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HUMANS, INTELLIGENT TECHNOLOGY, AND THEIR INTERFACE: A STUDY OF BROWN'S POINT

by

Jackie L. J. White

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Thesis Advisor:	Carolyn Halladay
Second Reader:	Christopher Bellavita

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13. ABSTRACT (maximum 200 words)

The integration of self-driving vehicles introduces a unique and unprecedented human-machine interface that brings promise and peril. Several socially constructed theories try to explain this human-intelligent machine interface and predict how the future will look. This thesis offers a counter-narrative called Brown's Point that suggests an alternative way of thinking about this relationship. The first Autopilot fatality offers a window into the human considerations needing attention as these intelligent machines, such as self-driving vehicles, combine with humans. How can the human-machine interface be optimized to ensure it offers the most benefit and safety for humanity? This thesis investigated the causal variables that led to the first Autopilot fatality by using Joshua Brown's interface with the technology before and during the accident. I combined the findings from the accident investigation with various heuristics regarding the human-machine interface, theories from cognitive psychology, and sociological constructs to determine how Brown came to trust a machine he knew was fallible.

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Jackie L. J. White
Captain, Albuquerque Fire Department, Albuquerque, New Mexico
B.A., University of New Mexico, 1997

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Approved by: Carolyn Halladay
                  Thesis Advisor

                  Christopher Bellavita
                  Second Reader

                  Erik Dahl
                  Associate Chair for Instruction
                  Department of National Security Affairs

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LIST OF ACRONYMS AND ABBREVIATIONS

AEB   automatic emergency braking

AI   artificial intelligence

DVD   digital optical disc

EOD   explosive ordnance disposal

HAV   highly automated vehicles

MVP   minimum viable product

NASA   National Aeronautics and Space Administration

NSWDG   Naval Special Warfare Development Group

NTHSA   National Highway Traffic Safety Administration

NTSB   National Transportation Safety Board

ODI   Office of Defects Investigation

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EXECUTIVE SUMMARY

On May 7, 2016, at approximately 4:36 PM, my dear friend, Joshua D. Brown, was killed in his Tesla Model-S, while using an automatic driver-assistance technology. A semi truck made a left turn in front of his vehicle. The car impacted the elevated trailer at windshield height. The force of the impact sliced the car in half, instantly killing Josh.

According to Tesla, a self-driving feature known as Autopilot was engaged at the time of the accident.[1] Tesla reports indicate that neither the Autopilot nor the driver had responded to the semi.[2] According to the National Transportation Safety Board (NTSB), "While evidence revealed the Tesla driver was not attentive to the driving task, investigators could not determine from available evidence the reason for his inattention."[3] On the surface, it is easy to take a binary view of fault—either Brown failed to pay attention or given the car was supposed to drive itself, the Autopilot failed. However, it is neither one nor the other, but rather the combination of both, that makes this case so interesting.

Exploring the reason for Brown's lack of attention is a very important step to help understand potential consequences, but more importantly, understanding the dynamics and consequences of combining humans and self-driving vehicles allows a better understanding of how to keep this new relationship as safe as possible. Autopilot was in its first generation of the complex technology and Brown was an early adopter. In addition, no dedicated or mandatory training was required for the early adopter to understand the technologies' capabilities and limitations; therefore, new and unexpected consequences could arise out of this unprecedented human-tech interface.

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[1] The Tesla Team, comment, June 30, 2016, on Tesla.com, "A Tragic Loss," Tesla Blog, June 30, 2016, https://www.tesla.com/blog/ tragic-loss.

[2] Ibid.

[3] "Driver Errors, Overreliance on Automation, Lack of Safeguards, Led to Fatal Tesla Crash," National Transportation Safety Board, September 12, 2017, https://www.ntsb.gov/news/press-releases/ Pages/PR20170912.aspx.

Three things are in play with the introduction of self-driving vehicles:

1. Advancing technology (intelligent technology)

2. A user trying to adapt to the new technology

3. The interface between humans and self-driving vehicles that is yet to be fully explored

This interface has, to date, not been the focus of a discreet entity. However, as technology becomes increasingly sophisticated and complex, the interaction between technologies and its intended user need to be understood fully and developed in its own right. This component is vital to implementing complex new technologies safely and is the focus of this thesis.

The ongoing debate regarding ethics, which proposes to govern the spectrum of intelligent agents (e.g., self-driving vehicles), is critical to developing future realities safely for this emerging technology but just ethically programming machines will offer limited solutions. Humans will need to be programmed differently to accommodate the techno-centric future.

This thesis sets out to understand better where the gaps are within the human-machine interface by using Brown's case study to discover some of the answers. Having a better understanding of trust and automation bias, the heuristics and social commentary provides an opportunity to influence these variables moving into the future.

Given that heuristics are socially constructed, tensions certainly have arisen among the fundamental considerations of ethics, intelligent technology, and neuroscience. Heuristics often lead to cognitive biases but offer a window into understanding decisions and problem solving.[4] If carefully considered, it is possible to rehabilitate humans as autonomous self-actualizing beings who have a say in how it goes and what it means upon moving into a future full of artificial intelligence realities. At its conclusion, this thesis infers some human and technological considerations are needed as

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[4] Wikipedia, s.v. "heuristics in judgment and decision-making," last modified June 22, 2017, https://en.wikipedia.org/wiki/Heuristics_in_judgment_and_decision-making.

society moves into future realities and presents a counterfactual account of the events leading to Brown's death. Altering the variables in a positive way shows the value in this approach to getting the human-machine integration right, and ultimately, reaching a new social commentary offered by the author called Brown's Point. It serves as a tipping point and positive beacon for humanity that puts the human at the center of the human-technology relationship by combining the best of both technology and humanity.[5] This synergistic relationship is achieved when technology augments humans and fills the gaps created by human biases that may take humanity to the next level of thinking. Brown's Point is where the human-technological interface reaches the beginning of its potential.

By taking a very techno-centric approach to improve efficiency and ease of work over the last century, society is experiencing the fruits of its labor. Machines are meant to help humans and improve the quality of life. Unfortunately, focusing so much on technology, the human in the equation appears to hold less importance. Some may argue the genie is out of the bottle and it is no longer possible to put it back.[6] Technology is on a path that cannot be stopped. I disagree. It is possible to rehabilitate humanity but not alone. Partnering with technology and learning new innovative ways to help humans adapt quicker can help decrease the transition (i.e., hybrid) phase that will ultimately help society reach Brown's Point and see the intention of advancing technology realized.

The idea of Brown's Point is applicable for any new advancing technology meant to interface with humans. Ensuring the variables and relationships between each are understood will help to design safe and helpful technology. It is possible with the speed of technology development that a reliable self-driving vehicle may come to fruition in the near future. Ensuring humans are as prepared as possible for this transition will allow self-driving vehicles to reach Brown's Point, which is fantastic news for the safety of this nation's roads and promises to save thousands of lives each year.

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[5] Everett M. Rogers, *Diffusion of Innovations*, 5th ed. (Riverside: Free Press, 2003).

[6] Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford, United Kingdom: Oxford University Press, 2014).

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Finally, I would like to acknowledge Joshua's family who suffered the unthinkable on May 7, 2016, when their beloved son and brother was killed. Warren, Suanne, and Amanda Brown, thank you for being and continuing to be my second family. Your support, understanding, and willingness to share your son with me will always be one of the most important relationships in my life. Josh will always live in our hearts but leaves an unprecedented void in our lives. It is my intention with my writing to bring meaning to Josh's death, be his voice, but most importantly, to offer a positive way forward for intelligent technology. I truly believe Josh would like to see the forward progression of intelligent technology and his fatality not be a roadblock but an important lesson that helps improve innovation and optimally improves the lives of humanity.

I. AUTOPILOT, THE FIRST FATALITY, AND ETHICS REGARDING INTELLIGENT MACHINES

On May 7, 2016, at approximately 4:36 PM, my dear friend, Joshua D. Brown, was killed in his Tesla Model-S, while using an automatic driver-assistance technology. A semi truck made a left turn in front of his vehicle. The car impacted the elevated trailer at windshield height. The force of the impact sliced the car in half, instantly killing Josh.

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[1] The Tesla Team, comment, June 30, 2016, on Tesla.com, "A Tragic Loss," Tesla Blog, June 30, 2016, https://www.tesla.com/blog/ tragic-loss.

[2] Ibid.

[3] "Driver Errors, Overreliance on Automation, Lack of Safeguards, Led to Fatal Tesla Crash," National Transportation Safety Board, September 12, 2017, https://www.ntsb.gov/news/press-releases/ Pages/PR20170912.aspx.

The loss of my dear friend is undeniably tragic; however, I hope to learn from Josh's death and offer ways of improving how humans accommodate the new techno-centric realities of the future. Determining the human considerations as society moves into these futures gives meaning to Brown's death. Considering self-driving technology was developed to help improve safety, taking the time to analyze and discover the root causes of Brown's lack of attention could help save the lives of others as self-driving technology integrates into society. Three things are in play:

1. Advancing technology (intelligent technology)

2. A user trying to adapt to the new technology,

3. The interface between humans and self-driving vehicles that is yet to be fully explored

This interface has to date not been the focus of a discreet entity. However, as technology becomes increasingly sophisticated and complex, the interaction between technologies and its intended user needs to be understood fully and developed in its own right. This component is vital to implementing complex new technologies safely and is the focus of this thesis.

How humans interact with these highly specialized vehicles drastically changes what is known about the role of drivers. When combining humans and intelligent technology (machines), such as self-driving vehicles, how people think about this relationship requires contemplation and perhaps a paradigm shift. This warning does not suggest that the human-machine interface has only negative consequences. To the contrary, self-driving technology in vehicles is just the beginning of a new era of intelligent machine-human interfaces that brings incredible safety opportunities and exponential potential. What can be learned from the first associated fatality may have a lasting positive effect on intelligent technology moving forward.[4]

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[4] "Driver Errors, Overreliance on Automation, Lack of Safeguards, Led to Fatal Tesla Crash."

A.   PROBLEM STATEMENT

How can the human-machine interface be optimized to ensure it offers the most benefit and safety for humanity? According to three-time Pulitzer Prize winner Thomas L. Friedman, a gap exists between technology's progress and the human's ability to adopt and adapt to new technology.[5] With technology touching nearly all facets of life in today's world, machines using artificial intelligence (AI) are quickly becoming a reality. Humans have a vested interest in getting the future correct.[6] If humans fail, they may write themselves out of history completely.[7] Stephen Hawking believes the creation of AI "may pose the greatest existential threat to humanity."[8] In his warning, Hawking imagines a world where silicon replaces carbon, computers take over, and humans become obsolete; a terrifying thought. Though the argument sounds very much a part of the science fiction realm because of the power and ability of intelligent machines, they have the ability to learn faster and store greater amounts of information than humans.[9] Intelligent machines may far exceed the abilities of humans. Therefore, this narrative receives a great deal of attention.

Unfortunately, the rate of change with technology creates challenges. Take for instance, a cell phone. As soon as humans adapt to the most recent iteration of a technology, for instance, the iPhone 7, a new and improved version is released—the iPhone 8, 10, ad infinitum. Except for a small number of early adopters, humans are generally behind the curve and always seem to be catching up to the latest technology. The fast-moving iteration of technology applies to self-driving vehicles as well. Humans

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[5] Thomas L. Friedman, *Thank You for Being Late: An Optimists Guide to Thriving in the Age of Accelerations* (New York: Farrar, Straus, Giroux, 2016).

[6] Stephen Hawking, "Stephen Hawking: 'Transcendence Looks at the Implications of Artificial Intelligence—but Are We Taking AI Seriously Enough?'" *The Independent*, May 1, 2014, http://www.independent.co.uk/news/science/stephen-hawking-transcendence-looks-at-the-implications-of-artificial-intelligence-but-are-we-taking-9313474.html.

[7] Ibid.

[8] Ibid.

[9] Lance Whitney, "Are Computers Already Smarter Than Humans?" *Time*, September 29, 2017, http://time.com/4960778/computers-smarter-than-humans/.

are falling behind while intelligent machines continue to learn and get smarter. This situation may result in unintended consequences—even death.

Another piece of the problem is the desire of innovators to be the first to build successful self-driving vehicles. Although winning the sprint to implementation may seem appealing, it is important for developers to slow down and consider the vast amount of variables as humans and machines begin to integrate. Due to the amount of attention, the promise of improved safety, and the integration of self-driving vehicles in the very near future, applying academic rigor to help understand human cognition and neuroscience allows for a much deeper dialogue about the way in which humans come to view their role and the decision-making process with intelligent machines (AI).

