

The Responsibilities of Knowledge

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Abstract. Knowledge and technology in the future will hold out almost limitless possibilities, but will also bring challenges and responsibilities relating to how they are used. This paper uses a story about space exploration in the future where Holodecks, advanced brain-computer and brain-brain interfaces, and other technologies, will enable exciting possibilities, but also create deep ethical dilemmas which have to be dealt with.

Keywords: Science Fiction, Science Fiction Prototypes, Holonovel, Holodeck, Space Travel, Space Exploration, Brain Computer Interface, Cyborg, Robot, Consciousness, Artificial Intelligence, Collective Intelligence, Ethics

1 Introduction

Developments taking place in many fields will transform our lives on this planet, as well as potentially affecting how we relate to the wider universe, through space exploration. Developments in robotics, computing and artificial intelligence, exemplified in the discussions about a forthcoming technological singularity, suggest a future where limitations of intelligence of the human brain, will not be a constraint. Developments in interfacing biology and machines, such as brain computer interfaces, imply that the combination between humans and machines can be exploited in ways which utilise the particular strengths of each to create novel and powerful synergies.

Yet paralleling these new possibilities are new ethical issues and dilemmas which are not immediately apparent. Traditionally, Science Fiction as a genre has been to the forefront of raising these questions. The concept of Science Fiction Prototyping and the Holonovel which this paper is guided by, builds on this to explore the technological and other pathways which could be followed as well as the consequences these may bring about. Through this it is hoped to help to influence current directions for development, but also to help pose wider societal and ethical issues which need to be considered and analysed. This paper uses a particular set of future technologies and an associated scenario to help elucidate some of these important issues.

2 Background

When Gene Dolgoff introduced Gene Rodenberry, the creator of Star Trek, to the concept of the Holodeck in the 1970s, the technological possibilities which existed at the time were relatively limited. But it still provided a major influence for later developments. For instance, John Carmack, who became the Chief Technology Officer for Oculus VR, the Facebook owned company that makes Virtual Reality headsets, states how he was inspired in his career by the Holodeck. Today in the epoch of virtual and augmented reality increasingly being available as consumer items, the technical context has moved to a different level. An interesting discussion of the possibilities of implementing a real Holodeck is provided by the science writer, Brian Clegg [1]. He thinks that producing a realistic moving holographic display feasible, but considers that one that can be walked around inside presents issues that will be difficult to overcome. However the problem can be looked at another way. In 2016, Alex Kipman, a key figure in the development of Microsoft's HoloLens smartglasses, as part of a TED talk demonstrated what using this looked like as he shared a space with a NASA scientist who appeared to be on Mars, using data from the Curiosity Rover there [2]. With the further development of technologies of this kind to be part of contact lenses and eventually integrated with vision directly, the subjective visual experience of the holodeck could be conceivable.

Reproducing physical contact was always the most problematical issue and envisaged originally in terms of "replicators" and "force fields". Physicist, Lawrence Krauss, is dismissive of this aspect of holodecks [3], and Mark Lasbury, who also looked at Star Trek technology [4], states that nothing currently available would "allow you to pick objects up like in a Star Trek holodeck". Notwithstanding this, at least in terms of simulating physical sensation, haptic devices are now relatively well-established. Recent novel developments in this area give some indication of what could be achieved. For instance, Ben Long and his group at Bristol University have demonstrated what have been called "haptic holograms", whereby focused ultrasound can produce the sensation of touching an object in mid-air [5].

Some of the other technologies mentioned in the story, such as direct connection to the brain's sensory cortex, are part of ongoing development. Miguel Nicolelis of Duke University who has been one of the researchers at the forefront of this work [6], has explicitly referred to the connection of this with the concept of the Holodeck. Techniques referred to in the story include brain computer interfaces and systems using clusters of biological neurons. Exemplifying the former is the Braingate system, originally developed by Brown University and the company Cyberkinetics. In one application this uses a array of 100 microelectrodes implanted in the primary motor cortex and has been used successfully with tetraplegics [7]. An example of the second type of technique are so-called rat brain robots. In one piece of work, approximately 100,000 neurons obtained from rat brains were used in a planar array and deployed in a robot control application, for instance to implement obstacle avoidance [8]. Although the type of system envisaged in the story, integrating human neuronal clusters with nanocomputer brain interfaces, lies considerably in the future, the underlying principles are already being demonstrated in practical applications.

