription Error and Ionic Radiation

Data transcription error may create differences between the individual and his subsequent self upon teleportation. In *The Next Generation*, transporter-phobic Lieutenant Reginald Barclay suggests that if a person's image is scanned, "There is no margin for error; one atom out of place and 'poof!' [The person] [will] never come back." Transporter Chief Miles O'Brien replies, "That's why each [transporter] pad has four redundant scanners. If any one scanner fails, then the other three take over" ("Realm of Fear"). Barclay's claim that death is caused from having one displaced or missing atom is probably not true; having a cut or losing skin cells takes away many atoms from our bodies, and yet we do not die. However, his exaggerated statement does bring to light a worrisome issue of distorted or lost data. One individual is comprised of roughly 10^{28} atoms, or approximately 10^{45} bits (Krauss 82; Caldwell). Suppose that while an individual's data is being transcribed, there is a "hiccup" in the program, causing the software to record a few pieces of data incorrectly. Statistically speaking, since each individual will require approximately 10^{45} bits of data, one may dismiss the few incorrectly recorded pieces of data as negligible in error percentage. However, *Battlestar Galactica* science advisor Kevin Grazier speculates that "you might lose a bit from your DNA, and while your body has DNA repair mechanisms, that repeated numerous times could lead to cancers, it could lead to deformities, it could lead to all sorts of maladies that you really probably wouldn't want to deal with" ("Science Fiction, Science Fact").

Although the transporter solution to data distortions raises the chance of maintaining an individual's exact integrity upon arrival, it does not guarantee that the transporter's data transcription of the individual will *always* maintain exact integrity. Nevertheless, this does give us a good idea of the type of safety measures we can take to make teleportation as safe as possible. For instance, we can develop similar safety measures to that of the transporter by relating the transporter's "image scanners" to our teleporter's quantum data recording program. We can repeat several program runs to verify data precision within the data set, thereby reducing the chances of a blip in the transcription process. As long as we have multiple scans to run comparison checks for consistency, we are raising the chances of the exact data integrity for any individual.

While we may be assured that our physical bodies will be teleported with a high chance of exact data integrity, perhaps we should also consider factors that may degrade physical and neurological integrity. The writers of *Star Trek* came up with a terminal syndrome called "transporter psychosis," which is "caused by a breakdown of the neurochemical molecules during transport, affecting the body's motor functions, autonomic systems, and the brain's higher reasoning centers" ("Realm of Fear"). The symptoms of transporter psychosis are similar to those of overexposure to ionic radiation. Symptoms of ionic radiation overexposure in humans include damage to the cataracts, reproductive organs, skin, bone, and nervous system; furthermore, “rapidly proliferating and differentiating tissues are most sensitive to radiation damage. Consequently, radiation exposure can produce developmental problems, particularly in the developing brain” (“Open Source”). People are commonly exposed to ionic radiation through X-rays and MRI scanners. In MRI scans, computer pixels are “a quarter of a millimeter on each side” (“How to Teleport”). In our teleporter, electromagnets that function as MRI scanners must be able to record data at the quantum level—which is significantly smaller than the typical size of today’s single MRI scan pixel. Doctor Raymond Vahan Damadian, inventor of the MRI scanner, states that, if we want electromagnetic scans to have smaller computer pixels for a higher data resolution, we must have electromagnets that are more powerful and have a “uniform” electromagnetic field (“How to Teleport”). If we want scans with quantum resolution, we will need incredibly powerful electromagnets, which may cause extreme overexposure to ionic radiation. Here, it may not be the data transcription program that is at fault, but rather the electromagnets from which data is transcribed. Thus, while we should look for precision of redundant data scans, we should also consider the molecular manipulation of individuals by the teleporter's electromagnets to avoid teleporter-induced psychoses.

4. Heisenberg's Uncertainty Principle and Quantum Teleportation

In the future, even if we will be able to invent technology that can handle gargantuan amounts of information and energy, Heisenberg's uncertainty principle cannot be satisfied. In quantum physics, Heisenberg's uncertainty principle states that “certain pairs of quantities such as position and momentum of a particle, cannot be measured simultaneously with arbitrary accuracy” (Hawking 55); thus “. . . the more [we] know the object's position, the less [we] know about [its] [momentum], and vice versa" ("Science Fiction, Science Fact"). The Heisenberg uncertainty principle also states that we cannot have a motionless electron, because "this [means] that in its lowest energy state, the electron [can]not be at rest in the nucleus, because, in that case, its position would be exactly defined (at the nucleus) and its [momentum] would also be exactly defined (to be zero)" (Hawking 55). Therefore, our electrons are constantly moving, and for our teleporter data transcription program, it is "impossible to resolve atoms and their energy configurations with the accuracy necessary to re-create exactly a human pattern" (Krauss 101). As a result, the energy in our bodies will be incorrect upon teleportation to our destination. Although we do not know what this will look like for an assimilated individual at his arriving point, we do know that his mass will be incorrect, according to Einstein's mass-energy equivalence equation $E=mc^2$.