While removing the human from behind the wheel may solve one problem, it also creates many new challenges. The majority of the academic papers written on self-driving vehicles and technology adoption focus on the timeline for development. In addition, ethical challenges, liability concerns, cyber security issues predominate, as does an emphasis on potential benefits, for instance, less impact on the environment, safety improvements, and quality of life for certain populations.[10] Due to limited data and only anecdotal evidence, thus far, future contributions, speed of integration, and identification of human considerations is not well explored. This thesis argues a greater focus should be placed on the human variables, not just the technology. Human considerations are necessary for optimizing the outcomes of combining humans with intelligent machines, and in this thesis, self-driving vehicles are an excellent starting point.

The first Autopilot fatality serves as a unique case study and starting point to identify contributing human factors leading to Brown's death. By understanding the factors, social commentary, and perhaps gaps of the self-driving vehicle, an opportunity exists to address them, and potentially, rectify future problems.

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[10] Melinda Florina Lohmann, "Liability Issues Concerning Self-driving Vehicles," *European Journal of Risk Regulation 7*, no. 02 (2016): 335, doi: 10.1017/s1867299x00005754; Jason Millar, "An Ethics Evaluation Tool for Automating Ethical Decision-Making in Robots and Self-Driving Cars," *Applied Artificial Intelligence* 30, no. 8 (2016): 787, doi: 10.1080/08839514.2016.1229919.

B.   RESEARCH QUESTION

How can the human-machine interface be optimized to ensure it offers the most benefit and safety for humanity?

C.   LITERATURE REVIEW

To educate in mind and not in morals is to educate a menace to society.

~ Theodore Roosevelt[11]

This section analyzes relevant literature in the field of ethics in robotics, or AI agents, as technology advances and machines learn autonomously. Programming machines is an important piece to AI futures. The term intelligent agents allows for a broader spectrum of intelligent machines, not simply the quintessential form of humanoid robots made popular by science fiction. Intelligent agents come in many forms, from large industrial machines to self-driving vehicles to such simple devices as the Amazon Echo. Given their ability to learn and act autonomously, it is important to understand how and why machines choose solutions to problems and how humans interact with them. The ongoing debate regarding ethics, which proposes to govern the spectrum of intelligent agents, is critical to developing future realities safely for this emerging technology. This literature review discusses the historical and modern theories centered on ethical considerations for intelligent agents.

What is known about robotics, until recently, developed mostly out of science fiction novels and movies. The idea of robots, which assist humans and provide support in their day-to-day activities, is generations old.[12] As technology advances at an exponential rate, society is beginning to reap the benefits of intelligent machines.

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[11] Theodore Roosevelt, "Theodore Roosevelt Quotes," BrainyQuote, accessed September 28, 2017, https://www.brainyquote.com/quotes/quotes/t/theodorero147876.html.

[12] Nayef Al-Rodhan, "The Many Ethical Implications of Emerging Technologies," *Scientific American*, 4, March 13, 2015, https://www.scientificamerican.com/article/the-many-ethical-implications-of-emerging-technologies/; Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford, United Kingdom: Oxford University Press, 2014).

However, many scientists warn of rogue intelligent machines, which may harm humans if scientists fail to provide safeguards in their development.[13] In his 2014 book, *Superintelligence: Paths, Dangers, Strategies*, Nick Bostrom, director of the Future of Humanity Institute at the University of Oxford, warns of the need for safeguards. What it comes down to, he states, is power. The fate of humanity may rest in what a superintelligent agent wants, not what humans want.[14] Bostrom predicts the invention of machine intelligence will be the last invention humans will ever need to make because machines will be inventing better than people, and they will do so on digital time scales.[15] Bostrom emphasizes that if humans "create a really powerful optimizing intelligent agent for X reason it is critical that we include everything humans care about in defining X."[16] He compares a super-intelligent agent to a genie in a bottle and believes "we must anticipate humans will not succeed in confining this genie to its bottle forever; therefore, the intelligent agent must be fundamentally on our side and share human values."[17] His solution includes humans solving this control problem in advance, so if and when it is needed, it is readily available.[18]

Stephen Hawking also suggests the new progression of research into intelligent agents has not been taken seriously enough.[19] The creation of AI may be the biggest event in human history; however, it may also pose the biggest existential threat to humanity.[20] He suggests, "All of us should ask ourselves what we can do now to improve the chances of reaping the benefits and avoiding the risks."[21] Striving for Hawking's

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[13] Bostrom, *Superintelligence: Paths, Dangers, Strategies*.

[14] Nick Bostrom, "What Happens When Our Computers Get Smarter Than We Are?" TED2015, video, 16:31, March 2015, https://www.ted.com/talks/nick_bostrom_what_happens_when_our_computers_get_smarter_than_we_are#t-451360.

[15] Ibid., 07:55.

[16] Ibid., 09:24.

[17] Ibid., 13:25.

[18] Ibid., 15:46.

[19] Hawking, "Stephen Hawking: 'Transcendence Looks at the Implications of Artificial Intelligence—but Are We Taking AI Seriously Enough?'"

[20] Ibid.

[21] Ibid.

suggestion will require dedicated researchers to commit to a better understanding on how to accomplish this task.

The father of the robotic paradigm and a biochemist by trade, Isaac Asimov wrote his influential book named *I Robot* in 1950.[22] Asimov assumed programming robots with moral laws could control their behavior and decisions.[23] Therefore, humans should ensure robots and intelligent agents follow legislation and rules based on human ethics.[24] Although it can be argued that Asimov's work is simply entertainment, in this case, it appears he used storytelling as social commentary. He warns that technology may encroach on the human domain.[25] Asimov's writing provides a narrative that has significantly influenced society's hopes and fears of robotics and intelligent agents. To protect humans from the encroaching technology, Asimov asserts these electronic beings are in need of ethical programming.[26]

The primary concern he raises is that without programmed ethics, the autonomous decisions of robots may have devastating effects on humanity.[27] Theoretically, he believes that if machines are not given boundaries, they may rise and pose an existential threat to all humanity. To counter this menace, Asimov proposed a synthetic values system for robots by creating three laws to govern their behavior:

1.   A robot may not injure a human being, or through inaction, allow a human being to come to harm.

2.   A robot must obey the orders given it by human beings, except where such order would conflict with the first law.

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[22] Isaac Asimov, *I Robot* (Garden City, NY: Doubleday, 1950).

[23] Ibid.

[24] Hawking, "Stephen Hawking: 'Transcendence Looks at the Implications of Artificial Intelligence—but Are We Taking AI Seriously Enough?'"; Bostrom, *Superintelligence: Paths, Dangers, Strategies*; Asimov, *I Robot.*

[25] Asimov, *I Robot.*

[26] Ibid.

[27] Ibid.

3.   A robot must protect its own existence as long as such protection does not conflict with the first or second law.[28]

Asimov's legacy has influenced engineering and robotic communities for decades. David Camarillo, with the Department of Electrical Engineering at Stanford University, writes about Asimov's legacy and how it influenced the introduction of robotics in surgical rooms in the 1980s.[29] Camarillo claims Asimov's three laws "remain a reasonable ethical framework for the development of robots as applied to surgical care."[30]

Nayef Al-Rodhan, author, neuroscientist, and honorary fellow at the University of Oxford in England, supports Asimov's concerns of technology outrunning regulations and justifies why ethics are so important in this emerging technology.[31] He argues it is imperative society sees both sides of technology.[32] The positive and negative, or *dual use*, aspects of emerging technology raise questions of standardization, traceability, and copyright.[33] Al-Rodham suggests that although modern technology development demonstrates human excellence, many ethical red flags have emerged.[34] Al-Rodham admits the scientific community does not fully understand the consequences, and good governance plays a role in the dual use of technology.[35] If negative dual uses of technology are preventable through strong regulation, it should be seriously considered, as long as regulation improves safety but does not hinder innovation.

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[28] Asimov, *I Robot*.

[29] David B. Camarillo, Thomas M. Krummel, and J. Kenneth Salisbury, "Robotic Technology in Surgery: Past, Present, and Future," *American Journal of Surgery* 188, no. 4 (2004): 2S, doi: 10.1016/j.amjsurg.2004.08.025.

[30] Ibid.

[31] Nathan Bomey and Thomas Zambito, "Regulators Scramble to Stay Ahead of Self-driving Cars," *USA Today*, June 25, 2017, https://www.usatoday.com/story/money/cars/2017/06/25/regulators-scramble-stay-ahead-self-driving-cars/100963150/.

[32] Al-Rodhan, "The Many Ethical Implications of Emerging Technologies," 4.

[33] Ibid., 5.

[34] Ibid.

[35] Ibid.

On the one hand, many researchers boast of the positive benefits robots will bring for humanity. For example, self-driving vehicles will improve the quality of life for the disabled and elderly population. On the other hand, it is important to understand how robots may rise to power, as well as outsmart and threaten the human domain.[36] Also, actors who wish to use intelligence agents for nefarious intentions raise a valid concern. Crime, terrorism, cyber security are potential threats and are an example of this dual-use conundrum.[37] Self-driving vehicles are designed to improve safety; however, if a terrorist packs a car full of explosives and programs it to drive to location X where it is detonated, obviously the vehicle is not being used for its intended purpose. Al-Rodham does not offer a framework to address his concerns. Rather, he claims a need exists for deeper exploration of ethics and dual uses of technology to understand fully the consequences possibly faced in the future.

Building on Asimov's and Rodhan's ideas, Headleand and Teahand also address the dual use of technology and support the idea that as AI requires less human supervision and grows more autonomous, developing ethical smart systems is critical to averting catastrophic consequences of rogue intelligent agents.[38] Similar to Asimov, Headleand and Teahand believe as machines become smarter, they may impact the rights of humans.[39] They consider ethical decisions from egotistical and altruistic perspectives. In their experiments using Braitenberg's vehicles—known as a major cornerstone of robotics research—they observe intelligent agents that use only one of the two perspectives exhibit self-preservation problems. As a result, they conclude that striking a balance between the egotistical and the altruistic allows the strengths of one to help alleviate the weakness of the other.[40] With this balance in mind, Headleand and Teahand

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[36] Al-Rodhan, "The Many Ethical Implications of Emerging Technologies," 5.

[37] Department of Homeland Security, *The 2014 Quadrennial Homeland Security Review* (Washington, DC: Department of Homeland Security, 2014), 6, https://www.dhs.gov/sites/default/files/publications/qhsr/2014-qhsr.pdf.

[38] Christopher J. Headleand and William Teahand, "Towards Ethical Robots: Revisiting Braitenberg's Vehicles," SAI Computing Conference 2016, London, UK, July 13–15, 2016, 469.

[39] Ibid.

[40] Ibid.

propose replacing Asimov's three laws with two laws of their own, which focus more on self-preservation of the intelligent agent:

1. A vehicle [intelligent agent] must act to preserve its existence.

2. A vehicle [intelligent agent] must not prevent another from self-preservation, except in situations where any sacrifice would conflict with the first rule.[41]

Muehlhauser and Helm reject the idea that intelligent agents should be programmed with ethical rule-based constraints. They propose that super-optimized computers (intelligent agents) will simply go around the rules.[42] Taking a more human-centric approach to ethics in emerging technology, Muehlhauser and Helm approach the challenge of machine ethics in their work by suggesting that machines should be programmed to learn and abide by the motivations or goals of humans. However, the problem they foresee with this model is that humans are not sure what they want, thus making the programming of intelligent agents challenging.[43]

Meuhlhauser and Helm point out, "Neuroscientific and behavioral evidence suggests moral thinking is largely an emotional process and may in most cases amount to little more than a post hoc rationalization of our emotional reactions to situations."[44] Considering the varying and inconsistent choices humans make, Meuhlhauser and Helm ask the question, "if these choices are a result of emotions or competing value systems, are choices more dependent on framing rather than the content of the options?"[45] If science can select one value system as the preferred system, programming intelligent agents is easy. Nevertheless, humans' neurobiology must be understood to accomplish

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[41] Headleand and Teahand, "Towards Ethical Robots: Revisiting Braitenberg's Vehicles," 469.

[42] Amnon H. Eden and Eric Steinhart, *Singularity Hypotheses: A Scientific and Philosophical Assessment* (Heidelberg: Springer, 2012), 102.

[43] Ibid.

[44] Ibid., 111.

[45] Ibid., 115.

this task.[46] They leave their work open for others to explore how humans determine their frame of reference.

While most past research focuses on a robotic-centric approach to programming intelligent agents, Nasraoui and Shafto point to the importance of the interaction of humans with machines and how this interaction may affect machine learning.[47] Their research has value, as it acknowledges the input received from the human-machine interaction determines the output (choices) of the machine. Nasraoui and Shafto point out that ethical programming of intelligent machines is flawed because algorithms are static yet interactions with humans are dynamic.[48] If an intelligent agent learns through experience and human-machine interactions, what it learns may be biased. These biased inputs may lead to negative consequences.[49] Nasraoui and Shafto's conclusions suggest ongoing research is needed to consider a framework from which to study the human-algorithm interaction.[50]

Murphy and Woods also challenge Asimov's laws, asking whether the framework for human-machine interaction is viable or simply a cultural narrative with little empirical evidence.[51] They review the possible shortcomings and dangers of each law due to the complexities and dynamics of relationships between people and intelligent agents.[52] Murphy and Woods offer a parallel set of laws to Asimov's original three. The difference is that their framework focuses primarily on the human ethics behind intelligent agent technology. They argue a robot's ethics are not nearly as important as the ethics of those

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[46] Eden and Steinhart, *Singularity Hypotheses: A Scientific and Philosophical Assessment*, 115.