Discussions of ethical issues concerned with technologies of this kind [9] are generally centred around issues arising in medical applications. However, some of the more general challenges which are raised in the story also have their counterparts in issues arising at the present time.

3 The Story

3.1 The Holodeck

Steve looked over the table at Ryan. For a space mission as important as this to humanity they couldn't have asked for anybody better - or more photogenic, he reflected.

"After that initial problem before launch," Steve commented, "I'm glad to hear everything's been going fine."

"Like clockwork," said Ryan, "although I guess there's very little of that around in this sophisticated piece of technology."

"I know you'll be formally taking over very soon from the boss," continued Ryan. The "boss" was Ricardo Gonzalez, commonly known as Rick, Director of the World Space Programme.

"I'm seeing him in an hour's time for the handover," said Steve, "the official announcement and ceremony is planned for tomorrow. It's going to be hard not to think of him being in charge after all this time. But I know he's looking forward to retiring. Not that we'll be short of any advice from him if we don't shape up, I'm sure. I'll see you at our next scheduled meeting."

Steve stood up and Ryan followed. They shook hands. This was the bit that Steve still found strange. Of course it was second nature to the younger generation, like Ryan, the Holodeck natives as they were referred to. But at the back of Steve's mind was the knowledge that Ryan in fact was roughly a million miles away.

3.2 Terrible Secrets

Steve found it hard to suppress a smile as he made his way to Rick's office. Rick was overall head of space missions and had particularly overseen the deep space programme which had relatively recently been initiated and included missions where those on the spacecraft would not return. Steve had been his deputy for over 10 years and was responsible for shorter range missions, but he had known Rick from when he first joined the programme so many years ago.

Steve recalled a phrase from Rick's presentation he and the new intake had been given on their first day.

"Knowledge as it develops presents new possibilities and opportunities which we must grasp. But we must also remember that it equally brings challenges and responsibilities, which we must face up to."

Rick had been his mentor from those early days, but also become a very close friend. Now Steve knew it was his turn to grasp the opportunities and he felt ready to take on this exciting new phase of development.

Steve knocked and went in. Rick beckoned him to sit down opposite to where he sat at his desk. Steve immediately knew something was wrong. He had not seen Rick since just before the launch and he was shocked at the change in him. Rick looked haggard, as if he had not slept. He was clearly highly agitated and distressed. Steve had never seen him like this before. He wondered whether the stroke which had necessitated Rick being off work for several months some years ago, and which Steve knew had been a major factor in him considering retirement, had recurred. Rick spoke as if he knew what Steve was thinking.

"I'm not ill Steve and this is certainly nothing to do with you or your abilities. You are indispensable to our programme and the person who both deserves the Director's post and who I would wish to take over from me. But I want to give you this opportunity to reconsider whether you want this."

Steve was stunned. He had spent his whole working life as part of the space programme, and although he certainly wouldn't have thought it likely that he would have reached the position he now was in when he started, this was his biggest ambition. Even as a child he had dreamt of this.

Rick spoke, again as if he could read Steve's mind. "I know that this has been everything you wanted, but I feel it is my duty, not just to you as a colleague but also one of my closest friends to ask you to consider your decision carefully."

Until then Rick had been looking down, but now he looked straight at Steve, who was shocked by the haunted and desperate expression in his eyes. "You see there are some things, terrible secrets, which I have responsibility for and which would fall on your shoulders. This has been preying on my mind and I cannot in clear conscience do this to someone I have been so close to and I know has trusted me, without putting them in the picture."