The *Star Trek* staff did not leave out the notion of Heisenberg's uncertainty principle; rather, they acknowledged—and then avoided—this principle by creating the one impossible machinery in the transporter. *Star Trek* technical consultant Michael Okuda addressed the issue imposed by the uncertainty principle during *The Next Generation* series by inventing a transporter mechanism called the "Heisenberg compensator" (Okuda and Sternbach 109). Krauss summarizes the Heisenberg compensator as a transporter mechanism that "allows 'quantum resolution' of objects" to be understood, in order to preserve both the position of the atoms and their electrons' energy state (101-102). However, how the Heisenberg compensator operates, even Okuda does not know; upon being asked how the Heisenberg compensator worked, "[Michael Okuda] merely replied, 'Very well, thank you!'" recalls Krauss (102). Because the uncertainty principle is fundamental to the well-established field of quantum theory, it cannot be avoided or overcome. As a result, the *Star Trek* staff silently admit defeat and concede to science fiction magic—but not without broadcasting the keyword “Heisenberg” as a call for scientific acknowledgment in the science fiction community.

Perhaps it is possible to bypass the uncertainty principle by replacing our original idea of teleportation with the recently discovered concept of quantum teleportation. Quantum teleportation of atoms requires the “entanglement” between atoms. Entanglement occurs when two atoms are set up so that they have the same “quantum mechanical state” (“How to Teleport”). Now, suppose we have three atoms and label them “A,” “B,” and “C.” Suppose we entangle atom “A” with atom “B,” and suppose that atom “B” is synchronizing with atom “C” far away from atoms “A” and “B.” After making measurements of atom “A,” we see that its quantum mechanical state changes. If atom “B” is entangled with atom “C,” atom “C” will mysteriously have the same quantum mechanical state as atom “A” before we measured it (Krauss 104). Although this could potentially give us a good basis for the teleportation of macroscopic objects, the teleportation of one human would require roughly 10^{28} quantum teleportation operations for the roughly 10^{28} atoms in his body. Theoretical physicists thus express doubt or hesitation for this method of teleportation, since quantum entanglement is so poorly understood today; the world of quantum entanglement might as well be mathematical magic. Until we know more about quantum entanglement, we cannot be sure that quantum teleportation can be applied to macroscopic teleportation.

5. Conclusion

The obstacles that transporters pose for Gene Roddenberry's characters in *Star Trek: The Next Generation* will be similar to our teleportation woes because of the conceptual similarities shared between the series' transporter and our theoretical teleporter. Even though the transporter beams objects to their destination and our theoretical teleporter acts more as a quantum duplicator, system failures in both machines can yield similar types of catastrophic results. Our generation has a fascination with technological advances and new findings in the physical sciences. But, in our pursuit for the next biggest invention, we may occasionally overlook the ethics of the mass distribution of possibly dangerous inventions. While there may be a lot of thought over whether we can build a safe and reliable teleportation machine, there is much less concern over the ethics of its distribution for public usage. The underlying concept of teleportation is the computerization of humans. If we can recompose our atoms as bits and our bits as atoms, we can essentially be copied or even held in storage, suspended in time, and considered immortal for as long as compatible technology exists. Thus, in a sense, our version of teleportation involving computerized humans can also mean time travel into the future.

In addition to the possibility of time travel, teleportation also raises other important questions. During the time we are held in storage, would we be defined as dead? The computerization of humans would mean the loss of individuality and uniqueness, since people can be replicated, disposed of, or replaced. Will we be caught in a religious and philosophical warfare? Or will this reshape both religion and philosophy in our future? Perhaps when the time comes, we will already have had laws or a redefined view of life. However, we first need to begin thinking about these ideas so that we may avoid human catastrophes—not only on the physical level but also on the philosophical and spiritual levels.

Word count: 3618

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