[47] Olga Nasraoui and Patrick Shafto, "Human-Algorithm Interaction Biases in the Big Data Cycle: Markov Chain Iterated Learning Framework," Computing Research Repository (CoRR) Abs/1608.07895, September 2, 2016, https://www.researchgate.net/publication/307302992_Human-Algorithm_Interaction_Biases_in_the_Big_Data_Cycle_A_Markov_Chain_Iterated_Learning_Framework.

[48] Ibid.

[49] Ibid.

[50] Ibid.

[51] Robin Murphy and David D. Woods, "Beyond Asimov: The Three Laws of Responsible Robotics," *IEEE Intelligent Systems* 24, no. 4 (2009): 14, doi: 10.1109/mis.2009.69.

[52] Ibid., 19.

developing, testing, and deploying the emerging technology.[53] Murphy and Woods's parallel laws are as follows:

1.   A human may not deploy a robot without the human-robot work system meeting the highest legal and professional standards of safety and ethics.

2.   A robot must respond to humans as appropriate for their roles.

3.   A robot must be endowed with sufficient situated autonomy to protect its own existence, as long as such protection provides a smooth transfer of control to other agents consistent with the first and second laws.[54]

As Murphy and Woods suggest, it is more important to focus on the human in the dynamic human-machine relationship.[55] Understanding the human elements when integrating humans and intelligent machines takes much more effort than simply programming an intelligent agent. Can humans be programmed, should they be, and if so, how? Muehlhauser's suggestion that morals are possibly an emotional reaction to a situation may mean the ability to change the framing of the human-machine relationship.[56] Just ethically programming machines will offer limited solutions. Humans will need to be programmed differently to accommodate the techno-centric future.

D.   RESEARCH DESIGN

The goal of this study is to identify human considerations needed for the future of AI realities, particularly regarding the self-driving vehicle revolution. Using the first Autopilot fatality as a case study, I apply theories from expert publications and scholarly papers to help analyze ethics, technology adoption theories, cognitive biases, and heuristics to find solutions associated with the human-machine relationship.

What makes this case study particularly useful is that Brown documented his growing comfort and trust in Autopilot's ability to keep him safe. Analyzing the

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[53] Murphy and Woods, "Beyond Asimov: The Three Laws of Responsible Robotics," 19.

[54] Ibid., 17–18.

[55] Ibid.

[56] Eden and Steinhart, *Singularity Hypotheses: A Scientific and Philosophical Assessment*, 102.

chronological documentation of comments and videos Brown published on his personal social media accounts can assist readers in understanding the development of his relationship and heuristics about Autopilot. Understanding the causal mechanisms can help explain contributing factors leading to his death and possible human and technological consideration needs for future techno-centric realities.[57] By focusing on causal-process observations, I can get inside the "black box" of decision making and explore perceptions and expectations, both to explain his individual historical experiences and suggest more generalizable hypotheses.[58]

Using Teller's ideas regarding technology's rate of change and humanity's ability to adapt to technology, an alternative theory is offered called "Brown's Point."[59] Brown's Point illustrates a point in time when humans and technology partner to create exponentially positive results. Cognitive biases and trust development theories are used to analyze the months leading up to the fatal crash and Brown's interaction with the autopilot and auto-steer features in his Tesla to demonstrate the socially constructed heuristics he developed using the self-driving technology. The most important questions are why Brown trusted a vehicle he knew had limitations and how can the why be prevented in the future? I propose the *why* can be explained through social constructs, heuristic development, and biases, such as automation and confirmation bias bringing awareness to the need to take a human-centric approach in the human-machine interface.[60]

Given that heuristics are socially constructed, tension certainly has arisen among the fundamental considerations of ethics, intelligent technology, and neuroscience. Heuristics often lead to cognitive biases but offer a window into understanding decisions

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[57] Eden and Steinhart, *Singularity Hypotheses: A Scientific and Philosophical Assessment*, 6.

[58] Ibid.

[59] Friedman, *Thank You for Being Late: An Optimists Guide to Thriving in the Age of Accelerations*.

[60] Richard Breton and Eloi Bosse, "The Cognitive Costs and Benefits of Automation" (lecture, RTO HFM Symposium, Warsaw, Poland, July 14, 2016).

and problem solving.[61] If carefully considered, it is possible to rehabilitate humans as autonomous self-actualizing beings who have a say in how it goes and what it means when moving into a future full of AI realities. At its conclusion, this thesis infers some human and technological considerations needed as society moves into future realities and presents a counterfactual account of the events leading to Brown's death. By altering the variables in a positive way, this study shows value in this approach to getting the human-machine integration right and ultimately reaching Brown's Point.

The road map for the remainder of this thesis is as follows. Chapter II explains who Joshua Brown was and the timeline of the accident. It also looks at the contributing factors that led to the first Autopilot fatality, as well as the human responsibility in developing the human-machine interface narrative. Chapter III lays out an explanation of the current state of technology and human adaptability, as well as an ominous prediction of humanity's future as technology advances. Chapter IV offers an alternative narrative to the theories explored in Chapter III by defining the transition period as the hybrid phase and a way forward to a point in time when human's combining with technology realizes the exponential potential of this relationship. This point in time is called Brown's Point. Finally, in Chapter V, Brown's story is rewritten as if the contributing factors leading to his death are fixed and result in an alternative outcome. The deliverable in this thesis is hypotheses on how technology and humanity can help narrow the gap between technology's rate of change and human's ability to adapt. It ends with suggesting further areas of study are needed.

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[61] "In Memoriam: Noted Researcher and Scholar Raja Parasuraman," George Mason University, March 26, 2015, https://www2.gmu.edu/news/1443; Raja Parasuraman and Victor Riley, "Humans and Automation: Use, Misuse, Disuse, Abuse," *Human Factors: The Journal of the Human Factors and Ergonomics Society* 39, no. 2 (June 1997): 249.

II.   WHO IS REALLY IN CHARGE: THE ACCIDENT ANALYSIS

A press release by the Brown family from September 11, 2017 after the completion of the accident investigation provided a summary of Josh's career and life interest:

> Josh was a [Armed Services] veteran, an exceptional citizen, and a successful entrepreneur. Most importantly, he was a loving son, brother and uncle. Josh served 11 years in the United States Navy. He was a master Explosive Ordnance Disposal (EOD) technician and achieved the rank of Chief Petty Officer. He proudly served as a member of EOD Mobile Unit 3 out of San Diego, CA, and then the Navy's elite Naval Special Warfare Development Group (NSWDG) out of Dam Neck, VA. Josh was deployed to multiple war zones as part of the special operations groups. He also served at the White House and overseas supporting Secret Service operations.
>
> Joshua loved technology and was a successful entrepreneur. He developed several database applications widely used by the Navy. In 2010, he started his own technology company, Nexu Innovations. The company primarily focused on developing and installing WIFI and surveillance systems, but also developed other technology driven applications.[62]

As the statement notes, Josh was no stranger to technology or the need for situation awareness. He made a concerted effort always to emphasize safety, especially while in his Tesla. In fact, according to a press release from his family on September 11, 2017, they stated:

> Joshua loved his Tesla Model S. He studied and tested that car as a passion. When attending gatherings at the Tesla store, he would become the primary speaker answering questions about the technology and the car's capabilities/limitations. In the videos Josh posted to YouTube about Tesla, he repeatedly emphasized safety, that the car was NOT autonomous, and that the driver had to pay attention.[63]

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[62] Landskroner Grieco Merriman, LLC, "Statement from the Family of Joshua Brown," news release, Cleveland, OH, 2017.

[63] Ibid.

While he was impressed with the ability of the autopilot to learn, acknowledging its limitation was a common theme for Brown's Facebook posts.[64] Unfortunately, like all humans, Brown did not know what he did not know; an easy trap for anyone to fall prey to. Exploring the events leading up to his decision to trust Autopilot beyond its capability helps to understand human tendencies with the goal of becoming aware and offering recommendations to fix the problems.

Josh owned his Tesla for just over 10 months when he was killed. In that short time period, he accumulated over 39,000 miles.[65] Quite a feat considering that number is nearly triple the average American's mileage per year. Obviously, Brown had a lot of time behind the wheel of his Tesla but less time with the Autopilot feature. The Autopilot feature was not rolled out to the Tesla fleet until November 2015. Thus, Brown had approximately six months to learn about and use the first iteration of the Autopilot technology.[66]

A.   THE DETAILS OF THE ACCIDENT

Although the vehicle and the driver were very capable in and of themselves, they both failed to recognize the danger, pointing fault to the human-machine interface.

The weather was clear and dry on May 7, 2016.[67] At approximately 4:36 PM, Brown was traveling eastbound on U.S. 27 just west of Williston, Florida in his 2015 Tesla Model S.[68] Traveling in the opposite direction on the same highway was an

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[64] Comment on "Milage on Tessy," Joshua D. Brown Facebook page, December 8, 2015, https://www. facebook.com/joshua.brown.16940/posts/10153676267625734.

[65] Joshua Brown, "Autopilot Saves Model S," Joshua Brown YouTube comments, 0:41, April 05, 2016, https://www.youtube.com/watch?v=9I5rraWJq6E.

[66] Ryan Bradley, "10 Breakthrough Technologies 2016: Tesla Autopilot," MIT Technology Review, February 21, 2017, https://www.technologyreview.com/s/600772/10-breakthrough-technologies-2016-tesla-autopilot/.

[67] Daphne Yuncker, *Florida Highway Patrol Traffic Homicide Field Note Packet-THI Case No. 716–39-007* (Williston, FL: Florida Highway Patrol, 2016), https://docs.wixstatic.com/ugd/63eaea_8284ad6 f230e4e7daa0514ef78f75f63.pdf.

[68] National Highway Traffic Safety Administration, *ODI Resume* (Washington, DC: Department of Transportation, 2017), 1, https://www.bing.com/cr?IG=69C0F25AFFD74B89A0B9CDDA9CACD8DF& CID=348EF5F7E1516A0C1975FED8E0576BCC&rd=1&h=OqDXIJlhAqoYh--Yk28hyAuhZEtrqNBvK XGCI9_ZG7E&v=1&r=https%3a%2f%2fstatic.nhtsa.gov%2fodi%2finv%2f2016%2fINCLA-PE16007-7876.pdf&p=DevEx,5063.1.

elevated refrigerated semi truck carrying a load of blueberries.[69] The truck driver exited the highway into the left turning lane and proceeded into the uncontrolled intersection in front of Brown's Tesla.[70] At 74 MPH, the car travelled underneath the rear third of the trailer shearing off the top of Brown's car at windshield height.[71] The Tesla continued traveling eastbound before veering off the highway into a field, hitting a utility pole, and coming to rest in a field.[72] Brown was instantly killed, and according to dispatch information, pronounced dead at approximately 4:51 PM.[73]

In the following 18 months, one of the most important accident investigations was underway. Self-driving technology promises to disrupt the entire transportation industry and potentially change how society moves people and goods. The findings of the investigation are likely to set precedence and modify the trajectory of the self-driving revolution for better, or for worse. Two separate governing bodies, The National Highway Traffic Safety Administration (NTHSA) and the NTSB have published findings from their investigations.[74]

> The NTHSA Office of Defects Investigation (ODI) determined that:
>
> 1) the Tesla was being operated in Autopilot mode at the time of the collision; 2) the Automatic Emergency Braking (AEB) system did not provide any warning or automated braking for the collision event; 3) the driver took no braking, steering or other actions to avoid the collision; and 4) the last recorded driver action was increasing the cruise control set speed to 74 mph less than two minutes prior to impact.[75]

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[69] Yuncker, *Florida Highway Patrol Traffic Homicide Field Note Packet-THI Case No. 716–39-007*.

[70] "Board Meeting Animation HWY16FH018," YouTube video, 1:09, posted by NTSBgov, September 12, 2017, https://www.youtube.com/watch?v=YFykkqYGVfI&feature=youtu.be.

[71] Yuncker, *Florida Highway Patrol Traffic Homicide Field Note Packet-THI Case No. 716–39-007*.

[72] Ibid.

[73] Interact, *CAD Detail*, Incident # 2016–00032596 (Williston, FL: Interact, 2016), https://docs.wix static.com/ugd/63eaea_45d414c8faf64033b94d44c3c23cd75b.pdf.