Steve felt a shiver running down his spine at the way the word "terrible" was said, as Rick continued.

"I know what I've just said will not make any sense to you, so what I've decided is that I will need to tell you now about some, but not all, of what the true situation is. At the end of this, the decision will be up to you. If you wish to have longer to decide you can have till tomorrow when we have the announcement scheduled. If you don't want to take up the post, you can forget everything I will have told you and of course you will be able to continue in your current job. I would then continue in my post until alternative arrangements can be made."

Rick paused, as if summoning up the strength to say what he had to say, and then continued.

"As you know, the deep space programme and the current mission especially, has a great deal riding on it, not just because of the state of our planet which necessitates us finding new territories and resources in order to continue viably, but also because it

represents hope and a future for humankind, without which civilisation itself could be undermined. Although your main responsibilities lie elsewhere, you were also part of the meticulous preparations we have been carrying out for this operation over many years, which of course has had to take place exactly at this time because of the particular conjuncture of planetary positions needed to provide a boost to the spacecraft and make the journey possible. A week before the launch, as was the main and almost only item in the news, there was the freak accident at the launch site, an explosion which destroyed one of the propulsion units. As reported, through a massive and coordinated effort we were able to replace this and carry out the necessary repairs so that the launch could go ahead as scheduled."

Steve butted in, "I know that this was a time of incredible stress and pressure on you, which you would not wish on anyone else. But I think I have proved myself over many years in smaller but still critical emergencies and I feel ready and willing to take on the responsibility and whatever goes with it."

Steve wasn't sure Rick had noticed what he had said, except for a deep sadness in Rick's eyes as he continued. "But there was a tragic consequence of what happened in the accident. Something which we couldn't report. Not with the universal expectations and hopes which were dependent on the mission."

Rick appeared very agitated, so Steve felt he had to come in. "Look, I spoke to Ryan earlier today, and he told me everything was fine. So whatever's the problem, we've been able to get over it."

Rick was looking down and shaking his head from side to side. "No, you don't understand Steve. Things are not fine. Ryan is ... Ryan is dead. He was killed in the accident."

Steve inadvertently let out a nervous laugh. "No, that's crazy, I've just spoken to him - met him." For a moment Steve wondered whether this was some kind of bizarre exercise devised to test him. But the anguish he saw in Rick's eyes as he looked up told him otherwise.

Rick stood up and started pacing up and down, turning to Steve from time to time. "I will have to tell you some things about which no one but I know. Remember that you have the choice. You can forget that you ever heard this and continue as you have been doing up to now. Ryan was seriously hurt in the accident. We played this down and said his injuries were minor. We sadly couldn't save him, but I put into place a deception so that even the medical staff involved didn't know this. For you to understand how this came about, I need to give you some background. To take you back about seven years when we were carrying out a mission that was one of the precursors to the deep space programme. It was just a one year voyage, a solo trip like the current one."

"I know the one you mean," Steve interjected. "Li Ming was the captain. There was the unforeseen meteor shower which damaged the ship and killed Li."

"That's the story we put out," Rick replied. "I know you were sceptical at the time, but had your own missions to look after and didn't have the opportunity to check further. Of course with the technology we have a meteor shower is never unforeseen. Li deliberately steered the ship off course."

"Why on earth would he do that?," Steve said incredulously.

"That was something that we couldn't predict unfortunately, whatever the technology we had," Rick replied. "Li's wife was suddenly taken very ill. It was not known how long she would live. When Li found out he was clearly distraught. He decided he would abort the mission and return to earth. As you know, a spaceship's course is almost entirely automatically determined, both through on-board systems and from mission control here. But especially because of the time lag involved in communications from earth, the ship's captain is given the ability to override this in an emergency. Li used this, and even though the ship's systems warned him of the meteor threat, decided to take the risk. By the time we were able to take control from him the ship was already badly damaged and Li was dead. In the light of what had happened, our political administration tasked me with coming up with contingency arrangements to deal with situations like that in the future. Particularly in the light of the extreme importance of the missions now taking place, it was emphasised that anything similar could not be envisaged. They did not wish to know how I was going to do it, just that a foolproof system was in place. I had effectively limitless resources at my disposal."