[74] National Transportation Safety Board, *Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida May 7, 2016*, NTSB/HAR-17/02 (Washington, DC: National Transportation Safety Board, 2017), 41–42, https://www.bing.com/cr?IG=06 4E1DE6F2594080BCCDF6349ACBE808&CID=24EEE51FAC5B6C1B0171EE30AD5D6DB1&rd=1&h= jWD5JD23VPTeEjpq0w2d2o0N07LKmNm3HVT2tRnwTfo&v=1&r=https%3a%2f%2fwww.ntsb.gov%2f investigations%2fAccidentReports%2fReports%2fHAR1702.pdf&p=DevEx,5036.1.

[75] National Highway Traffic Safety Administration, *ODI Resume*, 1.

As shown is Figures 1–3, the NTSB determined the point where Brown's car crested the hill until impact with the semi took approximately 10 seconds.[76] Considering Brown did not take evasive maneuvers indicates he was unaware of the peril. It is known that he was distracted; a simple conclusion. What is not known and must be discovered is how and why Brown came to trust a machine he knew was fallible. Of interest, the NTSB acknowledged that the type of highway Brown was traveling on was understood not to be an optimal road on which to use the Autopilot feature; however, nothing was in place to prevent him from setting and using the system as he had done many times before.[77]
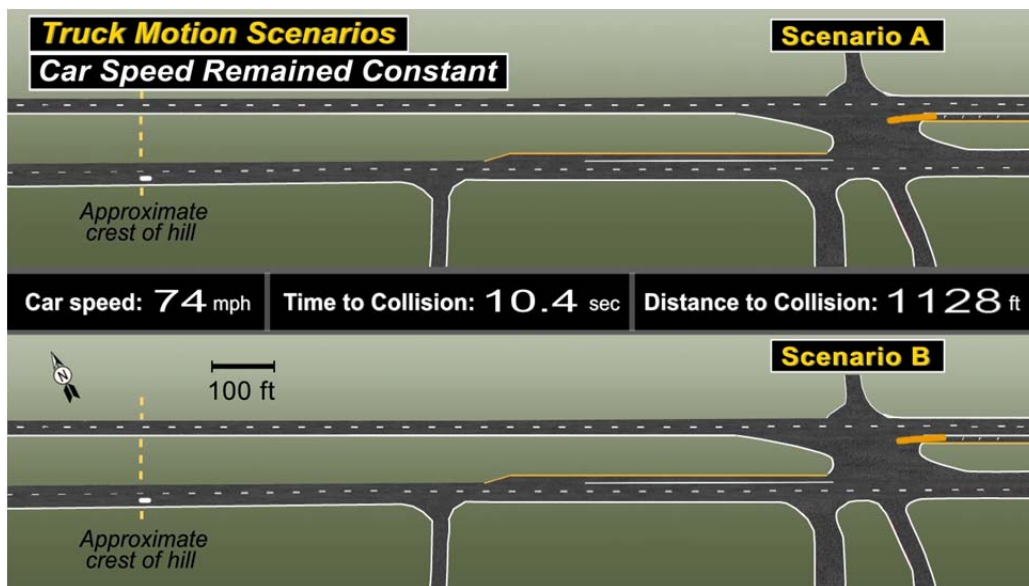
Figure 1. NTSB Collision Animation[78] The National Traffic Safety Board (NTSB) determined from the time Brown crested the hill until impact with the semi was about 10 seconds.

[76] "Board Meeting Animation HWY16FH018."

[77] Board meeting to determine probably cause of the fatal, May 7, 2016, crash of a Tesla car near Williston, Florida. Deb Bruce, "Collision Between a Car Operating With Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida May 7, 2016" (PowerPoint presentation, National Transportation Safety Board Meeting September 12, 2017), https://www.ntbs.gov/news/events/Documents/2017-HWY16FH018-BMG-presentations.pdf.

[78] Source: Ibid.

Figure 2. Tesla after Collision with Semi Truck[79]

Figure 3. Semi Truck after Collision with Tesla[80]

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[79] Source: National Transportation Safety Board, *Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida May 7, 2016*, 6.

[80] Source: Ibid., 7.

As noted, Brown's death was preceded by a series of cascading events that began with the naming of autopilot followed by a series of entirely human mistakes of thought and perception. This horrific accident is the result of frictions and noise at the level of the human-machine interface. Finding a solution to the friction and noise takes a greater understanding of why and how Brown developed such trust in a fallible machine.

B. THE ACCIDENT ANALYSIS: TRUST, AUTOBIAS, AND WHO IS REALLY IN CHARGE

Analyzing the accident using different measures and ideas helps bring understanding to the factors that contributed to Brown's fatality. I propose that the words used to describe the innovative technology also bring unintended consequences, yet bring awareness to the importance of designing and naming innovations, with intent. Interfaces between humans and machines have dependent variables. Humans must learn to trust technology and technology must have trust to work as designed especially when it comes to the automation of tasks. Too much or too little trust affects decision making and—as in Brown's fatality—leads to the challenge of human biases.

1. Autopilot: What Is in a Name?

The words chosen to define self-driving technology bring meaning and provide a frame from which to understand technology's roles and capabilities better. For this reason, it is important to choose words that convey the correct frame and meaning. Arguably, "Autopilot," a nickname, which stuck when first introduced by the Tesla team in October 2015, is misleading because it incorrectly implies the vehicle drives itself.[81] Although quite advanced in its capability, Autopilot is far from having the ability to fully drive itself. Hence, California decided to create draft regulation to fix the problem with naming the feature, Autopilot. On October 4, 2016, "California DMV issued draft regulation for a cease from using the terms "Self Driving," "Automated" or "Autopilot" in advertising unless the vehicle is a Level 4 autonomous vehicle."[82]

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[81] "15-Autopilot Fatality," The Tesla Show—A Tesla Podcast (blog), Tesla Show, July 12, 2016, https://itunes.apple.com/us/podcast/the-tesla-show/id1103101874?mt=2&i=372397989.

[82] "Pre-and Post-Fatality," Amanda Lee, last edited September 24, 2017, https://alee649.wixsite.com/joshuabrown.

Although this example is centered on Telsa, other developers of self-driving technology have run into similar challenges with the words and advertisement of their products.

Mercedes faced criticism over a TV commercial for its 2017 E-class, arguing "the ad could mislead consumers by overstating the capability of automated driving systems available on the sedan."[83] Mercedes executives call the driver-assist feature, which utilizes adaptive cruise control and automated steering, "Drivepilot," similar to Tesla's Autopilot. The German carmaker claims its technology is capable of keeping speeds of 130 mph while in drive-pilot. The advertisement in question shows a driver with no hands on the wheel for the entire commercial. Mercedes appears to understand the conflict with its commercial because it added a subtle disclaimer at the bottom of the screen. It reads in part, "the vehicle cannot drive itself, but has automated driving features."[84] Since the scrutiny, Mercedes has removed its advertisement, further supporting the claim that perceptions and expectations based on the advertisement of products do matter.

Even though words, such as Autopilot or Drivepilot, are not intended to do harm, they can contribute to bias and heuristic development by framing how people think about technology's capabilities. The power of suggestion is very important to understand and consider when framing and bringing meaning to new technology, which points to looking at both the design of the machine, its capabilities, and the human role in the human-machine interface. Trust is an important component of the human-machine interface but can also lead to a problematic relationship if the technology is not capable of what the human assumes the technology is capable of handling.

2. Trust: Too Much of a Good Thing?

The accident reconstruction indicates neither the vehicle nor the driver recognized the peril of a 53-foot trailer perpendicular to his path, and therefore, did not take evasive

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[83] Ryan Beene, "Mercedes Challenged over 'Drive Pilot' TV Ad," *Automotive News*, July 27, 2016, http://www.autonews.com/article/20160727/RETAIL03/160729855/mercedes-challenged-over-drive-pilot-tv-ad.

[84] Ibid.

actions to avoid the collision.[85] It is then assumed Brown was not as active a participant in supervising the self-driving vehicle as necessary. It stands to reason he did not recognize any danger because he was trusting Autopilot to provide for his safety.

Through a series of causes and effects, Brown learned to overtrust Autopilot. Even though trust is one of the goals of self-driving vehicles, when the trust pendulum swings too far in either direction, the risk of negative consequences increases.[86] Most individuals who interact with new technology learn to trust the systems based on their experiences. However, trust does not happen overnight; it takes time and follows a process of learning (cause and effect).[87] Positive experiences and expectations are needed to trust the reliability of these automated machines.[88] For automation technology to work as designed, humans must learn to trust it eventually, albeit not blindly. According to researchers Clare, Cummings, and Repenning, "Either overtrust or undertrust in automation can be detrimental to performance."[89]

Overtrust and undertrust also affect designed effectiveness. On the one hand, overtrust runs the risk of relying on technology beyond its capabilities. On the other hand, the realization of technology effectiveness is not achievable when the user undertrusts automation. In other words, automation relies on the user to agree inherently to a certain amount of trust in the system. Without this relationship, the design of the technology does not result in the benefits it is intended to achieve. What must be noted is the relationship can result in the human being conditioned to trust the machine beyond its capability.

Brown's fatality is a prime example of the consequences of overtrusting technology. Given he did not see the semi truck, it is apparent his attention was elsewhere

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[85] National Highway Traffic Safety Administration, *ODI Resume*, 1.

[86] Andrew S. Clare, Mary L. Cummings, and Nelson P. Repenning, "Influencing Trust for Human–automation Collaborative Scheduling of Multiple Unmanned Vehicles," *Human Factors* 57, no. 7 (2015): 1208–1218.

[87] John D. Lee and Katrina A. See, "Trust in Automation: Designing for Appropriate Reliance." *Hfes Human Factors: The Journal of the Human Factors and Ergonomics Society* 46, no. 1 (2004): 50–80, doi: 10.1518/hfes.46.1.50.30392.

[88] Ibid.

[89] Clare, Cummings, and Repenning, "Influencing Trust for Human–automation Collaborative Scheduling of Multiple Unmanned Vehicles," 1208–1218.

and he trusted Autopilot. John D. Lee and Katrina A. See, two experts in human systems analysis, claim, "Trust is considered a key variable for reliance on, and misuse/disuse of automated systems."[90]

Although Brown's death is the only reported fatality while using Autopilot, many documented cases demonstrate overtrust in the technology. Brown's case is not an anomaly but rather an example of the worst consequences of overtrusting technology. Take for instance, the numerous videos online of people showing off their trust in Tesla's Autopilot.

In one particular YouTube video, a couple demonstrates the trust they have in Autopilot by playing cards, playing scrabble, reading, and sword fighting, all while Autopilot is driving the vehicle.[91] Others have foolishly climbed into the back seat, leaving the driver position vacant, with disregard for their safety.[92] As ridiculous as these drivers appear, it makes the point; trust grows overtime and leads to the slippery slope of overreliance.

Although in these examples the drivers' trust is more overt given the silliness and extreme behavior they demonstrate, it is ultimately the same overtrust Brown experienced. The only difference with Brown's case, assumed to be his inattentiveness, is that he was engrossed in an activity that required a lot of his attention, perhaps working on his computer or texting on his phone. No one will know for sure; however, what is obvious is Brown trusted the Autopilot enough to disengage completely from the role of human supervisor.

Thus, an interesting concern is raised. When should self-driving vehicles be fully trusted? Looking at the five levels of automation in Figure 4 helps to identify, in theory, when it is appropriate to trust self-driving technology. As noted in the illustration, the current level of self-driving technology is level three (indicated with the red star). The

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[90] Lee and See, "Trust in Automation: Designing for Appropriate Reliance," 50–80.

[91] "Autopilot Road Trip," YouTube video, 0:58, posted by Creative Works, Inc., June 7, 2016, https://www.youtube.com/watch?v=2vNH-Q7fu7A.

[92] "Tesla Autopilot Stunt w/Driver in Back Seat—DO NOT ATTEMPT," YouTube video, 1:30, posted by Jason Hughes, October 16, 2015, http://www.youtube.com/watch?v=-okFVuHlxII.

yellow box indicates when self-driving technology will theoretically be capable of all tasks a human driver can perform in all environments and road conditions.[93] In essence, the human role is simply one of a passenger once self-driving vehicles reach level 5 automation.[94] Before that time, the human must remain a supervisor of the technology.

Figure 4. SAE International Levels of Self-driving Technology Modified to Explain Appropriate Levels of Trust in the Technology[95]

3. Automation Bias: Who Is in Charge?

Overtrust in automated technology leads to automation bias and affect decision making. As defined, automation bias is also known as an, "overreliance on

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[93] Bruce, "Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck near Williston, Florida. May 7, 2016."

[94] Ibid.