Steve looked at Rick pacing the floor and could almost feel the weight on his shoulders as he continued.

"A project was set up. Project Janus. Yes, after the two-faced Roman God. Many of the technologies we used already existed. For instance you'll be aware of one we use for the Holodeck. We are still largely constrained by the speed of light for communications. A conversation over distance would thus increasingly have an unacceptable time lag. As you are aware, we partly mitigate this through predictive thinking. When we speak to one of our astronauts in space, we have at our end a computer model of them and they one of us. At the same time this can be modified on the fly, not just through our conscious thoughts and words but also through the Brainlink we are set up with. This system brings together the most sophisticated technologies we have, originally developed mainly for medical purposes. We can interface the brain to computers, some of them nanocomputers which are integrated into the brain, but we can also use biological systems, neuron clusters we can create from stem cells, which become effectively an extension of our own brains. This originated as you may know with work on animal brain cells used to control robots. There are limitations of course, some which we will overcome through future development and some which are intrinsic, due to quantum effects for instance, but we are increasingly able to connect brains together to enable enhanced communication and collective thinking to a remarkable degree."

Senior personnel involved in the space programme had the Brainlink fitted as standard. Steve had been a little reticent when he had to undergo this procedure, but it was completely unobtrusive physically and in time he took its effects for granted. It meant that during a Holodeck conversation, for instance, he knew that his brain was being probed and was thinking about issues which he hadn't necessarily initiated. This would largely be subconscious, but then occasionally it would surface, and feel like a brainwave. Although longer time lags were more difficult to facilitate in this way, it could be done and the process then could carry on during sleep, where it could surface into dreams.

"Our use of Brainlink technology was originally intended for communications applications," Rick continued, "but of course even before the space programme's involvement with it, rather more disturbing variations of it were being envisaged and then developed. The functionality of the link could be extended so it could not only monitor but also control. Project Janus developed this much further. You can see how this could work in a case like Li's. The system monitoring his brain on the spaceship could detect what was motivating him to determine whether it was in response to a real emergency and override his actions if it wasn't. After the inevitable time delay, our long-distance communication system with our intervention here, could then refine and extend this."

"Yes, but that would still assume that Li was alive," countered Steve.

Rick's face contorted, as if he was in pain. "Originally we had no intention of going beyond this. But the terms of my brief required that the work we did be extended further. Some of this also came from Holodeck technology. As you know, there are many ways that we can reproduce physical sensations, such as when you shake hands. We can shape pressure and other waves. It can be through wearable technology, haptic devices which simulate what you would feel if the holographic image you are interacting with were real. A more sophisticated way that has been developed is to use Brainlink like techniques to directly stimulate the body's sensory nerve network at the brain. A different approach is to create something physical locally that simulates whatever is being interacted with. For many things we can use ultra-high speed 3-D printing and technologies. But with humans we need to do something different"

"You mean, like using a robot of some kind," said Steve. He noticed that Rick reacted nervously to this, as if he was not sure how to reply.

"In my brief for Project Janus," Rick continued eventually, "was included the scenario where in Li's case, for instance, he had been killed or injured very badly. Of course we could conceivably still control the ship remotely if the time lag was not too large or alternatively through local automatic systems. But we have a manned space program precisely because we need humans to carry out a myriad tasks, such as exploring some astronomical body or even meeting alien life forms, for instance. The project investigated and developed a spectrum of solutions. A robot as you have mentioned is a possibility, and of course we already use these for a number of purposes in space. But in the public's perception apart from anything else, this would

appear as if the mission had failed. So we looked at ways that an existing human could be ... repurposed shall we say, or where this was not feasible, could be ... reproduced."

"So what you are telling me," Steve said incredulously, "is that unbeknownst to the world at large, in place of the individual concerned you substitute some ... thing, which appears to be a human, but is in fact some technological concoction, a cyborg or robot."

Rick held his arms up in submission. "Physical damage or disability we can largely fix nowadays through medical techniques or prosthetics if necessary. Over a period of time, through the Brainlink, we collect an enormous amount of information about an individual's brain. Where someone's brain is largely intact but dysfunctional in some way or in some area we can use this information together with AI methods and computer technology and meld it with their existing brain functionality so that the change that takes place is minimised. The case of Ryan was extreme of course. The first time we had to start from scratch so to speak. But I had no choice. To deal with scenarios like this we had developed techniques which in other circumstances would be proscribed. We previously had created what was effectively a physical clone of him for eventualities like this. In this case a combination of biology and robotics for his body and the Brainlink information and nanocomputer infrastructure had to effectively substitute for his brain. Even in this case I know he fooled you on the Holodeck, but he would also have fooled anyone in real life. There was just so much, so many people, depending on him. Depending on us and our space programme. He was just indispensable for all our futures." He looked imploringly at Steve who was momentarily lost for words.

Finally Steve asked, "These people, you're doing this to. What do they feel about it all?"

Rick reflected before replying, "I suppose there's no real way of knowing. Consciousness, what we feel and think, is subjective. But we have done a lot of tests with people who have had various serious impairments and we have used these techniques with. Of course neither they nor the medical researchers and staff involved had any idea what the underlying objective of this work was. After perhaps a brief period of confusion, the subjects almost universally don't feel that anything has altered with themselves. Even where something had changed substantially, they just felt as if they had acquired this naturally, as if they had learnt a new skill or were seeing things in a new way. Of course as we all know our body is effectively completely replaced over a period of some 7 to 10 years. We don't feel we are a new person because of this. It's as if we had just speeded up this process but kept whatever is the feeling of self intact. Even in the case of Ryan, where all we could use was the Brainlink data and as much information as we could find elsewhere, he still seemed to be who he had been before. But there were gaps. There was no record of his brain activity when he was a child for instance. In this case we used Brainlink data from comparable children who had undergone this set up as part of medical procedures. We used this modified and filtered in various ways based on the information we did have

about his childhood. So he is a curious hybrid, but in the intense work which we only had a week to do before the launch, he still seemed to get back a cohesive sense of self."

"But the sense of which self," Steve butted in angrily, "you're talking about creating a new person in your image, or an image which you have decided on. They not only have no say in it, but they may not even know that it's taken place. You have made yourself God, but not even a God which people can accept or not, but a God by stealth."

Steve sat for a while trying to take things in. He finally asked, "Who knows about this? Is there any record about who is affected?"

"The whole project was carefully designed so that those taking part each only saw a particular aspect of it and thought they were working on something else. I am answerable to a small political subcommittee but they expressly don't want to know who's affected. The only record that exists for those involved in the space programme is a special status code in their restricted personnel file, which only I know the meaning of. It's the number '66', which doesn't appear in any other context. Sole responsibility effectively lies with me, and it would with you if you took over. That's why I wanted you to be able to make an informed decision knowing the true situation."

"Not quite the number of the beast," Steve said grimly. "I will give you my decision at 10 tomorrow morning," he said as he left.

3.3 A Question of Self

Steve spent the rest of the day alone in his office thinking about what he had been told. It was quite late when he returned home. He declined to answer any questions his wife Freya asked him about the day.

"There's an important decision I have to make by tomorrow morning," he said. "I just need to try and get some sleep." He lay in bed the events of the day repeatedly playing through his mind. Rick has said that he wouldn't tell him everything till he had made his decision. So what was it that he still didn't know? There was something that Rick had mentioned that he knew was significant, but he couldn't think what it was. It was many hours before he fell into a fitful sleep. Strange dreams filled with bizarre images and beings kept going through his brain. Suddenly he woke up. He knew what had stuck in his mind during his conversation with Rick. Rick had used the word indispensable when referring to him, the same word he had used to describe Ryan. A sudden and frightening realisation hit him. Was he who he thought he was? They could have just used the Brainlink he already had and extended it. He had been involved in a serious car accident about three years previously. While he was in hospital for this would have provided the perfect opportunity.