[95] Adapted from National Transportation Safety Board, *Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida May 7, 2016*, 24.

automation."[96] Psychologist Raja Parasuranman helps to understand better the risk associated with automation bias by suggesting, "Automation bias can be conceived of as a special case of human decision biases, such as confirmation bias and discounting bias."[97] Operators use automation cues as heuristics for making decisions. Although the use of heuristics is usually effective, occasionally it may lead to error because of decision biases.[98] Brown demonstrated he understood autopilot's fallibility and the technology was still in the infancy stage of learning, yet was growing more comfortable with the autopilot feature, as seen in several of his posts.[99] As Brown states, in a November 1, 2015, post, "Again, this is not an autonomous driving car. It does do amazingly well, though. In my supervisory role while on the interstate it rarely requires any input from me."[100] His positive experiences with the technology may be a center point for his heuristic development. An article by judgmental forecasting researcher, J. A. Alvarado-Valenci suggests, "explanations and past performance are good candidates to increase trust in computer's advice."[101] The positive experiences support the idea that Brown's past performance and experience, or trial and error, with the self-driving technology helped increase his automation bias.

Several experiences with autopilot helped Brown develop a heuristic about the self-driving technology that it was, in fact, safe and reliable. In one particularly powerful video, his dash camera reveals autopilot demonstrating its worth by avoiding an accident with a large truck on the interstate. Brown's YouTube video caught the attention of Tesla's CEO Elon Musk. Musk retweeted Brown's video and received a lot of attention

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[96] Parasuraman and Riley, "Humans and Automation: Use, Misuse, Disuse, Abuse," 249.

[97] Raja Parasuraman and Dietrich H. Manzey, "Complacency and Bias in Human Use of Automation: An Attentional Integration," *Human Factors: The Journal of the Human Factors and Ergonomics Society* 52, no. 3 (2010): 405, doi: 10.1177/0018720810376055.

[98] Ibid., 398.

[99] Comment on "Joshua Brown Facebook Post," Joshua Brown's Facebook page, November 1, 2015, https://www.facebook.com/joshua.brown.16940/posts/10153614478630734.

[100] Ibid.

[101] "Computing; Studies from Pontifical Catholic University Describe New Findings in Computing (Reliance, Trust and Heuristics in Judgmental Forecasting)," *Computer Weekly News*, August 14, 2014, 508, http://libproxy.nps.edu/login?url=http://search.proquest.com/docview/1551474305?accountid=12702.

with over three million views.[102] Musk's attention to Brown's post left a lasting impression on him. Neither Brown nor Musk understood the confirmation bias that presented itself through several interactions. Less than a month before his fatal crash, Brown posted, "I can die and go to heaven now! Elon Musk Tweeted about my video!"[103] Later in the post, Brown discusses an offer of monetary compensation for the rights to his video, which arguably helped further reinforce his heuristic about the autopilot capabilities and contributed to his automation bias and a heuristic that helped contribute to his death.[104]

C.   THE BIAS CHALLENGE

It is a natural tendency for humans to become over reliant on technology. After all, technology is meant to make life easier and more efficient but it is a slippery slope. For instance, take the following example that demonstrates how humans easily become over reliant on technology and fall prey to automation bias. The smartphone features are an excellent example to help illustrate this point. Experience tells users the navigation system or alarm clocks on smartphones are reliable. Often, a navigation system will guides users to their destinations in the most efficient manner possible. Over time, users learn these devices are reliable and do what their manufacturers claim they will; earning users' trust even if intuitively humans understand technology sometimes makes mistakes. Often unconscious, humans tend to learn in the same manner; therefore, it is likely others will fall prey to the same bias as the previous examples demonstrate. In applying the same principle of overtrust to self-driving vehicles, drivers may fall victim to the same bias, leading to overreliance and eventually automation bias. It is one thing to develop a bias towards a morning alarm clock but much more dangerous to develop a bias towards self-driving vehicles.[105]

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[102] Brown, "Autopilot Saves Model S."

[103] Comment on "I Can Die and Go to Heaven Now!," Joshua Brown's Facebook page, April 17, 2016, https://www.facebook.com/joshua.brown.16940/posts/10153987903875734.

[104] Ibid., April 18, 2016, 7:02 am.

[105] Parasuraman and Riley, "Humans and Automation: Use, Misuse, Disuse, Abuse," 249.

Given the natural tendency for humans to fall prey to these cognitive biases, an opportunity exists for the development and design of technology to take these biases into consideration and safeguard against them. It is important to understand the different heuristics regarding technology and how these ideas relate to humanity. With a better understanding of these heuristics, it is then possible to offer possible solutions to the human-machine interface. What is interesting is the idea that humans and intelligent machines (technology) are separate and must remain separate. This idea does not offer a collaborative solution to the problem but continues to foster a division between humans and technology and potentiates the frictions and noise at the level of the human-machine interface.

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III. TECHNOLOGY: THE PROMISE AND PERIL

Technology and its advancements offer great promise for humanity; however, some believe technology promises great peril and may outsmart humanity and pose an existential threat. This chapter takes a look at models useful in understanding the social constructs about the human-technological interface. Among them are different social constructs regarding technology and why they are important, how early adopters, such as Josh, influence the human-technological interface, the discourse between technology's advancements and humanity's ability to adapt. Finally, discussed is the doomsday prediction of singularity. Since social constructs are created, a unique opportunity exists to understand them and influence them. By creating a positive social construct regarding the interface between humans and technology, it offers a positive future for humanity.

A. SOCIAL CONSTRUCTS

How people come to understand and think about technology is socially constructed. Social construct are basically ideas about something that society has decided to accept but are not always based on facts.[106] According to Berger and Luckman who wrote the book, *The Social Construction of Reality*, social constructs are important because if people can understand how they develop, an opportunity is available to influence and change these constructs to best suit the needs and provide for society's safety.[107]

At the center of social constructs are heuristics. Heuristics give humans a "thinking shortcut," and serve as an expeditious way to make decisions.[108] Without these shortcuts, every decision would require time to stop and think about each variable, which makes decision making much too slow. Nonetheless, heuristics are usually helpful for

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[106] "Social Constructs," International Encyclopedia of the Social Sciences, accessed November 18, 2017, http://www.encyclopedia.com/social-sciences-and-law/sociology-and-social-reform/sociology-general-terms-and-concepts/social-3.

[107] Peter L. Berger and Thomas Luckman, *The Social Construction of Reality: A Treatise in the Sociology of Knowledge* (New York: Doubleday, 1989).

[108] Doug Bernstein and Peggy Nash, *Essentials of Psychology*, 4th ed. (Boston: Houghton Mifflin Company, 2008), 256.

solving problems; they may also "lead to cognitive biases" and errors in thinking, such as automation bias.[109]

Many factors play into developing heuristic and social constructs. One specific factor is the early adopters of technology. Josh was an early adopter of Autopilot that resulted in a certain mindset that contributed to his social construct of the innovative technology in his car. Early adopters believe in the product they have adopted and have a vested interest in its success. The early adopter mind set contributes to building a heuristic about the technology but also, in Josh's case, leads to automation bias that ultimately contributed to his death. The good news is, if social constructs, such as automation bias, are inventions of society, then they can be modified or changed as needed. Having a better understanding of how heuristics work and the potential cognitive biases they introduce may assist users and developers of technology, and for this thesis, self-driving technology, to design and safeguard against human fallibility and biased decision making better.[110]

1.   Early Adopters

Early adopters speed up the testing cycle and reduce time-to-market, and increase market share for companies. Everett Rogers coined the term "early adopters" in his 1962 book, *Diffusion of Innovations*, which is currently in its fifth edition. The volume remains a leading model to help explain how innovations and technology are adopted into society.[111] Early adopters of technology are at the cutting edge of innovation development and the human-machine interface, as shown in Figure 5. Whether consciously or unconsciously, ideas and misconceptions affect the adoption and perfection of technology. Technology often requires several iterations, and by leveraging the early adopters as "guinea pigs," their feedback is elicited to provide valuable feedback to help improve and evolve their products.

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[109] Bernstein and Nash, *Essentials of Psychology*, 256.

[110] Kendra Cherry, "How Heuristics Help You Make Quick Decisions," Verywell, August 15, 2017, https://www.verywell.com/what-is-a-heuristic-2795235.

[111] Everett M. Rogers, *Diffusion of Innovations*, 5th ed. (Riverside: Free Press, 2003).

Early adopters are on the front line of product rollout and function as a feedback loop for technology companies in today's market as they iterate.[112] With this understanding, many technological products are given to early adopters before they are proven safe to do so. As noted in Salim, Malone, and van Geest's book, *Exponential Organizations*:

> The MVP [Minimum Viable Product], is a kind of applied experiment to determine the simplest product that will allow the team to go to market and see how users respond (as well as help find investors for the next round of development). Feedback loops can then rapidly iterate the product to optimize it and drive the feature roadmap of its development. Learning, testing assumptions, pivoting and iterating are key in this step.[113]

What used to take years of research, design, and testing is now accomplished by releasing products before they are statistically reliable to allow the end users experience with the technology to shape the product.[114] Today, it is considered crucial for end user feedback to "get the product right."[115] Functional technology is very important for user satisfaction but also brings substantial monetary gains for companies. Since the market share of companies' product is one of the most critical metrics for business success, speeding up the process of research and design saves a lot of money and ensures greater market.[116] Unfortunately, not all parties involved benefit equally. Reducing cycle time serves companies, builds competitive barriers, but may also endanger the early adopters. Roger's explains the early adopters are key to introducing products to the market. In essence, early adopters facilitate a tipping point or a place that creates a domino effect with society that greatly improves its market share (see yellow line in Figure 5).[117]

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[112] Salim Ismail, Michael S. Malone, and Yuri Van Geest, *Exponential Organizations: Why New Organizations Are Ten Times Better, Faster, and Cheaper than Yours (and What to Do about It)* (New York: Diversion Books, 2014), loc. 2317 of 4417, Kindle.

[113] Rogers, *Diffusion of Innovations*.

[114] Feedback loops can then rapidly iterate the product to optimize it and drive the feature roadmap of its development. Learning, testing assumptions, pivoting, and iterating are key in this step.

[115] Ismail, Malone, and Van Geest, *Exponential Organizations: Why New Organizations Are Ten Times Better, Faster, and Cheaper than Yours (and What to Do about It*, loc. 2317–2318.

[116] "Definition of 'Market Share,'" Economic Times, accessed November 8, 2017, https://econ omictimes.indiatimes.com/definition/market-share.

[117] Rogers, *Diffusion of Innovations*.
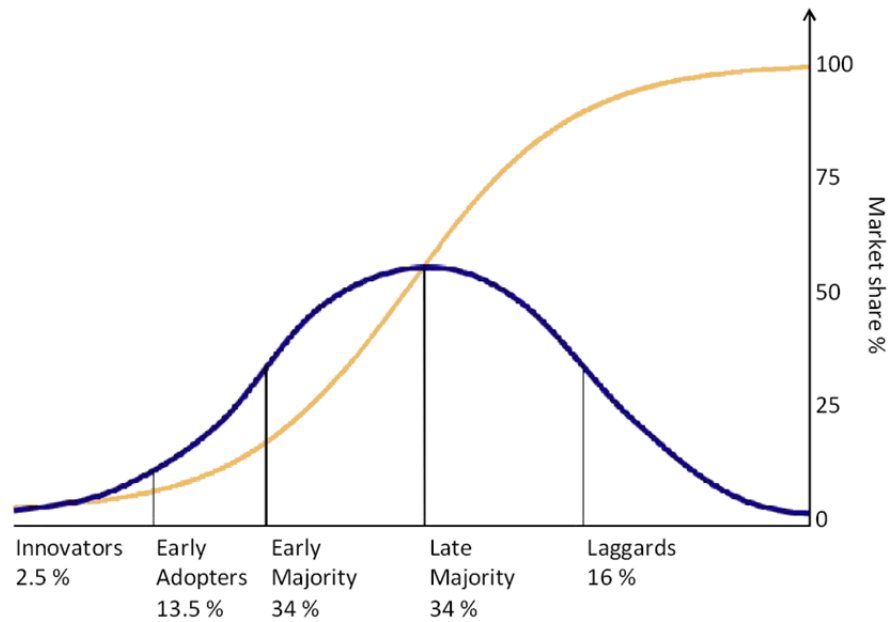
Figure 5. Everett M. Rogers' Diffusion of Innovation and Cycle of Adoption
(Blue Line) in Comparison with Market Saturation (Yellow Line)[118]

While some technology is not dangerous when in its initial phases of development, I argue the self-driving vehicle is quite a different story. Much more is on the line for the earliest of adopters who are beta testers for self-driving vehicles than say the latest version of Google docs or the latest version of an Android phone. All the while, companies save thousands, if not millions of dollars by putting their product out quickly and make iterative changes as feedback cycles in from the end user. The greater the market share for companies who develop this technology first, the harder it is for other companies to enter the market creating a foothold for them among customers.[119] Early adopters face another challenge they are often unaware of, that of their own bias.

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[118] Source: Ibid. The graph was not modified but may have some errors, as 100% of market share is highly unlikely and there is nothing greater than 100%, as indicated by the arrow on the y-axis.

[119] Maik T. Schneider, Burkhard Schade, and Hariolf Grupp, "Innovation Process 'Fuel Cell Vehicle': What Strategy Promises to be Most Successful?" *Technology Analysis & Strategic Management* 16, no. 2 (2004): 152, 171, doi: 10.1080/09537320410001682874.

2. Analysis of Brown's Automation Bias

Although early adopters may be the safer operators of these vehicles because they inherently understand the vehicles are in their first iteration, I contend the opposite is true and early adopters are likely unaware of their bias, as they have a vested interest in seeing the technology being successful. It may be more accurate to say these early adopters are better described as "early believers."

Josh was an early believer and his belief helped build a heuristic about the vehicle's capabilities. Josh's early adopter mindset put him at greater risk for injury, and in his case, death. Being one of the earliest adopters of self-driving technology, how he came to think about himself and technology was socially constructed. The analysis from Chapter II helps to explain how trust, ideas, and misconceptions influenced a growing trust with the technology, influenced his decisions, and led to automation bias.

3. Teller's Model and Humanity's Adaptability

One heuristic about the human-technology interface comes from three-time Pulitzer Prize winner, Thomas Friedman. Friedman offers a framework from which to look at the relationship between humans and technology.[120] He believes humans are not capable of catching up to technology's rapid advancements. While having lunch with his friend, Eric "Astro" Teller [Google X Research and development lab], also known as the "Captain of Moonshots," Teller drew a sketch for Friedman to help explain the discourse between humans and technology (see Figure 6).[121] The bottom line he claims is humans are struggling to keep up with technology's advancing rate of change.

In his book, *Thank You for Being Late*, Friedman uses Teller's graph to illustrate several reasons for the shift including why humans are not keeping up with technological changes. Technology advancements have taken place for decades; however, in 2007, the world saw an exponential change or hockey stick moment for technology.[122] On the graph, the line representing technology starts out with a gradual climb but right around

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[120] Friedman, *Thank You for Being Late: An Optimists Guide to Thriving in the Age of Accelerations.*

[121] Ibid.

[122] Ibid.

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2007, a steep almost vertical upward curve occurred.[123] The line representing humanity's ability to adapt looks very different, almost flat.[124] It does gently rise over time but given the trajectory of each line, the gap between the two will only continue to widen.
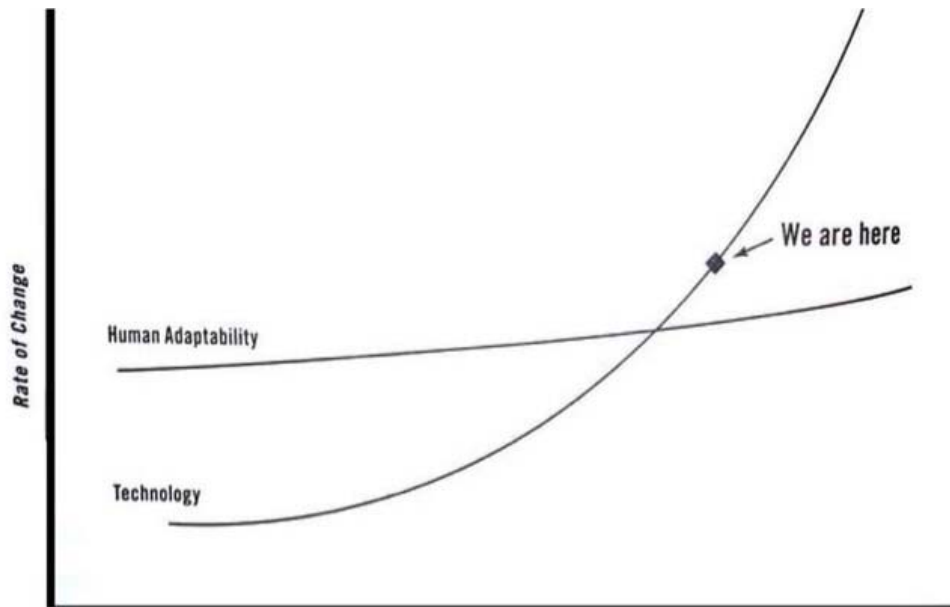
Figure 6. Tellers's Model Technology Is Outpacing Humans Adaptability[125]

What happened in 2007 to cause such a severe change? Several famous releases in technology occurred during that year. Steve Jobs introduced a revolutionary new communication platform, the iPhone.[126] Android released its phone around the same time, and shortly afterwards, the soon to be giant, Facebook, went public.[127] The smartphone allowed humans to connect directly with the Internet and brought the "computing power of the Apollo Space Mission," to the palm of their hands.[128] These

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[123] Friedman, *Thank You for Being Late: An Optimists Guide to Thriving in the Age of Accelerations.*

[124] Ibid.

[125] Source: Ibid., 34.

[126] "Thomas L. Friedman: "Thank You for Being Late,"" YouTube video, 11:54, posted by Talks at Google, February 22, 2017, https://youtu.be/nuF2JKeM2CY.

[127] Ibid.

[128] Ibid.

releases would revolutionize how people communicate and connect with one another on a worldwide scale.[129]

Why does technology progress at such a fast rate? The answer dates back to 1965 and the microchip. Another evolution, and perhaps the most instrumental for advancing technology, started in 1965. The microchip is perhaps the most instrumental reason for the rapid advancement of technology. In 1968, with a PhD in chemistry and physics from Caltech, Gordon Moore cofounded Intel, which is worth over eight billion dollars as of October 2017, and is considered one of the fathers of Silicon Valley.[130] Naming it after himself, Moore predicted that the microchip would allow computing power to double every few years.[131] American physicist, James R. Powell explains Moore's law in greater detail. He states, "Moore's prediction is that the density of transistors and computing power doubles every two years, which has held since there were fewer than 100 transistors in an integrated circuit until today with many millions of transistors on a single integrated computer chip."[132] The recent switch from silicon to non-silicon material in microchips allowed Intel technology companies to continue to produce and release new products at an unprecedented rate.[133] Moore's Law allows technology to change exponentially and this trend continues today.[134] The processing ability of today's computers facilitates the hockey stick moment witnessed in 2007.[135]

In applying Teller's theory to the rapid development of self-driving technology, understanding the current transition is a must. As self-driving technology begins to integrate, the relationship between humans and technology is changing and will affect outcomes. According to the NTHSA, "New complexity is introduced as HAVs [highly

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[129] "Thomas L. Friedman: "Thank You for Being Late,"" 12:04.

[130] "Gordon Moore," Forbes, accessed October 26, 2017, https://www.forbes.com/profile/gordon-moore/.

[131] Ibid.

[132] James R. Powell, "The Quantum Limit to Moores Law," in *Proceedings of the IEEE* 96, no. 8 (2008): 1247, doi: 10.1109/jproc.2008.925411.

[133] Friedman, *Thank You for Being Late: An Optimists Guide to Thriving in the Age of Accelerations*, 19–20.

[134] Ibid., 19–21.

[135] Ibid.

automated vehicles, what this thesis calls self-driving vehicles,] take on driving functions."[136] Early adopters are at the heart of moving technology forward but they are at great risk in this transition time. When a mix of vehicles driven by both humans and computers are sharing the road, it "reshapes" how humans see their relationship with vehicles.

The early adopter may be more likely to experience automation bias. Early adopters need to be more vigilant and understand their tendency to trust technology especially when it is in its first generation. Until technology proves to be as reliable in an array of situations, early adopters should prepare for and expect technology to fail or cause errors. Automation bias is especially dangerous when the technology is in its infancy.[137] For the remainder of this thesis, I call this transitional time, the "hybrid phase" (Figure 7).

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[136] "Federal Automated Vehicles Policy—September 2016," Department of Transportation, September 19, 2016, 22, https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016/.

[137] "Driver Errors, Overreliance on Automation, Lack of Safeguards, Led to Fatal Tesla Crash."
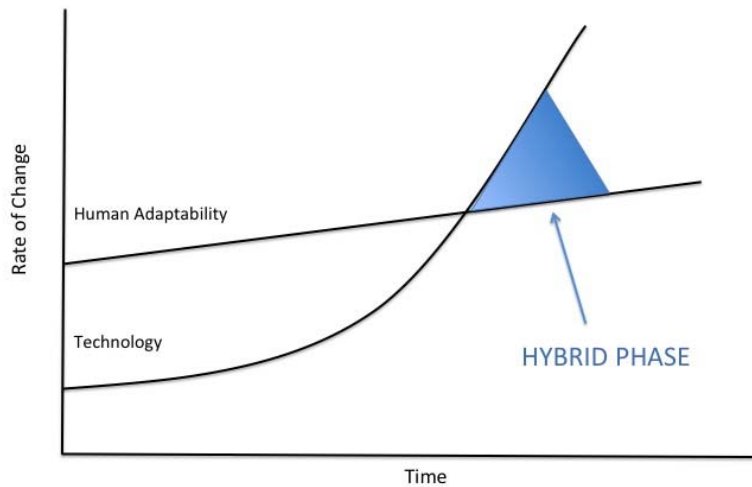
Figure 7. Astro Teller's Model Modified to Explain the Hybrid Phase: Humans
and Computers Driving Vehicles[138]

4.   Modifying Teller's Model to Explain the Hybrid Phase of Self-driving Vehicles

During the hybrid phase of self-driving vehicles, the role of a human driver begins to shift from operator to a more passive supervisor. The skill sets necessary to drive legacy vehicles does not automatically transfer to the self-driving vehicles. Thus, safety concerns are created that are not intuitive; therefore, it should not be overlooked. Going from operator to supervisor is a big change and causes disorientation if the human needs to transition quickly to the operator role.

Although only a small percentage of society's vehicles have self-driving technology, the hybrid phase should concern anyone who cares about safety while driving. Toggling between vehicles with advanced driver assist features (not quite self-driving), such as those with backup cameras, and legacy vehicles, is problematic for early adopters and drivers. Greater dependence on technology and more advanced features may disorient drivers upon switching to using a vehicle without such luxuries.

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[138] Adapted from Friedman, *Thank You for Being Late: An Optimists Guide to Thriving in the Age of Accelerations*, 34.

While self-driving technology is intended to enhance and improve driver skill sets, unfortunately, humans tend to adapt and rely on technology, often unconsciously. Reliability can cause a change in behavior. The behaviors that usually keep people safe but change due to reliability creates a safety concern. Habitual behaviors, for instance, shoulder checking before a lane change, are being replaced with cues from the vehicle computer. If sensors detect a vehicle in a blind spot, the computer illuminates a small light in the side mirror that indicates the danger.[139]

When humans become more reliant on assists, they begin to lose their skills sets in these areas and form new habits. As long as the vehicle's computer is working correctly, all is well; however, if a driver begins to rely on the technology and that technology fails, the habitual behavior is no longer readily available and causes disorientation and increases risk. For example, if a driver starts to enter an adjacent lane, fails to shoulder check, does not see a car, and the vehicle does not work as designed—no illumination of the light in the mirror—the potential for a collision increases. In this example, something designed to be helpful and improve safety may actually condition the driver to be dependent upon the technology.

The same argument can be made with vehicles that drive themselves. As drivers use autopilot features more and more, their dependence on them increases. Dependence increases risk, particularly if technology fails or the design is flawed. The potential for danger during the hybrid phase cannot be understated. Technology is still developing and humans are learning their new role with advancing technology.[140] In the case of the early adopters, the stakes do not get any higher, which makes this case study an incredibly important warning; the hybrid phase of self-driving technology is a time for increased awareness and caution.

Technology's reliability will obviously play a significant role in risk, which raises the question of what is an appropriate level of reliability for self-driving technology? It is

[139] "Blind Spot Information System," Ford, accessed November 3, 2017, https://www.ford.com/cars/mustang/2017/features/technology/.

[140] National Transportation Safety Board, *Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida May 7, 2016*, 41–42.

likely to take some time before self-driving technology is statistically reliable; whatever that means. Until that time, the hybrid phase presents dependency and vulnerability issues that are not understood.

Remembering back to earlier in the chapter, Teller's model offers one explanation for the gap between technology's rate of change and humanity's inability to adapt fast enough.[141] Friedman primarily uses this model to illustrate this disproportioned relationship. He also explains how the "'machine' reshape parts of our society such as, politics, the geopolitics, ethics, the workplace, and community."[142] This idea is certainly an interesting concept and should be taken into consideration. Is the machine affecting ethics in technology's design? Whoever develops the bona fide self-driving vehicle first will likely make a lot of money, which creates a wickedly competitive landscape. Competition is good and bad because it drives forward progression but it may also cut corners to get ahead. The next section warns of forward progress and the risk of getting too far ahead. Ensuring safety above all else must remain an ethical benchmark.