He hurriedly woke up Freya. "Have you noticed any difference in me lately?," he asked her.

"You mean other than waking me up in the middle of the night asking stupid questions," she said sleepily.

"Some significant change, perhaps after I had the accident," he persisted.

"Not really," she replied, "you're probably just as annoying as you always have been. What's this all about? Go back to sleep."

Steve waited till she was asleep. He knew how he could find out what he needed to know. He got out of bed and sent a text to his friend Jamal. Jamal headed the IT section of the space administration. Steve had known him since their schooldays.

Steve was waiting for Jamal when he got into work at 7 AM. "I need a big favour, Jamal," he said, "I need you to run a search on the restricted section of the personnel records."

Jamal was dubious. "Hey, I know that you're going to be the big boss very soon, but even then there are various approval procedures I have to go through."

"I need this very quickly," Steve replied, "and it's very simple, I just need to know whether my record is correct. I need you to look for a number, '66', in my status codes."

"Well," said Jamal, "I guess I can make an exception in this case then. But this is certainly going to cost you in terms of favours you owe me."

At 9.30 AM Steve was in Jamal's office.

"I ran that search you asked for," Jamal said, "but there's no '66' in your status codes. What's it supposed to represent? Even I don't know what the codes in the restricted sections mean."

Steve let out an audible sigh of relief. "It's nothing important," he replied, "let's say something would have been wrong if it had been there."

"I can't recall seeing that code before so I ran a search for it just out of interest. It does come up, but it's extremely rare," said Jamal.

"I guess that was Ryan," said Steve.

"Yes" said Jamal, "You obviously know about this, so I guess I'm not giving away any secrets. I presume it signifies some special status, which I suppose you won't get till you're officially appointed as Director. I figured that out because of the other '66' it came up with - Ricardo Gonzalez."

3.4 The Decision

At 10 AM sharp, Steve entered Rick's office.

"I know who ... or what you are," he said.

A look of relief came over Rick's face, as if a great weight had been lifted off his mind.

"I would have told you anyway but I'm glad you found it out yourself. Let me try to explain how all this came about. When I had my stroke I had a terrible decision to make. Now I know that I have a possible successor who I can be confident in, but I felt you weren't ready then. At that time, my views about using technology in this way

would have been very similar to what I think yours are now. I was fully conscious, but scans showed certain parts of my brain had been affected. Even if I recovered, I didn't know whether I would be able to continue in my role. But I faced an awful dilemma. I felt the future of the space programme and all that it entailed would be jeopardised just because of some abstract moral principle on my part. Believe me the choice wasn't easy. Without anyone knowing that it was me that was being treated, I had the process carried out that had been developed for astronauts. I have deduced that you found out my secret because you suspected you might have been one of the '66ers' and investigated accordingly. When you had your accident and I thought I might lose you I must confess I did seriously consider taking this course of action with you for similar reasons I had done for myself. But one of the reasons I didn't was that in a way you represented my chance of redemption. My decision to retire was partly motivated by my desire to put someone without my ... dubious pedigree, back in charge. We'd had no major problems at all with missions after Li's one. The last one with Sophia made me think that we had dealt with all the potential issues. And then Ryan's accident took place. Again I felt what I did was the only way out. But with that decision came the guilt, the guilt that I would be handing over that terrible secret and the responsibility arising from it to someone who trusted me and I was so close to. Nothing can absolve me from what I've done. The decision whether you wish to accept some of that responsibility is yours Steve, you mustn't feel any pressure from me as to how you decide."