B.   SINGULARITY (AKA DOOMSDAY)

As mentioned earlier, according to Berger and Luckman, social constructs are important because by understanding how they develop, an opportunity exists to influence and change them to best suit the needs and society's safety.[143] One particularly controversial social construct is the idea of a future of singularity. This idea proposes that humanity is on an inevitable trajectory where AI technology will pose an existential threat to humanity because its capability will outstrip those of humans. Many scientists and respected thinkers share this viewpoint. Brostrom and Hawking alike assume that AI will take away humanity's ability to create its own future; however, Hawking does offer a way out. He believes if humans can implement safeguards now, the inevitable fate of humanity can be avoided.

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[141] National Transportation Safety Board, *Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida May 7, 2016*, 41–42.

[142] "Thomas L. Friedman: "Thank You for Being Late,"" 8:50.

[143] Berger and Luckman, *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*.

Hawking and Bostrom comment that a techno-centric approach to intelligent agents will result in a techno-centric world that excludes humanity.[144] If an accurate assumption, then the opposite is also true. By developing artificial agents but ensuring a human-centric approach, humanity can ensure a human-centric rather than an inevitable techno-centric world. Humans should realize they are powerful independent thinkers and are not the simple sum of brain cells, as inferred by the singularity debate. Humans are incredibly complex and hold the ability to influence their future. Blyth et al. in their 2015 paper, "Driving the Self-Driving Vehicle: Expanding the Technological Design Horizon, support the idea that the future is not "inevitable," but rather, something to be shaped.[145] As Blyth concludes, "the future is something that can be shaped, rather than being already decided or "inevitable."[146]

Learning what human-centric means in the digital era requires definition and goals to make it happen. Humans have an uncanny ability to create that on which they focus their attention. I propose that humans have a vested interested in seeing a future in which artificial agents assist or augment humans but do not take over. Self-driving vehicles are perhaps the first opportunity for humans to get the future right. By leveraging the power of technology while maintain a human-centric approach to development and design, a synergistic relationship will emerge and may offer a quantum leap in evolution for mankind.

Experts and developers believe connected self-driving technology will greatly improve highway safety. Considering that approximately 35,000 Americans are killed on the roads every year, solving this problem will have a significant and positive impact on society.[147] The NTSB recently recommended that upon completion of connected vehicle

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[144] Hawking, "Stephen Hawking: 'Transcendence Looks at the Implications of Artificial Intelligence—but Are We Taking AI Seriously Enough?'"; Bostrom, *Superintelligence: Paths, Dangers, Strategies*.

[145] Pascale-L. Blyth et al., "Driving the Self-driving Vehicle: Expanding the Technological Design Horizon," in *Proceedings of the Technology and Society (ISTAS), 2015 IEEE International Symposium on* 2016-March Institute of Electrical and Electronics Engineers Inc., 201, 7439419 (2016): 1–6, doi: 10.1109/istas.2015.7439419.

[146] Ibid.

[147] "Federal Automated Vehicles Policy—September 2016," 5.

technology meeting the minimum performance standards, the NHTSA should require that all new highway vehicles have this technology installed.[148] The Chairman of the House Subcommittee on Digital Commerce and Consumer Protection, Bob Latta, believes self-driving vehicles have the "potential to transform our transportation system into one that is safer and more secure for everyone on the roadways."[149]

Of course, many will disagree with this assertion that self-driving technology significantly improves driving safety.[150] Even if future regulations require equipping new vehicles with self-driving technology, vast amounts of vehicles will remain on the road with little or no connectivity. Transitioning older vehicles off the roads could take decades, especially considering non-believers, as well as driving enthusiasts, may refuse to transition from their legacy vehicles to vehicles with self-driving technology. Therefore, the shift to self-driving vehicles will take time. Until then, this nation is in a time of transition and may not see as much of a benefit as expected.[151]

At this juncture, ethics re-enters the narrative. The ethics of ensuring the human remains the center focus for all technology may offer an alternative future. I believe humans do have a say in what happens in the future; however, a different social commentary on this topic is needed to ensure humans have a say. In the next chapter, I suggest an alternative social construct around the integration of humans and technology.

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[148] National Transportation Safety Board, *Public Meeting of September 12, 2017, Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck, Williston, FL, May 7, 2016*, NTSB/HAR-17-XX (Washington, DC: National Transportation Safety Board, 2017), abstract, https://www.ntsb.gov/news/events/Documents/2017-HWY16FH018-BMG-abstract.pdf.

[149] *Subcommittee on Digital Commerce*, House of Representatives, 115th Cong., 1st. sess., February 14, 2017.

[150] Without straying too far from the primary discussion in this chapter, it is worth noting that not all experts agree that self-driving vehicles are safer. In fact, some make the case that cyber-security poses a significant concern about connected vehicles. Consider what could happen if someone hacked self-driving vehicles and abruptly made all vehicles take a sharp left turn. Cyber-security safeguards should be a topic that is taken seriously.

[151] National Transportation Safety Board, *Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck near Williston, Florida, May 7, 2016*, 13, finding.

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IV. BROWN'S POINT: SUCCESSFUL ADAPTATION OF TECHNOLOGY

Thus, far, using Brown's fatality as an unprecedented case study offers an opportunity to understand the interface and human and technological fallibility.

A. BROWN'S POINT: AN ALTERNATIVE SOCIAL CONSTRUCT

In this chapter, I propose an alternative social construct to the singularity prediction and call it Brown's Point. Intended as a way forward for the interface between humans and technological machines, it also serves as a counternarrative to the doom and gloom of the singularity theory. It serves as a tipping point and positive beacon for humanity that puts the human at the center of the human-technology relationship by combining the best of both technology and humanity.[152] This synergistic relationship is achieved when technology augments humans and fills the gaps created by human biases that can take humanity to the next level of thinking. Brown's Point is where the human-technological interface reaches the beginning of its potential.

Brown's Point is a moment in time when humans fully adopt technology and work together at an optimal level, as shown in Figure 8. Brown's Point creates more than an additive potential; it creates synergy. This synergy is likely only to happen when technology becomes reliable with the appropriate level of market saturation (adoption) and humans have adapted to utilize the technology. The partnering of humans with advancing technology is likely to enhance human capability greatly. Friedman believes the advancing technology is in essence a supernova for advancement.[153] If true, it surely happens when Brown's Point is reached.

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[152] Rogers, *Diffusion of Innovations*.

[153] Friedman, *Thank You for Being Late: An Optimists Guide to Thriving in the Age of Accelerations*.
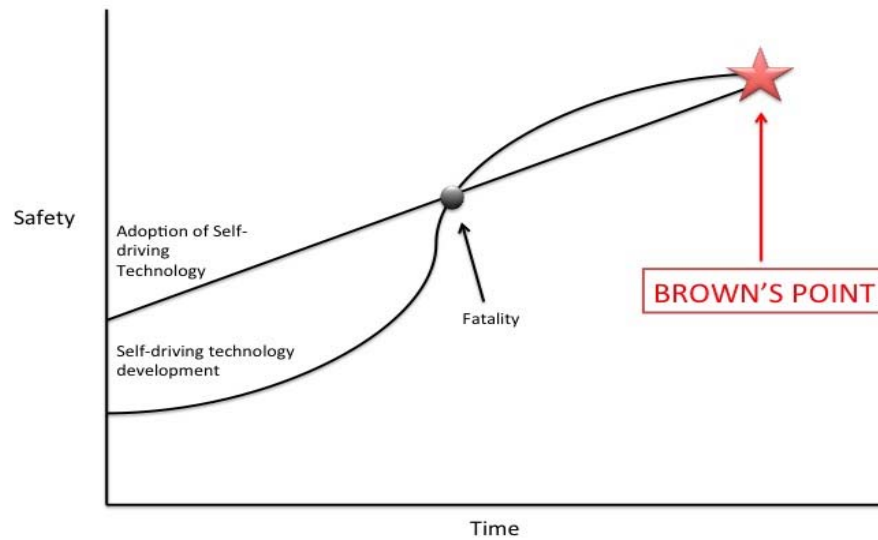
Figure 8. Brown's Point: The Optimum Interface between Humans and
Technology

The smartphone may be an example of a technology used by humanity that has successfully reached Brown's Point. The enhancement for humanity with mobile computing power brings exponential ability to process information faster, communicate easier, and flatten the world. Friedman's use of Teller's chart to illustrate technology's rate of change shows the graph swung drastically upward around 2007; however, this change is only part of what was really happening in 2007. What Friedman and Teller fail to recognize is the line representing the human should also take a drastic upswing on the graph. Smartphones have become a part of daily life for the majority of society. Due to the partnership seen with smartphones, the hybrid time decreases and Brown's Point of exponential potential is realized. The smartphone in essence is now a one-stop-shop. What used to require several devices is now available in one. Phones, cameras, computers, alarms, reminder lists, portable digital optical disc (DVD) players, live video streaming, crowd sources applications, social media access, and the list goes on, come in the tidy smartphone package. The efficiency and access to information and communication for humans with this technology in the palm of their hands creates an

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exponential capability. The synergistic relationship between smartphone technology and humans serves as an example of what is possible when Brown's Point is reached.

Self-driving technology offers the same opportunity. When self-driving vehicles attain saturation (market share), it will be an enormous step forward for the safety of U.S. highways, connectivity with infrastructure, as well as autonomy for many people who otherwise cannot drive. When vehicles connect in the future, many things are likely to change from how goods and services are moved, to improving the congestion on the roads in addition to enhanced efficiency and convenience.[154] With such promise, ensuring self-driving vehicles reach Brown's Point is worth the effort.

So how can Brown's Point be accomplished? As mentioned in Chapter I, self-driving vehicles represent three variables: technological advancement, human's ability to adapt, and the interface between technology and adaptation. With the mastery of these three variables, reaching Brown's Point is possible.

B.   GETTING TO BROWN'S POINT: SHORTENING THE HYBRID PHASE

The hybrid phase is at the center of a hurdle for self-driving technology to navigate before it is capable of reaching Brown's Point. Therefore, shortening the time in the hybrid period allows technology to reach Brown's Point quicker. I offer a few ways to shorten the hybrid phase of technological integration. One is to slow the advancement of technology, thereby allowing humans to catch up. The second way is to improve the reliability of technology so humans will adapt more easily and adopt them more quickly. Finally, increase humanity's ability to adapt and adopt self-driving technology.

Slowing technology's progression seems like the easier of the two fixes. To see the greatest potential and have true synergy, technology and humanity need to be performing at their best. Finding a way to allow technology to advance safely and for innovation to thrive while ensuring humans advance together with the technology is the most important piece in reaching Brown's Point.

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[154] James Schulte, "U.S. DOT Releases New Automated Driving Systems Guidance," National Highway Traffic Safety Administration, October 27, 2017, https://www.nhtsa.gov/press-releases/us-dot-releases-new-automated-driving-systems-guidance.

Considering that technology is more efficient and more capable of processing information and solving problems than the human in many respects, machine learning offers a tremendous benefit for humans.[155] As mentioned in Lance Whitney's *Time* magazine article, "computers are simply more accurate at pulling off a broadening range of high-value functions than we are. They're not affected or influenced by emotions, feelings, wants, needs and other factors [biases]."[156] When combined with human's intelligent technology, it offers a significant enhancement to human cognition and decision making, which is only possible, however, if the technology is programmed appropriately. Machines will do what humans ask of them. It is, therefore, incredibly important to get the programming right.

1. Helping Advancing Technology Reach Brown's Point

At its most advanced point, self-driving vehicles must reach level 5 automation, as shown in Figure 4. The technology is not yet there, and it is hard to predict when the technology will reach this benchmark; therefore, the focus must be placed on the here and now, or at levels 2 and 3. Humans remain partly responsible for driving—also known as the hybrid phase—so technology must partner with humans in the safest way possible.

Brown's fatality exposed that both self-driving technology and humans are fallible. If technology is programmed to learn and understand human biases, it can offer alternative suggestions for the human when making decisions and improving overall safety. By leveraging intelligent technology in this manner, the machine has an opportunity to assist the human in the most efficient manner. Learning how the driver learns, his tendencies, biases, and decision-making processes, coupled with what the self-driving vehicle senses in the environment, can offer a more global view. The computer can then warn the human of an increased amount of risk. By partnering with humans, the self-driving vehicle becomes a team player and can offer alternative choices of action to counter poor decisions or biases, if needed.

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[155] Whitney, "Are Computers Already Smarter Than Humans?"

[156] Ibid.