Steve sat motionless for a while, his mind in turmoil. Finally he spoke. "I hadn't made my final decision till now. But I will take the job. I acknowledge what's happened cannot be undone. Maybe faced with the choices you had to make I would have acted similarly. I don't know. But as I think you feel as well, I believe I can take responsibility without feeling compromised in some way as you do, whether that's actually the case or not. Perhaps I can work towards a situation where there are no more '66ers', where perhaps all of humanity has to collectively take the decisions, however difficult they might be."

For the first time since he had seen Rick the day before Steve detected something else in his eyes, a feeling of hope, even optimism. A brief smile crossed Steve's lips. Maybe the Rick he had looked up to and respected was still there. As Steve left the room he felt his confidence and purpose return. He would live up to the expectations that the Rick he knew had shown in him over all those years they had been together. He would grasp the opportunities, but also face up to the responsibilities of knowledge.

4 Conclusion

The ethical and moral issues involved with the ability to effectively create life is a perennial topic for fiction. 2017 is the 200th anniversary of the first publication of Mary Shelley's Frankenstein, which explored that issue in a different age. In that story, Victor Frankenstein who creates the monster is not evil, but a scholar and

researcher, although unconventional in his outlook and methods. It is his quest for knowledge that has tragic consequences and is his undoing.

In today's world the development of knowledge and technology as part of it is intrinsically embedded in society and the economy at every level. How aspects of this can have unintended and sometimes uncontrollable consequences is a problem that frequently arises. Unlike in Mary Shelley's time, the capabilities of doing what is described in the story do not lie too far in the future, and in basic form already exist, as discussed in the paper. So we could say we are moving towards a period where both the motivation as well as the capability for the type of scenario depicted in the story to arise is not unrealistic.

The technologies discussed in the paper are ones which have important and positive contributions to make. As indicated, many of them have arisen from extremely beneficial developments tackling problems in the areas of health and disability. Even the space travel scenario of the story is not implausible and in itself could have positive connotations. Undoubtedly the importance of how technology is organised and controlled is a key issue which the story highlights. Technologies that arise in the story and are discussed could of course if suitably directed also be used to enable collective thinking and democratic discussion which could help to obviate some of the dilemmas that arise. But one of the key conclusions of the story must be that there are no easy answers and the future will increasingly pose complex ethical questions related to technological developments. Hopefully as well, the story will help to demonstrate that the methodology of Holonovels and Science Fiction Prototyping is an important way to help facilitate wider engagement with these difficult issues and foster the discussion and debate which is necessary.

References

1. Clegg, Brian: Ten Billion Tomorrows: How Science Fiction Technology Became Reality and Shapes the Future, St Martin's Press (2015)
2. TED. Alex Kipman: A futuristic vision of the age of holograms [Video File]. (2016, February) Retrieved from:
https://www.ted.com/talks/alex_kipman_the_dawn_of_the_age_of_holograms.
3. Krauss, Lawrence M. The physics of star trek. Basic Books (2007)
4. Lasbury, Mark E: The Realization of Star Trek Technologies: The Science, Not Fiction, Behind Brain Implants, Plasma Shields, Quantum Computing, and More. Springer (2016)
5. Long, Benjamin, et al. "Rendering volumetric haptic shapes in mid-air using ultrasound." ACM Transactions on Graphics (TOG) 33.6 (2014)
6. Lebedev, Mikhail A., and Miguel A.L. Nicolelis: "Brain-Machine Interfaces: From Basic Science to Neuroprostheses and Neurorehabilitation." Physiological Reviews, 97.2 (2017)
7. Rowland, Nathan C., Jonathan Breshears, and Edward F. Chang: "Neurosurgery and the dawning age of Brain-Machine Interfaces." Surgical Neurology International 4. Supplement 1 (2013)
8. Warwick, Kevin: "Creating and Controlling Complex Biological Brains." Complex Systems. Springer International Publishing, (2016)

Presented at Holonovels'17, Canterbury, UK - 11th September 2017

9. Clausen, Jens: "Ethical Implications of Brain–Computer Interfacing." Handbook of Neuroethics. Springer Netherlands, (2015)