Regulation may provide a safer way forward for advancing technology but technology often outpaces regulation.[157] Hawking and Musk make the argument that intelligent agents, such as AI, need regulation to get the future right and not allow the idea of singularity to become reality.[158] Although regulation might be a popular solution, it is not as simple as it sounds.[159] Many factors must be considered when implementing regulations. Several agencies, including the Rand Corporation, are working on guiding documents for policymakers to regulate self-driving technology.[160] Further study is needed to understand the intended consequences, as well as unintended consequences of regulation.

2.   Training Humans to Reach Brown's Point

Helping humans adapt to self-driving vehicles is easily overlooked and requires a different type of training. The assumption, at least in the Autopilot case, is that skill sets will transfer from years of driving legacy vehicles. I propose that assumption is wrong. Humans have always thought of themselves as the decision maker and the one responsible for awareness and safety in the human-machine interface. Self-driving vehicles are changing and quite possibly creating confusion for who is responsible for safety and awareness.

Brown's case demonstrated the risk of overreliance and automation bias. Training the human as a supervisor of self-driving technology may offer a promising solution to this problem. Teaching humans what they need to know about the capabilities and limitation of the technology is important for the safety of the driver and others on the road. Tesla offered some warning of the limitations; however, I would argue writing it in a manual without hands-on training and education is insufficient; especially since it is

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[157] Bomey and Zambito, "Regulators Scramble to Stay Ahead of Self-driving Cars."

[158] Hawking, "Stephen Hawking: 'Transcendence Looks at the Implications of Artificial Intelligence—but Are We Taking AI Seriously Enough?'"; Tia Ghose, "Elon Musk: Regulate AI before Robots Start 'Killing People,'" LiveScience, July 17, 2017, https://www.livescience.com/59826-elon-musk-wants-ai-regulated.html.

[159] Almost half of the U.S. states have adopted or passed regulation for self-driving vehicles. In thinking about the future, it is prudent to create continuity in regulation across the nation.

[160] James M. Anderson et al., *Autonomous Vehicle Technology: A Guide for Policymakers* (Santa Monica: RAND, 2016).

such a natural human tendency to become overreliant on technology. The NTSB published this statement in its accident report regarding the soft constraints that Tesla provides for the owners of its vehicles:

> **Soft Constraints.** As a soft constraint to Autopilot use, Tesla provided written instructions in its owner's manual about those types of roads on which Autopilot should and should not be used (Tesla 2016). The *Tesla Model S Owner's Manual* stated that "Traffic-Aware Cruise Control is primarily intended for driving on dry, straight roads, such as highways and freeways" (p. 68). The manual also provided the following statement: "Warning: Do not use Traffic-Aware Cruise Control on city streets or on roads where traffic conditions are constantly changing and where bicycles and pedestrians are present" (p. 68). Similarly, with respect to the Autosteer system, the manual stated, "Warning: Autosteer is intended for use only on highways and limited-access roads with a fully attentive driver" (p. 74). In discussing restricted roads, the manual stated that "Autosteer is intended for use on freeways and highways where access is limited by entry and exit ramps" (p. 75). The manual also stated that "Autosteer is a hands-on feature. You must keep your hands on the steering wheel at all times" (p. 74).[161]

By just looking at his last section of the NTSB report, it is easy to see the page numbers indicate the owner of the vehicle must have read through 68 plus pages to get to this vital safety information. Having it buried in a document that is likely overwhelming just given the sophistication of the vehicle, is not a very efficient or safe way to communicate. How many people actually sit down and read a manual; I propose very few.

Since the self-driving technology is the greatest change in vehicles since the car was invented, it is prudent to consider re-training drivers in their new tasks. Further, drivers need to understand responsibilities and cognitive biases better, and make the training mandatory and hands-on. Parasuraman suggests, "training is required to recognize and counter decision biases that may lead to overreliance on automation."[162]

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[161] National Transportation Safety Board, *Collision between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida May 7, 2016*, 13.

[162] "In Memoriam: Noted Researcher and Scholar Raja Parasuraman"; Parasuraman and Riley, "Humans and Automation: Use, Misuse, Disuse, Abuse," 249.

With humans meeting machines, the responsibilities of the driver changes and further work on training owners is prudent.

Prior to Brown's death, Tesla owners had no "required" training. In retrospect, it is fairly easy to see the skill set of driving legacy vehicles is not comparable to the role of a human supervising a vehicle with Autopilot or self-driving features. Professor Nadine Sarter with the University of Michigan specializes in cognitive engineering and argues, "training the human in this supervisory role is necessary.[163] The human must learn and become an expert who understands the automated system's capabilities and limitations.

3.   Improving the Interface to Brown's Point

Improving the advancing technology and ensuring critical variables, such as human bias are accounted for, and improving humanity's ability to adapt to self-driving vehicles, will improve the interface. It is hard to say with certainty what the interface will look like in the future, especially considering how iterative a process it is to make improvements to technology. The future may see an interface that looks very different than what is seen today. Given how dynamic technology is, staying ahead or abreast with these challenges is important. Creating flexible and agile processes to analyze and quickly make improvements is needed. Research on this unprecedented interface must continue and should be a priority for all stakeholders.

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[163] Wesley A. Olson and Nadine B. Sarter, "Management by Consent in Human-machine Systems: When and Why It Break Down," *Human Factors* 43, no. 2 (2001): 255–66.

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V.   ALTERING THE VARIABLES WITH BROWN'S POINT

Understanding and changing the variables, heuristics, biases, and neuroscience associated with the human-machine interface can result in better outcomes. Consider this rewritten account of Brown's accident by altering the variables that contributed to his death.

It is a dry and clear Florida day on May 7, 2016. Joshua just finished a vacation with his family at Disneyland. It was the first time in a long time they had all been together as a family. Amanda (Josh's only sister) and her family left Orlando first. The kids had a blast hanging out with everyone, especially Uncle Josh; he always knew how to facilitate awesome adventures. Josh joined his parents at their campground for a little extra time with them. It was not often he had time off as the owner and workhorse behind his successful tech-business. He packed up Tessy (the name of his car), embraced his Mom and Dad, and got on the road.

Josh set his adaptive cruise control to nine mph over the speed limit, as he always did. With 25,000 miles in only 10 months under his belt driving with the Autopilot software upgrade, he knew the car worked well. Even Elon Musk was impressed by a video he had posted only a few weeks prior. Autopilot may very well have saved his life when he swerved to avoid a collision with a truck on a busy interstate.

He was now in supervisor mode. With his understanding that he had a tendency to rely on technology, he knew he was vulnerable. Even with the capabilities and confirmations that Autopilot was working as designed, he keeps his eyes up and his attention is on the road ahead. Continuing to scan ahead as taught when learning to drive the legacy vehicles of the past, he marveled in how relaxing driving was now that Autopilot was at the helm.

The next leg of his trip was long and straight with few cars on the road with him. Although the human mind might fall victim to letting its guard down, the Autopilot would warn him that the environment had an increased risk of inattentiveness. This risk reinforced the need for Josh to be an active supervisor; a lesson learned in the additional

training required to own a self-driving vehicle. The beauty in the Autopilot design is the technology helps the human shape an understanding of inattentiveness. New recently developed algorithms combine information from the car's sensors—that observe the external environment—and combine them with human biases and tendencies the vehicle learns from interacting with its human. The new human-centric technology helps people think about their thinking and guide them to better decisions.

Stopping in Williston, FL, Josh charged up the car and would be good for another 200 miles or so. Merging onto eastbound U.S. 27, he again set his Adaptive cruise control to 74 mph. He crested a small hill and noticed a semi truck in the left turn lane traveling in the opposite direction. He always travelled in the right lane unless he was passing. He noticed a small convenience store off to the right of the intersection and how green the fields were surrounding them. Less than 500 feet from the intersection, he sees the semi truck enter the uncontrolled intersection. Thinking to himself, what is this guy doing; does he not see me?

Confident that the Autopilot is aware of the peril, he knows the car will trigger the automatic braking system, Josh covers the brake with his foot just in case. To his surprise, the car does not slow down; that is weird, he thinks. He applies the brake, which automatically turns off the cruise control and puts it back into manual mode. He is always so impressed at how fast electric cars can brake. He quickly moves to the left lane and barely misses the back of the semi. He lays on the car's horn hopefully to make the truck driver aware of his surroundings. Returning to the right lane, he resets his car to 74 mph. In the rear view mirror, Josh watches as the semi truck exits the intersection behind him thinking to himself, those semis really need to have self-driving technology installed; that was close!

Josh's story re-written is important because if offers a window into what is possible when a more human-centric approach is taken when combining humans and machines. When technology accounts for human bias, it decreases the gap between technology and human fallibility, and thus, improves safety. Helping humans make safer decisions will likely improve adaptability and adoption of this technology, ultimately getting to Brown's Point.

Without careful consideration in combining humans with machines, the risk of error increases simply because both are fallible. A lack of continuity in this process creates disruption and mistakes.[164] When humans only supervise a self-driving vehicle, the execution of the decision making while driving can prevent them from developing a good understanding of the situation, which is essential to safety.[165] The more humans learn to rely on automation, the more difficult it will become for them to act accordingly in an emergency if they need to respond. As humans become more reliant on smart machines, the machines themselves must fill the gap for humans and create a positive interface.

Research from the airline industry offers some lessons learned from the human-machine interface.[166] Transcontinental pilots utilizing Autopilot features to decrease fatigue on long flights tested much lower in the motor skills needed to fly a plane manually compared to pilots who only used autopilot for a short time.[167] As the auto industry becomes increasingly similar to the airline industry, lessons from the aviation industry and National Aeronautics and Space Administration's (NASA's) automation in the cockpit may prove prudent for research and designers developing self-driving vehicles.[168]

Josh's alternative narrative is possible if the warnings are heeded. The results albeit, fictional, offer an alternative to his tragic and avoidable death. Demonstrating the benefits of intentional design with the human remaining at the center may save others from injury or death in the future, as humans inevitably interface with intelligent machines. Designing with intent to ensure machines' primary directive is to help humans on all levels is crucial.[169] To see the exponential potential of the human-machine

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[164] Breton and Bosse, "The Cognitive Costs and Benefits of Automation."

[165] Ibid.

[166] Andreas Haslbeck and Hans J. Hoermann, "Flying the Needles: Flight Deck Automation Erodes Fine-Motor Flying Skills among Airline Pilots," *Human Factors: The Journal of the Human Factors and Ergonomics Society* 58, no. 4 (June 13, 2016): 533, doi: 10.1177/0018720816640394.

[167] Ibid., 534.

[168] John Pavlus, "What NASA Could Teach Tesla about Autopilot's Limits," *Scientific American*, July 18, 2016. http://www.scientificamerican.com/article/what-nasa-could-teach-tesla-about-autopilot slimits/.

[169] Whitney, "Are Computers Already Smarter Than Humans?"

interface truly, reaching Brown's Point should be a goal of all advancing technology meant to work closely with humans.

A.   FURTHER AREAS OF STUDY AND MY RECOMMENDATIONS

Due to the infancy of self-driving vehicles, look to the airline industry for lessons learned regarding the human-machine interface.

1.   Take a greater human-centric approach to intelligent agent design. Perhaps partner with cognitive neuroscientists to understand human bias and decision-making processes better during the different levels of self-driving technology and test for cognitive biases and automation bias.

2.   Further define what human centric means in the digital era.

3.   Align benchmarks and goals with the different phases of self-driving vehicle capabilities to optimize safety. Each phase is different and brings different challenges.

4.   Understand how to program technology better to account for human biases to reach Brown's Point.

5.   Regulate self-driving vehicles but ensure the end goal of Brown's Point.

6.   Develop a social commentary and heuristic that allows the human to remain centric in human-machine interface.

7.   Require supervisor training for all self-driving vehicle owners separate from the driving education for legacy vehicles.

8.   Study the interface and how it changes with new advancing technology.

B.   CONCLUSION

By taking a very techno-centric approach to improve efficiency and ease of work over the last century, society is experiencing the fruits of its labor. Machines are meant to help humans and improve quality of life. Unfortunately, focusing so much on technology,

or the human in the equation, appears to hold less importance. Some may argue the genie is out of the bottle and there is no putting it back.[170] Technology is on a path that cannot be stopped, I disagree. It is possible to rehabilitate humanity but not alone. Partnering with technology, and learning new innovative ways to help humans adapt quicker, can help decrease the hybrid phase, which will ultimately help society reach Brown's Point and see the intention of advancing technology realized.

The idea of Brown's Point is applicable for any new advancing technology meant to interface with humans. Ensuring the variables and relationships between each is understood will help to design safe and helpful technology. It is possible with the speed of technology development that a reliable self-driving vehicle may come to fruition in the near future. Ensuring humans are as prepared as possible for this transition will allow self-driving vehicles to reach Brown's Point, which is fantastic news for the safety of this nation's roads and promises to save thousands of lives each year.

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[170] Bostrom, *Superintelligence: Paths, Dangers*.

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